City of San Diego Public Utilities Department

Final Draft Title 22 Engineering Report

North City Pure Water Project

April 2019

The City of SAN DIEGO

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City of San Diego
Public Utilities Department

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The City of SAN DIEGO

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List of Abbreviations

ABBREVIATION	DEFINITION
°F	Degrees Fahrenheit
°C	Degrees Celsius
1,2,3-TCP	1,2,3-Trichloropropane
2,4-D	2,4-Dichlorophenoxyacetic acid
2,3,7,8-TCDD (Dioxin)	2,3,7,8-Tetrachlorodibenzo-p-dioxin
2,4,5-TP	2,4,5-Trichlorophenoxyacetic acid
4,4'-DDT	4,4'-Dichlorodiphenyltrichloroethane
4,4'-DDE	4,4'-Dichlorodiphenyldichloroethylene
4,4'-DDD	4,4'-Dichlorodiphenyldichloroethane
Alpha BHC	1,2,3,4,5,6-hexachlorocyclohexane
AWT	Advanced Water Treatment
AF	Acre-feet
AFY	Acre-foot/feet per year
AOP	Advanced oxidation process
avg	Average
BAC	Biological activated carbon
BMP	Best Management Practice
BOD	Biological oxygen demand
$C_6H_8O_7$	Citric Acid
$CaCO_3$	Calcium carbonate
CAEDYM	Computational Aquatic Ecosystem Dynamics Model
CCR	California Code of Regulations
CCT	Chlorine contact tank
CEC	Constituent of Emerging Concern
CEPT	Chemically enhanced primary treatment
CFR	California Federal Regulations
CFU/mL	Colony forming unit per milliliter
CIP	Capital Improvement Program
CIU	Categorical Industrial User
Cl_2	Chlorine
CN	Cyanide
CO_2	Carbon dioxide
CTR	California Toxics Rule
DEET	N,N-Diethyl-meta-toluamide
DDW	Division of Drinking Water

ABBREVIATION	DEFINITION
DWTP	Drinking Water Treatment Plant
EC	Electrical conductivity
ELCOM	Estuary Lake and Coastal Ocean Model
EPA	United States Environmental Protection Agency
ESPA2 LD	Energy Saving Polyamide Low Differential
FLEWR	Filter Loading Evaluation for Water Reuse
Freon 12	Dichlorodifluoromethane
ft	Feet or foot
GAC	Granulated activated carbon
gpd	Gallons per day
gpm	Gallons per minute
gpm/sf	Gallons per square foot per minute
H_2CO_3	Xarbonic acid
H_2O_2	Hydrogen peroxide
H_2SO_4	Sulfuric acid
HAA5	Haloacetic acids
HOCl	Hypochlorite
HMX	Cyclotetramethylenetetranitramine
hp	Horsepower
HRT	Hydraulic retention time
IAP	Independent Advisory Panel
IWCP	Industrial Wastewater Control Program
JPA	Joint Powers Authority
LT2SWTR	Long-Term 2 Enhanced Surface Water Treatment
LF	Linear foot/feet
LRV	Log Reduction Value
LSI	Langelier saturation index
MBAS	methylene blue-activated substances
MBC	Metro Biosolids Center
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
MF	Membrane filtration
MG	million gallon
mgd	Million gallons per day
mg/L	Milligrams per liter
mg-min/L	Milligram-minute per liter
mJ/cm^2	Millijoule per square centimeter

ABBREVIATION	DEFINITION
MIBK	Methyl isobutyl ketone
MPN	Most probable number
MRP	Monitoring and reporting program
MS2	MS2 bacteriophage
MTBE	Methyl-tert-butyl ether
N	Nitrogen
NaOCl	Sodium hyprochlorite
NaOH	Sodium hydroxide
NCDPWF	North City Demonstration Pure Water Facility
NCPW	North City Pure Water
NCPWF	North City Pure Water Facility
NCWRP	North City Water Reclamation Plant
ND	Non-detect
NDEA	N-Nitrosodiethylamine
NDMA	N-Nitrosodimethylamine
NDPA	N-Nitrosodi-n-propylamine
ng/L	Nanograms per liter
N:P	Nitrogen to phosphorous
NPDES	National Pollutant Discharge Elimination System
NPR	Non-potable reuse
NTU	Nephelometric Turbidity Units
O&M	Operations and maintenance
OOP	Operation Optimization Plan
P	Phosphorous
pCi/L	Picocuries per liter
qPCR	Quantitative polymerase chain reaction
PDT	Pressure decay test
PLWTP	Point Loma Wastewater Treatment Plant
pMCL	Primary maximum contaminant limit
psi	Pound(s) per square inch
psig	Pound(s) per square inch gauge
PUD	Public Utilities Department
RDX	Hexahydro-1,3,5-trinitro- 1,3,5-triazine
RMSE	Root means square errors
RO	Reverse osmosis
RWQCB	Regional Water Quality Control Board
SDCSD	San Diego County Sanitation District

ABBREVIATION	DEFINITION
SDCWA	San Diego County Water Authority
sf	Square foot or feet
SIU	Significant Industrial User
SM	Standard method
sMCL	Secondary maximum contaminant levels
SOPs	Standard Operating Procedures
SRT	Solids retention time
SWA	Surface water augmentation
SWRCB	State Water Resources Control Board
SWTR	Surface Water Treatment Rule
TBA	Tertiary butyl alcohol
TCEP	Tris(2-carboxyethyl)phosphine
TCPP	Tris (chloroisopropyl) phosphate
TDCPP	Tris(1,3-dichoro-2-propyl) phosphate
TDS	Total dissolved solids
TMF	Technical, managerial, and financial
TNT	2,4,6-Trinitrotoluene
TOC	Total Organic Carbon
TON	Threshold odor number
TSS	Total Suspended Solids
TTHM	Total trihalomethanes
UCMR	Unregulated Contaminate Monitoring Rule
UF	Ultrafiltration
UV	Ultraviolet Light
UV/AOP	Ultraviolet Light/Advanced Oxidation Process
V/G/C	Viruses, *Giardia* cysts, *Cryptosporidium* oocysts
V/Q	Theoretical retention time
WRP	Water reclamation plant
WRRF 14-12 Study	WateReuse Research Foundation Demonstrating Redundancy and Monitoring to Achieve Reliable Potable Reuse Study
yd^3	Cubic yard
µg/L	Microgram(s) per liter
µm	Micrometer (one millionth of a meter)
µmhos/cm	Micromho(s) per centimeter
µS/cm	MicroSiemens per centimeter

Glossary

TERM	DEFINITION
Advanced Water Treatment	Additional engineered treatment of wastewater after secondary or tertiary treatment to remove contaminants of concern and achieve public health, environmental, or specific beneficial reuse parameters. In the case of the North City Pure Water Project, advanced water treatment refers to the NCPWF treatment train, which includes the following treatment processes: ozonation, BAC filtration, MF, RO, UV/AOP, chemical conditioning and chlorination.
Basin Plan	Water Quality Control Plan for the San Diego Basin (9), which was originally adopted by the California RWQCB San Diego Region on September 8, 1994, and since has been amended various times.
Critical Control Limit	Maximum and/or minimum value to which a biological, chemical, or physical parameter must be controlled at a critical control point. Conditions outside the designated target or goal activate alarm(s) and require that corrective actions be taken.
Critical Control Point	A point in the treatment train (i.e., a unit treatment process) that is designed specifically to reduce, prevent, or eliminate a human health hazard. Biological, chemical, or physical parameters called critical control limits are continuously or frequently measured or monitored to assess whether the critical control point is performing as intended and meeting its performance goals. In the case of the North City Pure Water Project, each pathogen barrier (secondary treatment, tertiary filters, ozone, MF, RO, UV/AOP, and pipeline chlorination) is considered a critical control point, and some cases, a treatment process may involve more than one critical control point.
Demonstration Project	The Water Purification Demonstration Project was the second phase of the City's Water Reuse Program. The project, which was completed in 2013, involved the operation of a 1-mgd demonstration-scale treatment facility, referred to as the NCDPWF, as well as reservoir studies and public outreach.
Direct Potable Reuse	The planned delivery of purified water to a DWTP or a drinking water distribution system without a significant environmental buffer. Additional treatment, monitoring, and/or an engineered buffer(s) would be used in place of an environmental buffer to provide equivalent protection of public health and response time in the event that the purified water does not meet specifications.
Environmental Buffer	A water body such as an aquifer, wetland, river, or reservoir that provides a number of benefits, including contaminant removal, dilution and blending, and time to detect and respond to failures before final treatment and distribution. These benefits, in conjunction with varying levels of upstream treatment, provide the necessary public health assurances required of indirect potable reuse projects.

TERM	DEFINITION
Finished Water	Water produced by a water treatment facility. In this report, finished water refers to water produced by the NCPWF (also referred to as purified water) and by the Miramar DWTP (also referred to as potable or drinking water).
Groundwater Replenishment	The planned addition of recycled water to a groundwater basin designated in a Basin Plan (Water Quality Control Plan) for use as a source of water for drinking water supplies. Groundwater replenishment using recycled water may be accomplished via surface applications (spreading) or subsurface applications (injection).
Independent Advisory Panel	Independent panel of experts convened by the National Water Research Institute on behalf of the City to guide the development of the Pure Water San Diego Program and provide specialized peer review of the technical, scientific, and regulatory aspects of the North City Pure Water Project.
Indirect Potable Reuse	The addition of recycled water to augment groundwater or surface waters. Groundwater and surface waters are considered environmental buffers for providing public health protection benefits, such as contaminant attenuation, dilution, and time to detect and respond to failures before final treatment and distribution.
Metro Wastewater Joint Powers Authority	Coalition of the municipalities and special districts that share in the use of the City's Metropolitan Wastewater/Sewerage System. Representatives from each of the 12 Participating Agencies serve as an advisory body to the San Diego City Council on the operation of the Metropolitan Wastewater/Sewerage System.
Metropolitan Wastewater/Sewerage System	Regional wastewater system that conveys, treats, and disposes of the wastewater from the City and 12 other Cities and districts (referred to as Participating Agencies).
Non-potable Reuse Water	Includes all recycled or reclaimed water reuse applications allowable under the Title 22 Water Recycling Criteria, other than those related to water supply augmentation and drinking water (i.e., potable reuse). Typical applications for non-potable reuse water include industrial uses, agricultural or landscape irrigation, recreational impoundments (e.g., lakes), or environmental uses (e.g., wetlands that support wildlife).
Off-spec Water	Any final effluent from the NCPWF (measured at the NCPW Pump Station) that does not meet all the regulatory requirements for discharge to Miramar Reservoir.
Participating Agencies	Twelve agencies that represent the 15 nearby cities and districts that discharge wastewater into the Metropolitan Wastewater/Sewerage System. Participating Agencies include: Cities of Chula Vista, Coronado, Del Mar, El Cajon, Imperial Beach, La Mesa, National City, and Poway; Lemon Grove Sanitation District; Otay Water District; Padre Dam Municipal Water District; and County of San Diego (on behalf of the Winter Gardens Sewer Maintenance District, and the Alpine, Lakeside and Spring Valley Sanitation Districts).

TERM	DEFINITION
Potable Reuse	A general term for the planned use of recycled water to augment drinking water supplies. Potable reuse, which covers both indirect and direct potable reuse, involves various forms of treatment options and barriers to protect public health.
Product Water	Processed water that has gone through a specific treatment process or treatment train.
Program	The Pure Water San Diego Program is a phased, 20-year public infrastructure program that will produce 83 mgd of purified water. At full completion in 2035, the facilities built under the Program will provide a third of San Diego's water supply and reduce the City's ocean wastewater discharges by more than half.
Project	The Pure Water North City Project is the first phase of the Pure Water San Diego Program. The Project is scheduled to be operational by 2021 and is designed to augment the City's Miramar Reservoir with approximately 30 mgd (on average) of purified water.
Purified Water	Water that has passed through a wastewater treatment plant and full advanced treatment plant, and has been verified through monitoring to be of a quality suitable for augmenting drinking water supplies.
Raw Wastewater/Sewage	Wastewater or sewage collected in the City's Municipal and Metropolitan Wastewater/Sewerage System before it receives any treatment.
Reclaimed Water	Wastewater, which as a result of treatment, is suitable for NPR. Refer to Recycled Water definition.
Recycled Water	Water that is used more than one time before it passes back into the water cycle. Wastewater that has been treated to a level that allows for its reuse for a beneficial purpose in accordance with Title 22 Water Recycling Criteria, (e.g., irrigation or groundwater replenishment via spreading). Recycled water is sometimes referred to as reclaimed water or non-potable reuse water. With additional treatment, including advanced treatment, recycled water can be used as a source of water for a drinking water supply (refer to Potable Reuse and Groundwater Replenishment).
Redundancy	The use of measures beyond the minimum requirements to ensure that treatment goals are more reliably met or performance can be more reliably demonstrated. Redundancy is a failure prevention strategy.
Reliability	The ability of a treatment process or treatment train to achieve the desired degree of treatment consistently, based on its inherent redundancy, robustness, and resilience. Reliability can be achieved by two different strategies: failure prevention and failure response.
Resilience	The ability to respond to and recover from treatment failures. Early detection, pro-active adjustments, and diversified response options all contribute to the North City Pure Water Project's resilience. Resilience is a failure response strategy.

TERM	DEFINITION
Robustness	The use of multiple and diverse treatment barriers to control a broad variety of constituents and resist catastrophic failures. Robustness is a failure prevention strategy.
Source Control Program	City's IWCP, which applies and enforces federal pretreatment regulations for the entire Metropolitan Wastewater/Sewerage System.
State Expert Panel	Independent expert panel convened by the SWRCB in 2013 to advise the State of California on public health issues and scientific and technical matters regarding: (1) development of uniform water recycling criteria for indirect potable reuse through surface water augmentation, and (2) investigation of the feasibility of developing uniform water recycling criteria for direct potable reuse.
Surface Water Augmentation	Planned placement of recycled water into a surface water reservoir used as a source of domestic drinking water supply.
Tertiary Treated Water	Product water from the tertiary filters at the NCWRP. A portion of the tertiary treated water is chlorinated to comply with Title 22 Water Recycling Criteria and used as disinfected, tertiary effluent (recycled water) for non-potable reuse. The majority of the tertiary treated water is not chlorinated and conveyed to the NCPWF.
Water Recycling Criteria	CCR, Title 22, Division 4 "Environmental Health", Chapter 3 "Water Recycling Criteria", which set forth requirements for recycled water production and use.
Working Group	The Pure Water Working Group was formed by the City to provide diverse viewpoints on the planning and implementation of the Pure Water San Diego Program. It serves as a forum for gaining input and feedback from many stakeholder groups representing broad community interests.

1. Executive Summary

The North City Pure Water Project ("North City Project" or "Project") is the first phase of the Pure Water San Diego Program ("Pure Water Program" or "Program"). The City of San Diego's (City) Project is designed to augment Miramar Reservoir, which is a source of domestic drinking water supply, with purified water produced at the North City Pure Water Facility (NCPWF).

This document comprises the Title 22 Engineering Report for the North City Project.

1.1 Report Overview

This Title 22 Engineering Report describes the City's plan for compliance with the California Code of Regulations (CCR) Title 22 Water Recycling Criteria, including Surface Water Augmentation (SWA) regulations (CCR, 2018, in progress). This report is prepared in fulfillment with the State Water Resources Control Board (SWRCB) Division of Drinking Water (DDW) requirements and contains 18 sections, as described in this Executive Summary.

1.2 Project Overview

The Project, as illustrated on Figure 1-1, is designed to produce a total annual average of up to 34 million gallons per day (mgd) (38,080 acre-feet per year [AFY]) of purified water for potable reuse and salinity management of non-potable reuse (NPR) water. Of the total purified water supply, an annual average of approximately 30 mgd (33,600 AFY) will augment the City's Miramar Reservoir, and an annual average of approximately 4 mgd (4,480 AFY) will be used to reliably and cost effectively manage the salinity of the NPR water. The Project is scheduled to be operational by late 2021.

The Project will involve diverting additional untreated municipal wastewater to the North City Water Reclamation Plant (NCWRP) via the Morena Pump Station and Pipeline. The permitted capacity of the NCWRP will be modified to enable production of tertiary treated water for the NCPWF and satisfy NPR water demands supporting both potable and non-potable reuse. Wastewater treated at the expanded NCWRP will be further treated at the NCPWF to produce a safe, high-quality, sustainable source of water to supplement existing water supplies. From the NCPWF, purified water will be conveyed to Miramar Reservoir via the North City Pure Water (NCPW) Pump Station and Pipeline. Miramar Reservoir is a source of supply to the Miramar Drinking Water Treatment Plant (DWTP), which provides drinking water to the northern portion of the City's service area.

1.2.1 Purpose of the Title 22 Engineering Report

The purpose of this Title 22 Engineering Report is threefold:

- To request approval from DDW for the North City Project and form the basis for the Regional Water Quality Control Board (RWQCB) to issue a National Pollutant Discharge Elimination System (NPDES) permit for the Project;
- To request approval from DDW for modifying the NCWRP and form the basis for the RWQCB to issue a new or amended master water recycling permit for the NCWRP; and
- To request approval from DDW and form the basis of the water supply permit amendment to use Miramar Reservoir, as augmented with purified water, as a source of supply in the City of San Diego's drinking water system.

Figure 1-1: North City Pure Water Project Schematic

1.2.2 Background

The evolution of the Pure Water Program began with the 2004 authorization by the City Council to evaluate viable options to maximize recycled water use through the Water Reuse Study (City, 2006) and subsequent studies and master planning activities. These efforts led to the North City Demonstration Pure Water Project ("Demonstration Project") (City, 2013b), forming the foundation for the Pure Water Program. The original implementation plan for the Program envisioned 15 mgd of purified water production by 2023, 30 mgd by 2027, and 83 mgd by 2035. Now, the City's plan involves 30 mgd of purified water production by 2021.

1.2.3 Project Participants

The North City Project is being sponsored and implemented by the City. The City owns San Diego's water, wastewater, and recycled water systems and operates those systems through the City's Public Utilities Department (PUD). Along with providing wastewater collection and conveyance services within the City, the PUD treats and disposes of the wastewater from 12 other cities and districts (referred to as Participating Agencies).

1.2.4 Project Development and Supporting Activities

The 2006 Water Reuse Study was the first phase of the City's Water Reuse Program. The second phase of the Water Reuse Program featured the Demonstration Project, which consisted of the construction and operation of a 1-mgd advanced water treatment facility (referred thereafter in this report as the North City Demonstration Pure Water Facility [NCDPWF]), treatment and limnology studies and investigations, culminating with the 2013 adoption of the Demonstration Project Report by the City Council (City, 2013b). In 2014, the City Council approved advancement of the Program towards implementation. The North City Project is the first component of the Pure Water Program.

1.2.5 Public Outreach

Public outreach for the Pure Water Program and the City's water recycling efforts is a robust effort that involves ongoing informational meetings and tours designed to educate the public and residents on the benefits of potable reuse. Section 3 describes the City's public outreach activities in more detail.

1.2.6 Independent Advisory Panel

The City has engaged an Independent Advisory Panel (IAP), which was formed and managed by the National Water Research Institute, to provide guidance and specialized peer review of the technical, scientific, and regulatory aspects of the Project. In October 2015, the IAP opined that, "the delivery of purified water to Miramar Reservoir coupled with the additional treatment and monitoring proposed by the City for the North City Project is protective of public health." This finding is documented in a memorandum prepared by the National Water Research Institute (NWRI, 2015). Additionally, in 2016, two IAP Subcommittees were formed to address the limnology and NCDPWF elements of the Project.

In October of 2017, the IAP was re-convened to provide additional opinions regarding dilution modeling in Miramar Reservoir and pathogen removal credit at the NCWRP. The Panel's input regarding the pathogen removal credit and modeling is included in the discussion in Sections 10 and 11, respectively.

1.2.7 Environmental Compliance

The Program Environmental Impact Report for the Pure Water Program (State Clearinghouse No. 2014111068) was completed and certified by the City Council in October 2016 (City, 2016a) for compliance with the California Environmental Quality Act. A Project-level joint California Environmental Quality Act and National Environmental Policy Act Environmental Impact Report and an Environmental Impact Statement were released in September 2017. The comment period has closed, the documents were finalized in February 2018. The City Council certified the documents in April 2018, and a Record of Decision by the Bureau of Reclamation is expected in June 2018.

1.2.8 Project Goals

By ultimately producing one-third of the City's water supply, while reducing flows to the Point Loma Wastewater Treatment Plant (PLWTP), the phased Pure Water Program will address two considerable water challenges faced by the City:

- Lack of local control over the City's water supply; and
- Requirement to renew PLWTP's Clean Water Act Section 301 (h) modified permit every five years.

The North City Project is the first phase of the multi-year Program that will achieve water supply and wastewater management goals and objectives to provide an integrated solution.

1.3 Public Outreach

The City's public outreach effort is an integral part of the Pure Water Program. In addition to all ongoing programmatic initiatives to gain and maintain public and stakeholder support, more focused project-specific outreach activities are now being initiated as individual Project facilities are developed. The ongoing Program-level outreach plan conveys key messages about how the Program:

- Provides a safe, reliable, cost-effective drinking water supply;
- Provides a locally controlled, drought-proof water supply; and
- Uses proven technology and is environmentally friendly.

A comprehensive education and outreach plan, focusing communication efforts on community leaders and stakeholder groups or organizations, has been successful in informing San Diego residents about and gaining support for the Pure Water Program. A variety of outreach activities has been employed to educate the public about the safety and reliability of the water purification process and how the Pure Water Program will address both San Diego's water and wastewater challenges. Stakeholder and partner communications are actively continuing; more specific outreach activities are planned to inform residents in communities near the Project.

1.3.1 Background

Since 2004, public perception in San Diego about water recycling and various forms of water purification has evolved positively. Extensive public outreach and education have largely transformed initially skeptical attitudes into supporters and Program stakeholders. Since 2010, a variety of outreach activities have been employed to educate the public about the safety and reliability of the water purification process and how the Pure Water Program will address the City's water and wastewater challenges.

1.3.2 Outreach Activities

Outreach activities include educational materials, speakers' bureau presentations to various community groups and organizations, public tours of the City's NCDPWF, engagement via social media platforms, in-person stakeholder interviews, participation in water industry conferences, hosting information booths at community events, youth outreach activities, annual open house events held at the NCPWF and NCDPWF, and a partnership with the University of San Diego Communication Studies Department.

1.3.3 Stakeholder and Partner Communication

The City formed the Pure Water Working Group ("Working Group") comprising representatives from community planning groups, businesses, city council district offices, non-profit environmental organizations, and community leaders to provide input on the City's efforts to provide a safe, reliable, and sustainable drinking water supply. Stakeholder interviews and involvement in multicultural events and in-person communications are the other strategies being used to expand knowledge about the Program.

1.4 Regulatory Requirements

The California Water Code supports and encourages recycled water use and Title 22 Water Recycling Criteria (CCR, 2014) to regulate recycled water production and use, establishing water quality standards and treatment reliability requirements. In 2009, the SWRCB adopted Resolution 2009-0011, "Policy for Water Quality Control for Recycled Water" (Recycled Water Policy) (SWRCB, 2009). The Recycled Water Policy set a mandate for increasing the use of recycled water by 200,000 AFY by 2020, and an additional 300,000 AFY by 2030, with a goal of replacing the use of potable water with recycled water for appropriate NPR water uses (e.g., landscape irrigation, agricultural uses, industrial uses, urban uses, and recreational/environmental uses), thereby allowing potable water supplies to be conserved for potable uses.

As a potable reuse and SWA strategy, the Project will be regulated by the various state laws and requirements that are discussed in Section 4 of this Title 22 Engineering Report.

1.4.1 Water Recycling and Potable Reuse in California

Groundwater replenishment using recycled water has a long history in California, beginning in 1962 and continuing today with six projects currently in operation using surface (spreading) and subsurface (injection) applications with more projects on the horizon. SWA, using recycled water as indirect potable reuse, has not yet been implemented in California. Uniform water recycling criteria for SWA are in development by DDW in accordance with California Water Code Section 13562 and are discussed further, below. SWA is defined in California Water Code, Chapter 7 titled "Water Reclamation" as Section 13561(d): *"Surface water augmentation means the planned placement of recycled water into a surface water reservoir used as a source of domestic drinking water supply."*

1.4.2 Regulatory Requirements to Protect Public Health

Section 13562 of the California Water Code states that an Expert Panel must review the water recycling criteria for surface water augmentation and find that the proposed regulations adequately protected public health. The Expert Panel convened on behalf of DDW adopted the finding that the Proposed SWA criteria would adequately protect public health on October 31, 2016. Following a review by the Office of Administrative Law, the Draft SWA Regulations were issued by DDW in July 2017 for public review. Following public review, proposed SWA regulations were issued by DDW in October 2017 and later adopted by the SWRCB in March 2018 (SWRCB, 2018). The adopted SWA regulations have been submitted to the Office of Administrative Law for review, approval, and filing with the Secretary of State.

The regulations contain provisions that apply to the Project, including plan development, technical, managerial and financial capability of the City, demonstration that the treatment processes can be operated for their intended purpose, compliance monitoring, and reporting. The regulations describe specific advanced treatment criteria, wastewater source control measures, approaches to pathogenic microbial and chemical contaminant control, and requirements for augmented reservoir operation and monitoring.

1.4.3 Regulatory Requirements to Protect Receiving Waters

The NPDES permit for the Project will be issued by the RWQCB to establish purified water quality requirements that implement state and federal water quality standards for Miramar Reservoir, statewide standards for inland surface waters that have been imposed by the United States Environmental Protection Agency (EPA) within the California Toxics Rule (CTR) (40 CFR 131.38) (EPA, 2000a), and statewide policies established by the SWRCB for chlorine residual.

1.5 Source Wastewater

The source wastewater for the Project is raw, municipal wastewater from the northern portion of the City's Metropolitan Sewerage System, which encompasses the existing NCWRP sewershed and the new Morena Pump Station sewershed. Figure 1-2 illustrates the NCWRP and Morena Pump Station sewersheds.

The City administers and enforces the Industrial Wastewater Control Program (IWCP). Due to the PLWTP's modified NPDES permit, the City's Source Control Program, which spans the entire Metropolitan Sewerage System, is more comprehensive than other federal industrial pretreatment programs. The City provides enhanced source control to protect public health, the environment, and the quality of recycled water. The IWCP will be further enhanced for potable reuse as required by the SWA regulations.

1.5.1 Sewershed Description

Adding the new Morena Pump Station sewershed flows to the existing NCWRP sewershed flows will increase the volume of raw wastewater conveyed to the expanded NCWRP, resulting in a total annual average wastewater flow of about 52 mgd being treated at the expanded facility. The existing NCWRP sewershed will provide 26 mgd of wastewater flow, while the new Morena Pump Station will provide an equivalent flow. Industrial discharges currently comprise less than three percent of the municipal wastewater flow in these two sewersheds.

1.5.2 North City Water Reclamation Plant Flows and Characteristics

The NCWRP began treating a relatively constant raw wastewater flow rate of approximately 16 mgd in mid-2011 to minimize the amount of treated water that is sent back to the PLWTP (i.e., recycled water produced at the NCWRP, but not reused). Since then, the average annual flows have varied from 15.3 in 2013 to 16.8 in 2015. The characteristics of the wastewater that will be treated at the NCWRP following implementation of the Project were projected by using sampling data from the existing plant influent and the four sewers that will be diverted to the Morena Pump Station. Table 1-1 presents the projected raw wastewater characteristics of the NCWRP influent.

Table 1-1: Projected Wastewater Characteristics for the North City Project

Parameter	Units	Value[a]
Flow Rate	mgd	51.6
Raw Influent BOD	mg/L	308
Raw Influent TSS	mg/L	348
Ammonia	mg-N/L	37.3
Raw Influent Phosphate	mg-P/L	2.8
Alkalinity	mg $CaCO_3$/L	310

[a] Estimated raw wastewater concentrations are based on water conservation and adding Morena Pump Station to NCWRP

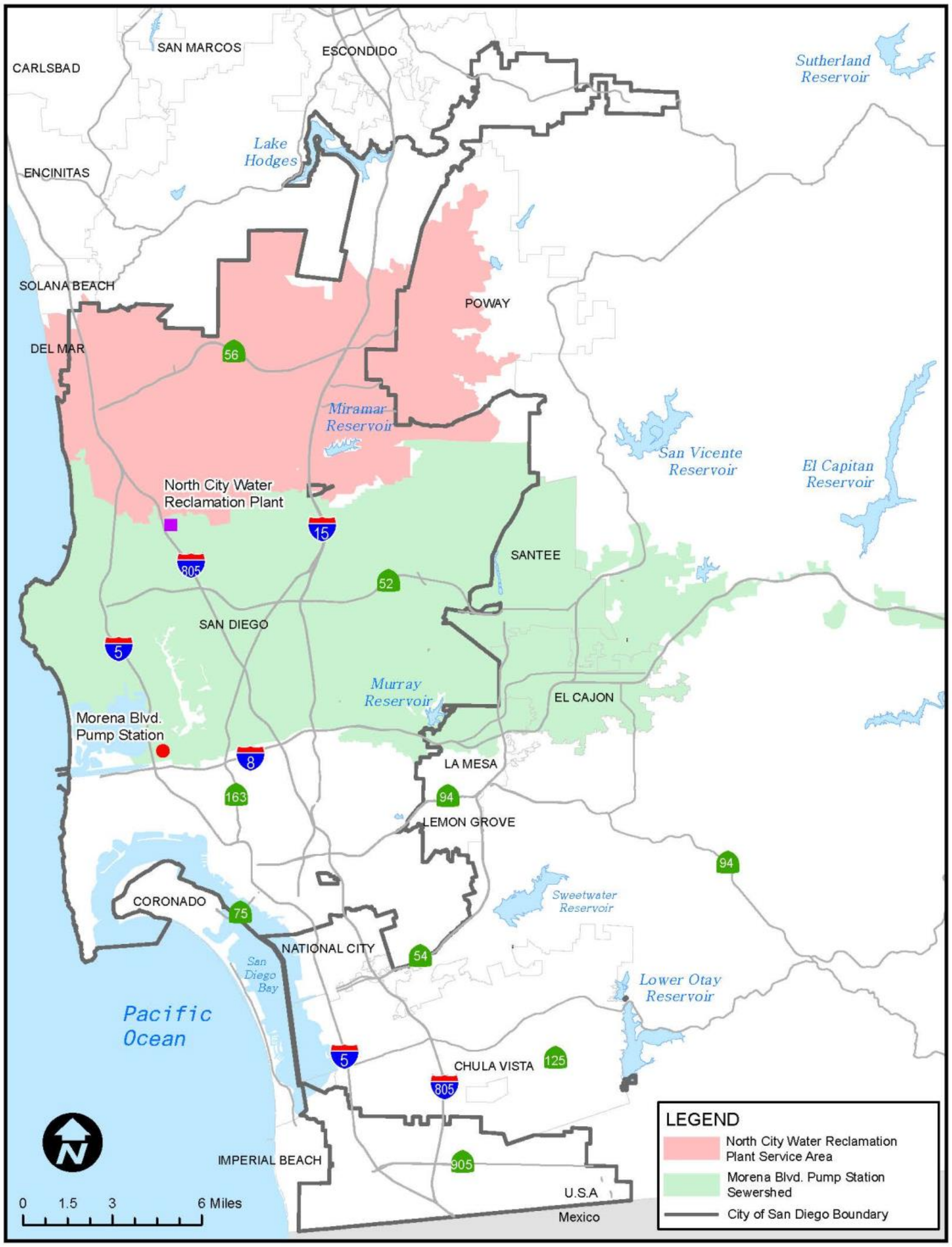


Figure 1-2: NCWRP and Morena Pump Station Sewersheds

1.5.3 Regulatory Requirements to Protect Receiving Waters

The City's IWCP administers and enforces the source control requirements, including federal pretreatment regulations set forth by the EPA and Clean Water Act, for the entire San Diego Metropolitan Sewerage System. One of IWCP's objectives is protection of the quality of recycled water. An industrial wastewater discharge permit system is being implemented through the IWCP to regulate pollutant discharges into the Metropolitan Sewerage System from industrial facilities. This involves issuing permits that establish enforceable pollutant limits and authorize civil and criminal penalties for discharge violations.

The IWCP also establishes sampling, reporting, record keeping, and notification requirements. Enhancements to the City's Source Control Program are a critical part of the Project and will include source investigations to develop an expanded inventory of potential contaminants and dischargers, an assessment of the fate of specified contaminants through treatment, and a new local limits analysis for the NCWRP.

1.6 Project Facilities Description

1.6.1 Project Overview

The Project is a planned SWA project that will treat municipal wastewater to generate tertiary treated water to be processed further at an advanced water treatment facility, which in turn will produce purified water to supplement a reservoir that supplies a drinking water treatment plant. The Project is designed to produce a total annual average up to 34 mgd (38,080 AFY) of purified water and satisfy NPR water demands as follows:

- Up to 30 mgd (33,600 AFY) of purified water to augment Miramar Reservoir as a source water to the Miramar DWTP;
- Approximately 4 mgd (4,480 AFY) of purified water to supplement and reduce the total dissolved solids (TDS) concentration of the NCWRP NPR water; and
- Approximately 11.8 mgd (13,200 AFY) of NPR water to meet demands of existing and future NPR customers.

The Project involves multiple treatment processes and barriers to protect public health and the environment, as well as a reservoir that provides a significant environmental buffer. An overview of the Project's processes and barriers is illustrated on Figure 1-3.

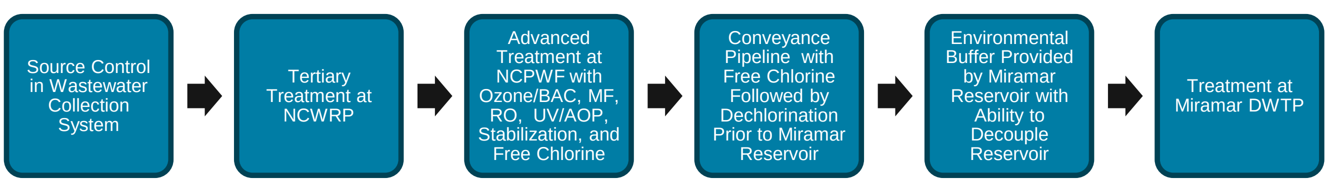


Figure 1-3: North City Pure Water Project Process and Barrier Overview

Facility descriptions for the Project are highlighted as part of this executive summary and Figure 1-4 illustrates the North City Project's process schematic. Section 6 of this Engineering Report includes detailed facility descriptions.

1.6.2 Wastewater Collection System

The expanded NCWRP will treat municipal wastewater from two different sewersheds in the regional collection system – existing NCWRP sewershed and new Morena Pump Station sewershed. Existing pump stations that deliver wastewater to the NCWRP are not currently able to deliver the 52 mgd required during average dry weather conditions to provide source water for production of 34 mgd of purified water and 11.8 mgd of NPR water. The Morena Pump Station and Pipeline, along with new diversion structures, will be built to allow the NCWRP to operate at the required 52 mgd average annual flow of municipal wastewater consistently. The Morena Pump Station will be located northeast of the intersection of Interstate 5 and Interstate 8. The Morena Pipeline, a new 48-inch-diameter forcemain extending approximately 10.4 miles, will convey wastewater to the NCWRP. Figure 1-5 illustrates the Morena Pipeline planned alignment.

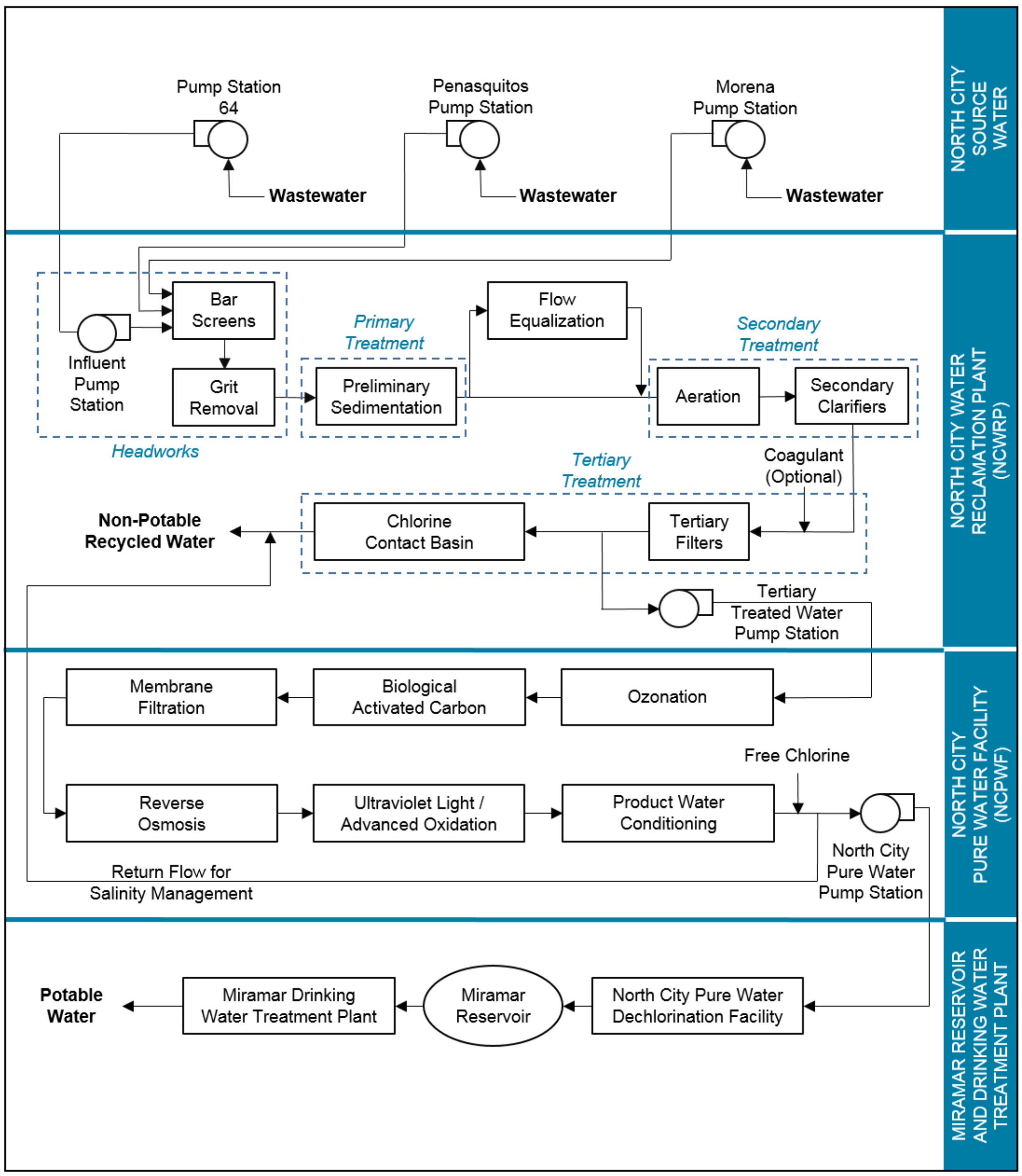


Figure 1-4: North City Project Process Schematic

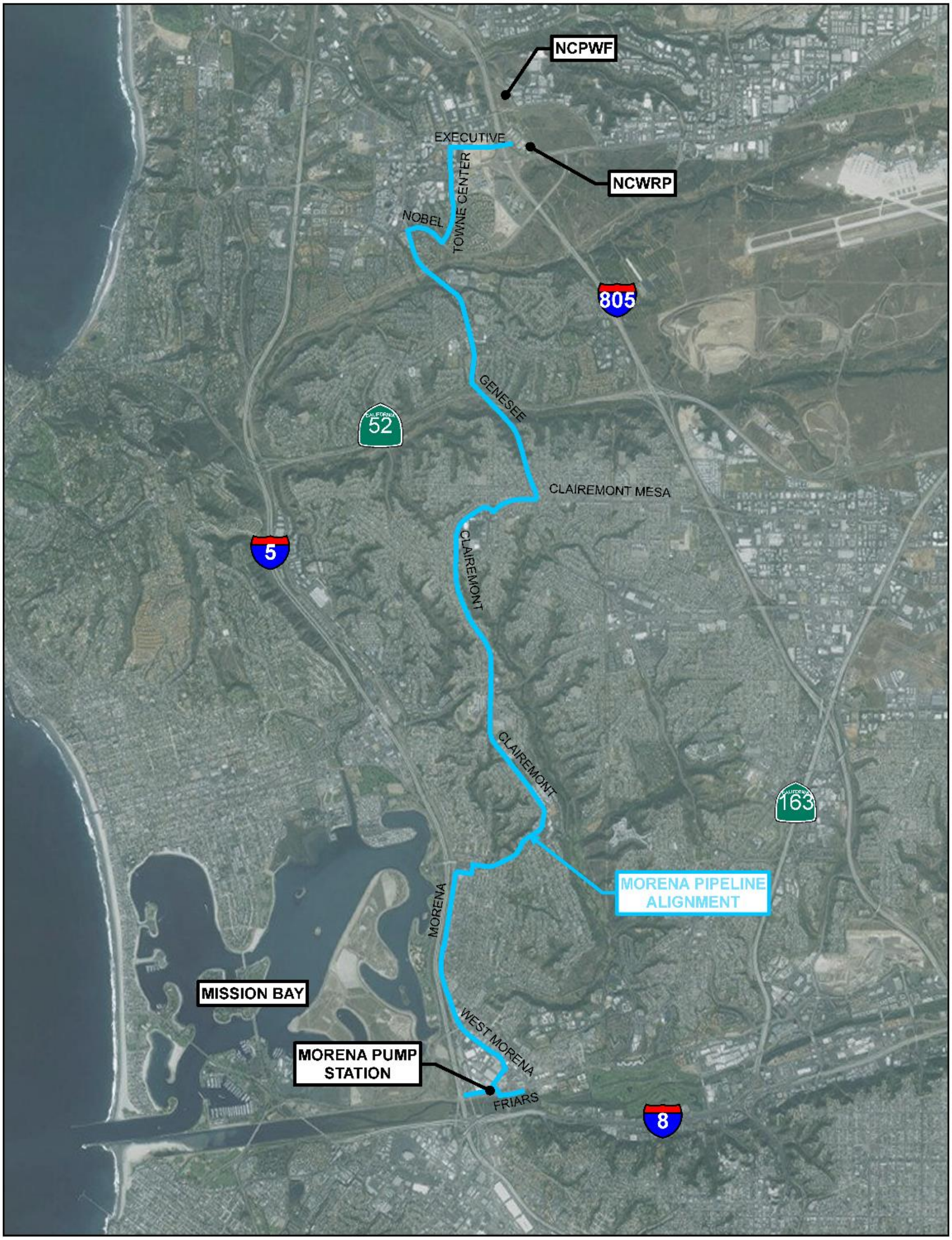


Figure 1-5: Morena Pump Station and Pipeline Alignment

1.6.3 North City Water Reclamation Plant Expansion

The existing NCWRP, located at Eastgate Mall and Interstate 805, has an average dry weather flow rated capacity of 30 mgd and acts as a scalping plant, receiving flows that would otherwise be treated at the PLWTP. The NCWRP will be expanded and upgraded to produce sufficient NPR water to meet NPR water demands in the existing system and generate tertiary treated water as source water for the NCPWF. The NCWRP expansion will increase the plant's rated average annual flow capacity from 30 to 52 mgd average with a peak design flow capacity of 55 mgd.

Treatment at the expanded NCWRP will feature primary treatment, flow equalization, secondary treatment, tertiary filtration and chlorine disinfection. Secondary and tertiary treatment are the initial treatment barriers for pathogen reduction for potable reuse. The NCWRP expansion will add chemically enhanced primary treatment (CEPT) to increase treatment efficiency and include the use of the 4-stage Bardenpho biological treatment process for nutrient removal. Design of the NCWRP expansion assumes a total solids retention time (SRT) of ten days. Sizing of treatment processes is based on an N+1 concept, such that at least one additional standby unit or basin will be provided for redundancy.

Flow equalization facilities will help mitigate impacts from diurnal flow variations, supporting a stable biological process and filtration. The flow equalization and treatment upgrades will also allow the NCWRP to produce a relatively constant flow to continue production of disinfected, tertiary treated water (recycled water) for NPR uses, and a sufficient tertiary treated water stream as source water for advanced treatment at the NCPWF, where purified water will be produced. The annual average NPR flow has been established at 11.8 mgd. Solids from the NCWRP will be conveyed to the Metro Biosolids Center (MBC) for treatment and disposal. A schematic of the expanded NCWRP is illustrated on Figure 1-6.

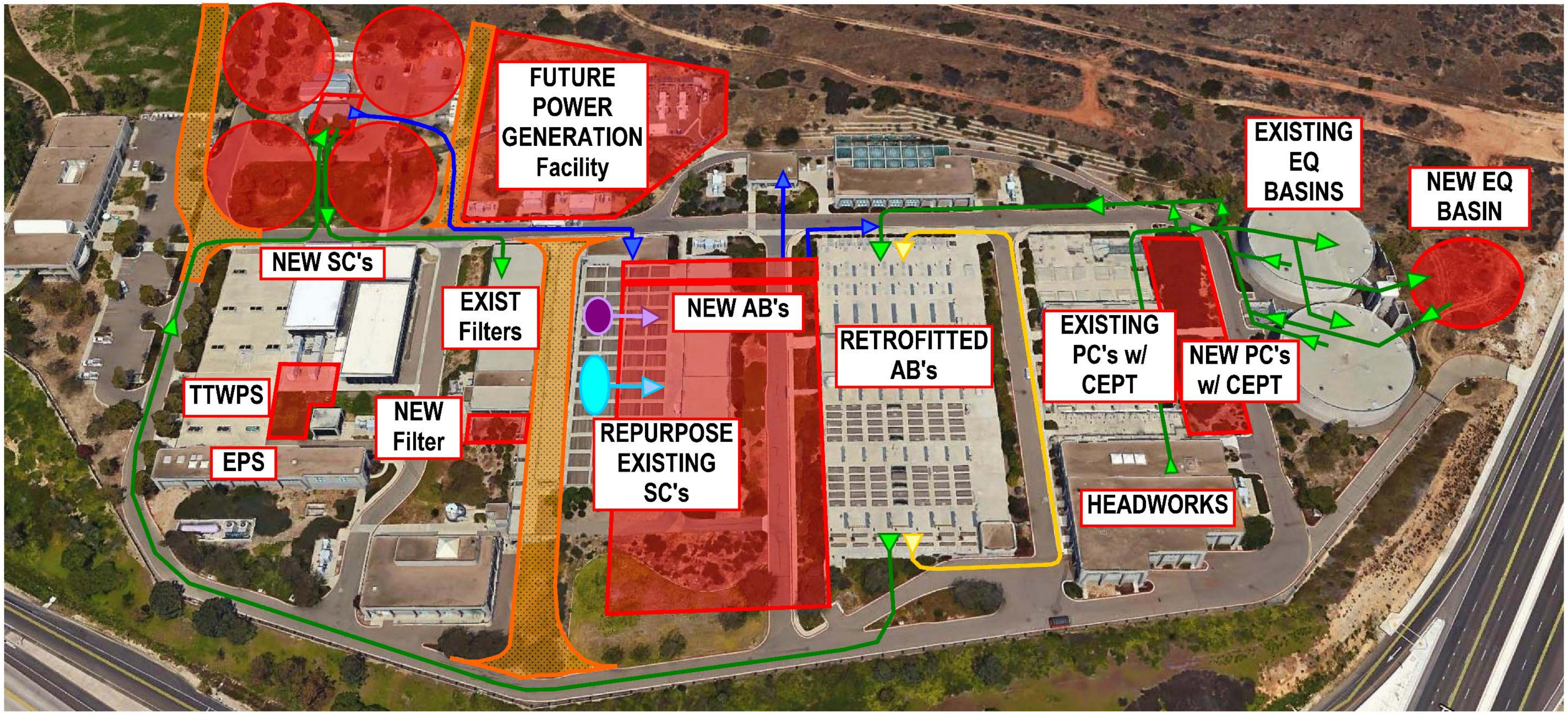
1.6.4 Non-Potable Reuse Water Conveyance System

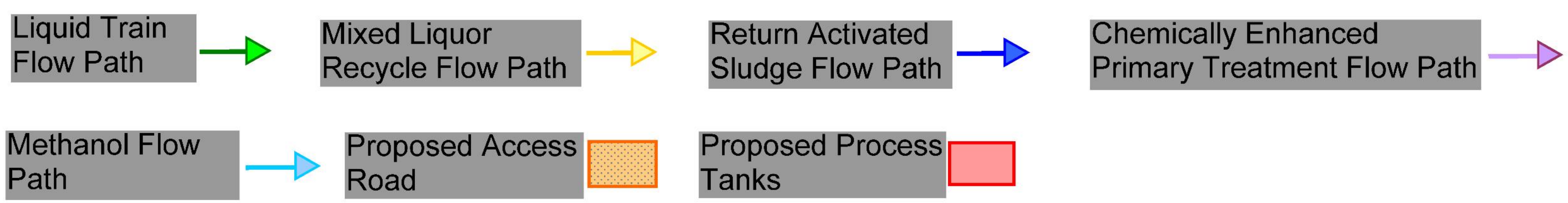
The City currently operates the NCWRP and NPR water system in compliance with RWQCB Order No. R9-2015-0091, which is a "Master Recycling Permit" (RWQCB, 2015). The NPR Water Pump Station, located at the NCWRP site, will accommodate the projected NPR water demands. As of 2015, the NPR water system supplied by the NCWRP comprises approximately 94 miles of pipelines, two storage tanks, and two pump stations.

The system supplies NPR water to retail customers in the City of San Diego and two wholesale customers: (1) City of Poway, and (2) Olivenhain Municipal Water District. Approximately 99 percent of the retail and wholesale customers use NPR water for irrigation. The number of customers and NPR water use has gradually increased in the past decade. The NCWRP is being designed to produce the NPR water needed to satisfy demands.

1.6.5 Tertiary Treated Water Conveyance System

The Tertiary Treated Water Pump Station will be located at the north end of the NCWRP site and convey a maximum of 42.5 mgd of non-chlorinated tertiary treated water (filtered effluent) to the NCPWF, which will be located across Eastgate Mall. Based on the evaluations and analyses performed as part of predesign, four duty pumps and one standby pump will be located in a new structure to be built adjacent to the existing chlorine contact tanks (CCT). The 48-inch-diameter Tertiary Treated Water Pipeline will be approximately 1,600 feet (ft) long. Figure 1-7 illustrates the alignment of the Tertiary Treated Water Conveyance System relative to the NCWRP.





AB's = aeration basins
CEPT = chemically enhanced primary treatment
EPS = NPR water pump station
EQ = flow equalization
PC's = primary clarifiers
SC's = secondary clarifiers
TTWPS = Tertiary Treated Water Pump Station to NCPWF

Figure 1-6: Schematic of Expanded NCWRP

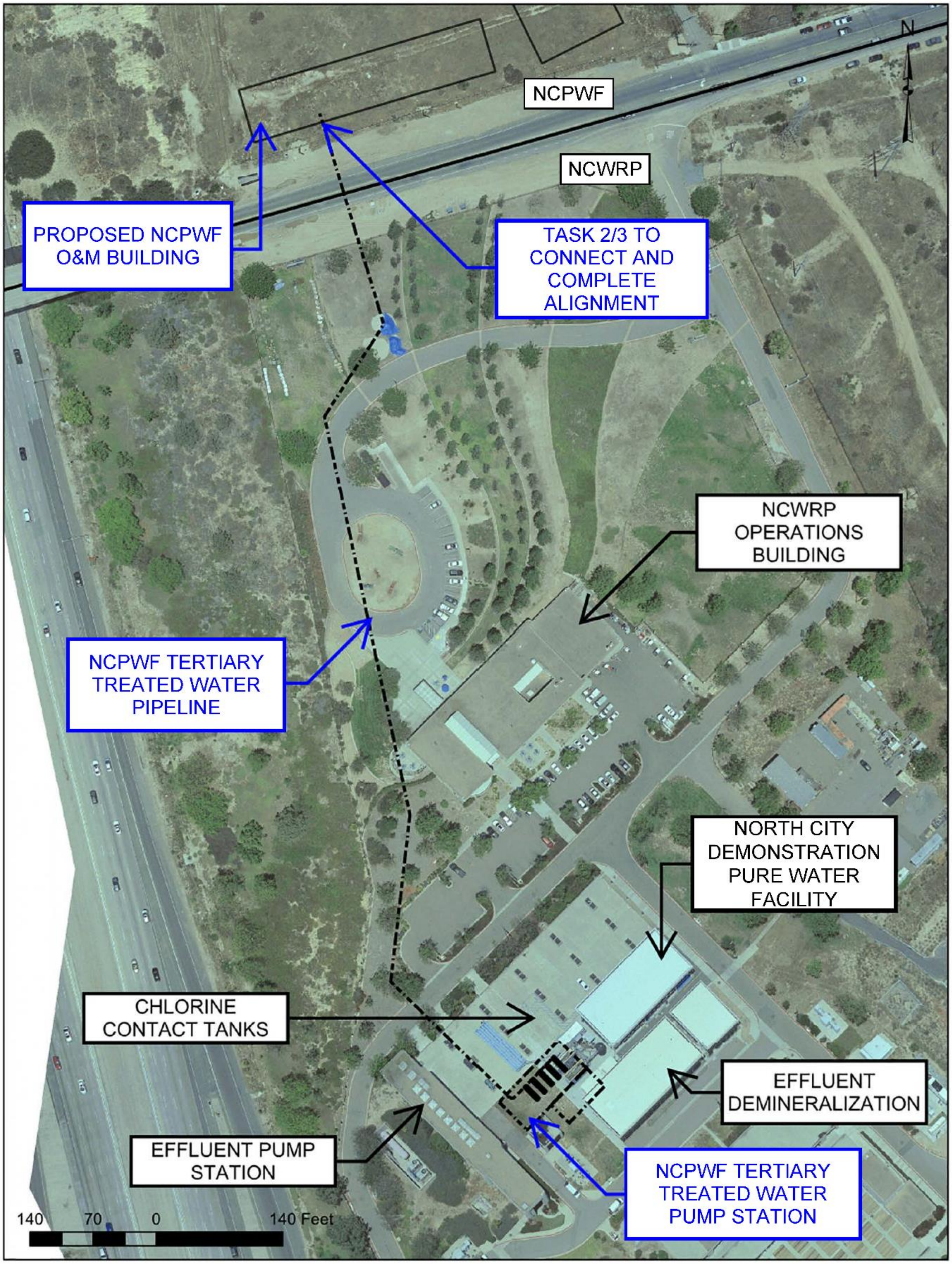


Figure 1-7: Tertiary Treated Water Conveyance System Alignment

1.6.6 North City Pure Water Facility

Located immediately to the north, across Eastgate Mall and adjacent to the NCWRP, the NCPWF is designed to produce up to 34 mgd of purified water. An average of approximately 30 mgd of purified water will be pumped to Miramar Reservoir and the remainder will be used for in-plant water uses and salinity management in the NPR water system. The NCPWF will feature the following seven key processes:

1. Ozone disinfection;
2. Biological activated carbon (BAC) filtration;
3. Membrane filtration (MF) using ultrafiltration membranes;
4. Reverse osmosis (RO);
5. Disinfection with ultraviolet light/advanced oxidation process (UV/AOP) with sodium hypochlorite as the oxidant;
6. Product water stabilization using lime and carbon dioxide; and
7. Sodium hypochlorite disinfection to maintain a free chlorine residual in the NCPW Pipeline.

The facilities at the NCPWF site will include an operations and maintenance (O&M) building, ozone injection and contactors, ozone generation system, liquid oxygen facility, BAC filtration system, a combined process building (including an MF system, RO system, and UV system), chemical system and storage facility, main electrical building, product water tank, NCPW Pump Station, and provisions for future addition of a testing facility. A site plan of the NCPWF is illustrated on Figure 1-8.

1.6.7 North City Pure Water Conveyance System

The NCPW Pump Station and Pipeline will convey an average flow of 30 mgd of purified water from the NCPWF to Miramar Reservoir. The NCPW Pump Station will house four 1,000 horsepower (hp) pumps to optimize operational flexibility and site footprint. The pipeline will be approximately 8 miles long and installed primarily within public rights-of-way. The majority of the pipeline alignment will be 48 inches in diameter, terminating at Miramar Reservoir with a submerged pipeline with numerous ports to promote the introduction of purified water in a distributed fashion. Figure 1-9 illustrates the NCWP Pipeline planned alignment.

Approximately 1,500 ft upstream of the reservoir, the NCPW Dechlorination Facility will inject sodium bisulfite into the pipeline to dechlorinate the purified water prior to release in Miramar Reservoir. A free chlorine residual will be maintained in the NCPW Pipeline from the NCPW Pump Station to just upstream of the inlet at Miramar Reservoir, where the purified water will be dechlorinated.

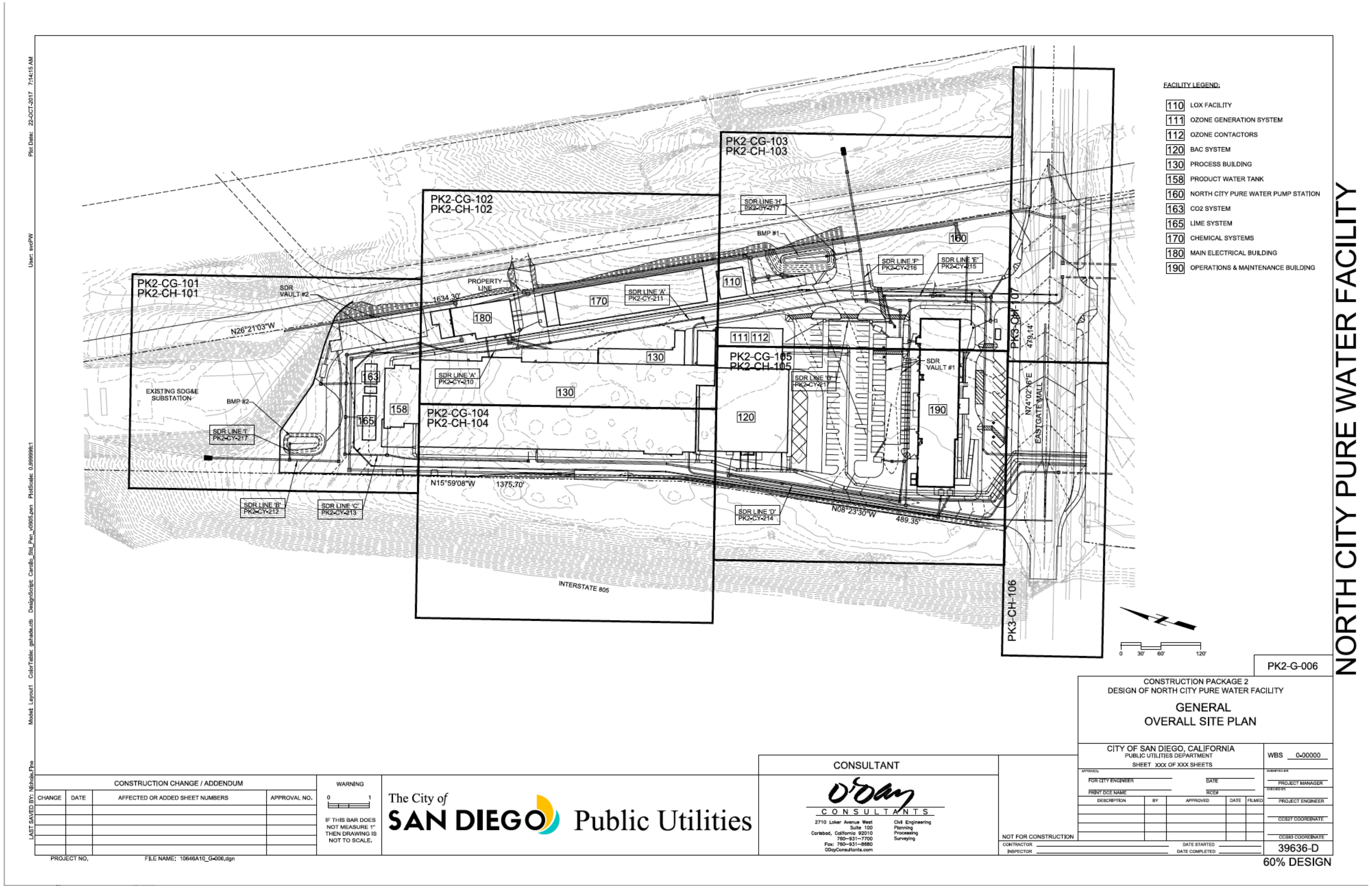


Figure 1-8: Overall Site Plan for the NCPWF

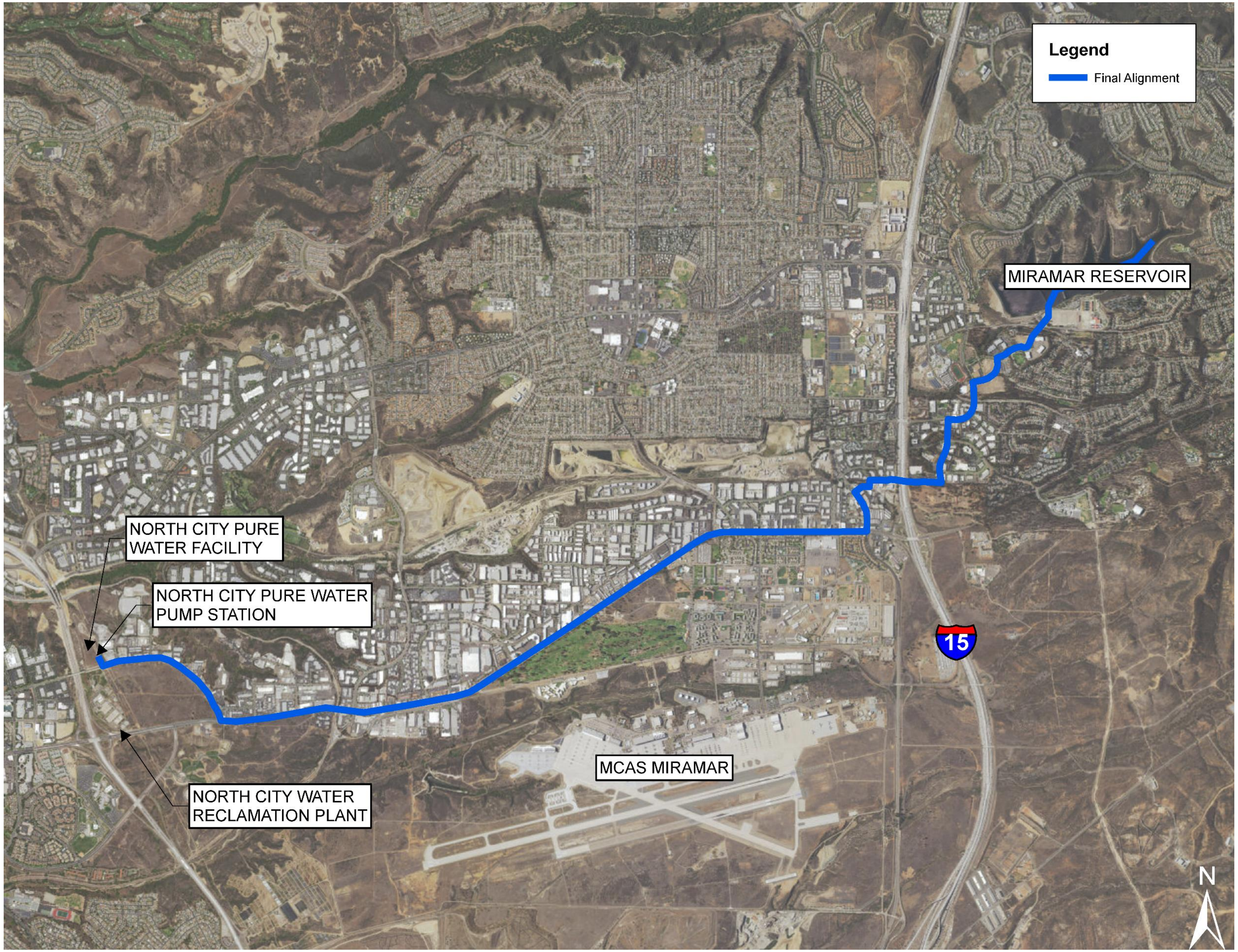


Figure 1-9: NCPW Pipeline Alignment

1.6.8 Miramar Reservoir

Miramar Reservoir is owned, operated, and maintained by the City. The reservoir's earth-fill dam was built in 1960 and impounds a small, naturally dry canyon. Miramar Reservoir has a maximum volume of 6,700 acre-feet (AF), surface area of about 162 acres when full, and a maximum depth of approximately 114 ft. The operational storage ranges from 5,800 to 6,100 AF. The reservoir's dominant use is municipal water supply and subordinate uses are limited to recreational activities. Miramar Reservoir is primarily used to store and balance imported water flows as a source for the Miramar DWTP. Since its creation in 1960, the reservoir has impounded only imported water from the Colorado River Aqueduct and State Water Project conveyed to the reservoir in aqueducts owned and operated by the San Diego County Water Authority (SDCWA). The local watershed contributes essentially no runoff to the reservoir. Figure 1-10 illustrates an aerial view of Miramar Reservoir.

Water stored in Miramar Reservoir will be conveyed (i.e., lifted) to the Miramar DWTP using the existing lake pumps station (also referred to as Miramar Reservoir Pump Station). The Pump Station will be refurbished as part of the Project, including outfitting several pumps with variable frequency drives.

While the Project will augment Miramar Reservoir with a 30 mgd (33,600 AFY) annual average of purified water, it is anticipated that seasonal variations in the inflow of purified water to the reservoir will occur due to variable NPR water demands at the NCWRP. Average daily inflows may vary seasonally from approximately 23.4 mgd in the summer to 32.8 mgd in the winter. At an average reservoir withdrawal rate of 30 mgd (to match average purified water inflows), and at a typical reservoir volume of 5,800 AF, the theoretical average purified water retention time in Miramar Reservoir will be greater than 60 days. Thus, Miramar Reservoir provides an important environmental buffer. The City will develop an operating plan for Miramar Reservoir to comply with the retention time requirements in the SWA regulations.

1.6.9 Miramar Drinking Water Treatment Plant

The Miramar DWTP has been operating since 1962 and currently serves approximately 500,000 customers in the northern part of San Diego as illustrated on Figure 1-11. The Miramar DWTP utilizes conventional water treatment processes (e.g., coagulation, flocculation, sedimentation, filtration, pH adjustment, and disinfection), pre-aeration to mitigate air entrainment and two stages of ozonation to improve disinfection and control of dissolved organic compounds. Owned and operated by the City, the Miramar DWTP is permitted for a maximum drinking water production of 144 mgd, and plant flows vary seasonally depending upon demands. The minimum flow rate of the Miramar DWTP is set by the turndown range of the chemical feed systems. This minimum flow rate is roughly 50 mgd.

The Miramar DWTP is currently supplied by imported water via direct connections to the SDCWA Aqueduct; however, water stored in Miramar Reservoir can also be pumped to the plant for treatment. With implementation of the North City Project, the Miramar DWTP's raw water supply will be a blend of imported water and stored purified water. Each of these sources of supply is under the immediate control of the City's plant operator and can be shut off without disrupting the Miramar DWTP's ability to supply the distribution system. Should Miramar Reservoir need to be taken off-line for any reason, the Miramar DWTP can continue to meet system demands using the direct connections to the SDCWA's raw water system. This ability to decouple the purified water stored at Miramar Reservoir from the Miramar DWTP is another key mechanism that allows the City to provide full protection of public health.

Figure 1-10: Miramar Reservoir and Miramar DWTP

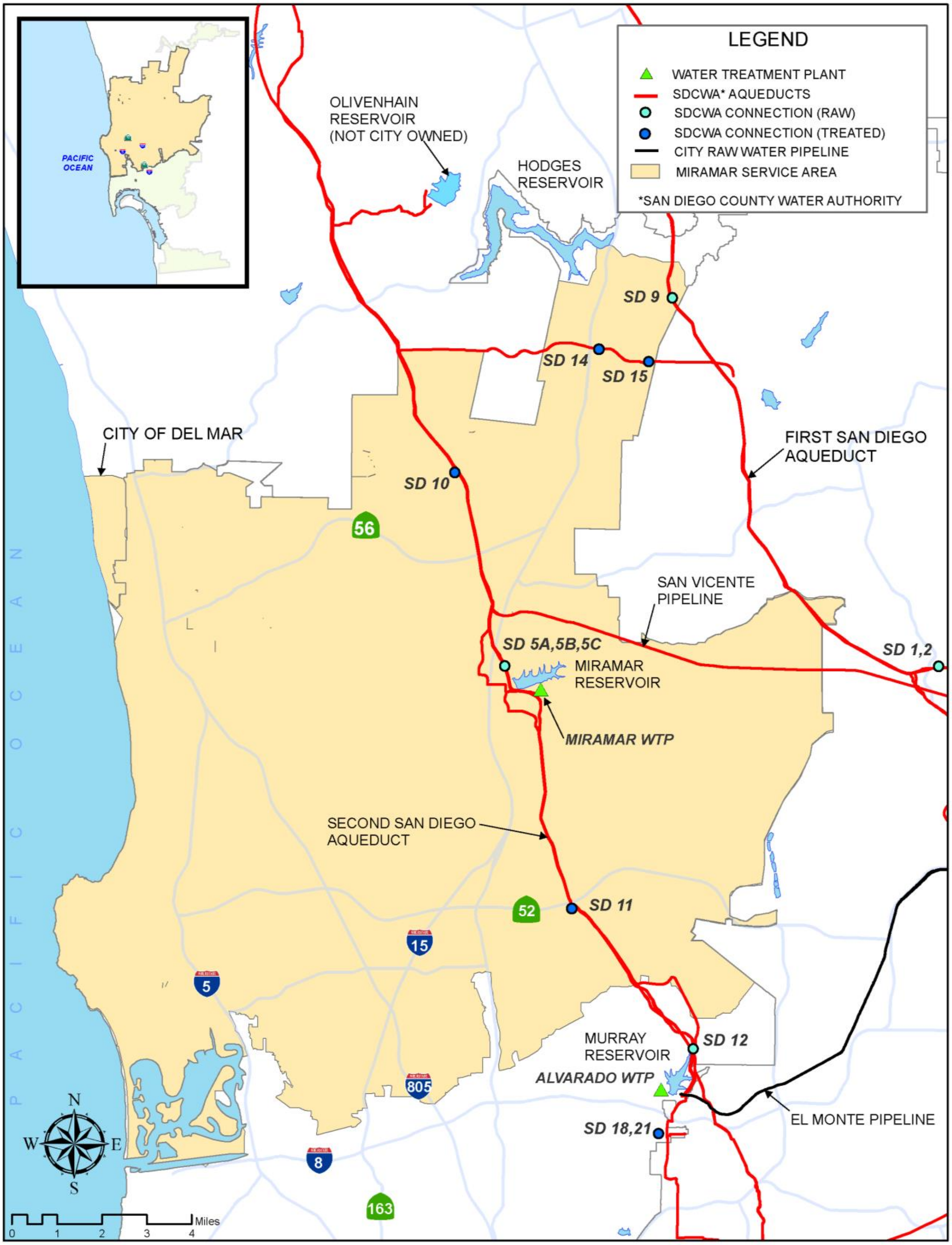


Figure 1-11: Map of Miramar DWTP Service Area

1.7 Filter Loading Rate Evaluation

The City performed a Filter Loading Rate Evaluation through an increase in the filtration rate from 5 to 7.5 gallons per minute per square foot (gpm/sf). The higher filtration rate would allow the City to produce sufficient tertiary treated water for both the production of both purified and NPR water at the NCPWF with the addition of one tertiary filter.

1.7.1 Background

The filtration rate for tertiary granular media filters is limited to 5 gpm/sf under the Title 22 Water Recycling Criteria (CCR, 2014); however, DDW approved a set of criteria for determining equivalent filter performance at a filtration rate of 7.5 gpm/sf. The filter loading evaluation began in January 2017 and concluded in March 2017. The tertiary filters at the NCWRP are deep bed, monomedia with 84 inches of anthracite (effective size of 1.4 – 1.5 mm with a maximum uniformity coefficient of 1.3) supported by 18 inches of gravel.

1.7.2 Summary of Previous Filter Loading Evaluation for Water Reuse Study

The 2007 FLEWR Study, which was performed to evaluate the effects of loading rates on tertiary wastewater filtration and led to DDW's development of the equivalency criteria, are presented in this Engineering Report. Five water recycling facilities successfully completed full-scale FLEWR testing to demonstrate equivalency of treatment at the higher filter loading rate.

1.7.3 Filter Loading Rate Evaluation Testing at the North City Water Reclamation Plant

The NCWRP filter loading rate evaluation was concluded in March 2017 and detailed results are presented in Section 7 of this Engineering Report. The testing was performed in accordance with a protocol and operations plan approved by DDW and the RWQCB in late 2016.

1.7.4 Conclusions

An analysis of the filter loading rate evaluation results show that the NCWRP tertiary filters successfully met all the equivalency criteria established by DDW and demonstrated that there was no significant increase in the filter effluent turbidity and particles. Based on the results of the evaluation, DDW approved the NCWRP to operate at tertiary filtration rates up to 7.5 gpm/sf. At this higher loading rate, the rated capacity of the existing filters will increase from 32.1 to 48.1 mgd (n+2 configuration), which is sufficient for both the production of purified and NPR water at the NCPWF.

1.8 North City Water Reclamation Plant Water Quality

The NCWRP will be upgraded to produce an increased and relatively constant flow to continue production of NPR water and to provide a new tertiary filtered effluent stream for advanced treatment at the NCPWF to produce purified water. Tertiary treated water (non-disinfected) for the NCPWF source water must be oxidized wastewater (as defined in CCR Title 22 Section 60301.650). Disinfected tertiary treated water is required for NPR in compliance with the requirements set forth in the Title 22 Water Recycling Criteria (CCR, 2014) for uses of recycled water, including irrigation, supply for non-restricted recreational impoundments, cooling water, and other non-direct reuse purposes.

A portion of the tertiary treated water (post-filtration and prior to chlorination) will be pumped from the NCWRP to the NCPWF. As discussed, the NCWRP tertiary filters are being tested to gain approval from DDW to operate the filters at a higher loading rate. Based on historical data, it is anticipated that the NCWRP tertiary filters will achieve the DDW-specified daily average filtered effluent turbidity limit of 1.5 Nephelometric Turbidity Units (NTU).

The remaining tertiary treated water will be disinfected by the existing NCWRP CCTs, producing NPR water that will be pumped to the NPR water distribution system. The expanded NCWRP will provide disinfected, tertiary treated water (recycled water) to satisfy existing and future NPR water demands.

Section 8 of this report describes the historical tertiary treated water and NPR water quality from the NCWRP, as well as projected water quality based on the anticipated changes to the wastewater quality as a result of the plant's expanded sewershed.

1.8.1 North City Water Reclamation Plant Historic Water Quality

A summary of the historical NPR water quality produced by the existing NCWRP is presented in Table 1-2. The table is a subset of key constituents covering 2012 through 2016.

Table 1-2: Historic Non-Potable Reuse Water Quality for Key Constituents

Parameter	Units	Minimum (2012-16)	Maximum (2012-16)	Average By Calendar Year				
				2012	2013	2014	2015	2016
Alkalinity, total	mg/L as $CaCO_3$	68.0	167.5	89.3	95.1	98.8	91.5	87.7
Bromide	mg/L	0.00	0.34	0.03	0.00	0.00	0.00	0.00
Calcium	mg/L	47.4	74.6	55.0	61.7	65.8	64.2	65.4
Nitrate-N	mg/L as N	6.8	17.3	12.0	12.3	11.9	12.2	12.4
N, total	mg/L	8.2	25.2	13.7	14.0	13.7	13.2	16.4
Orthophosphate	mg/L as P	0.29	2.09	0.83	0.90	1.09	1.27	1.10
pH	pH	6.19	8.61	6.88	6.96	6.97	6.97	7.02
Sodium	mg/L	148	225	166	167	176	181	186
TDS	mg/L	560	1145	805	828	865	864	877
Turbidity	NTU	0.06	10.5	0.57	0.56	0.54	0.46	0.65

1.8.2 North City Water Reclamation Plant Projected Water Quality

The projected quality of the tertiary treated water and NPR water produced by the expanded NCWRP was determined through a water quality development study performed in 2015 (Trussell, 2016a). These tertiary effluent water quality projections for the expanded and upgraded NCWRP are based on numerous sources, including water quality measurements made at the NCDPWF; tertiary treated water monitoring; data generated by special studies of ozonation and BAC; wastewater quality measurements comparing the existing NCWRP and new Morena Pump Station sewersheds; and BioWin wastewater treatment plant modeling used to forecast nitrogen, phosphorus, pH, and alkalinity levels.

The nitrification-partial denitrification improvements will benefit water quality by reducing the ammonia concentration in the NCPWF source water. The NPR water will comply with the Title 22 Water Recycling Criteria. The TDS concentration of the NPR water will be reduced to comply with the salinity requirements in the RWQCB permit. Blending purified water with disinfected tertiary recycled water is the most cost-effective and reliable way to manage the salinity of the NPR water.

Table 1-3 presents the projected tertiary treated water quality for key constituents.

Table 1-3: Projected Tertiary Treated Water Quality

Parameter	Units	Average	Parameter	Units	Average
Alkalinity, total	mg/L as $CaCO_3$	173	pH	pH	7.2
Bromide	mg/L	0.334	Phosphorus, total	mg/L	0.78
Calcium	mg/L	100	Sodium	mg/L	215
Ammonia-N	mg/L as N	0.15	TDS	mg/L	1169
Nitrogen, total	mg/L	10.4	Total Organic Carbon	mg/L	7.24
Nitrate-N	mg/L as N	7.7	TTHM	µg/L	2.7
Orthophosphate	mg/L as P	0.78	Turbidity	NTU	0.2

1.9 Purified Water Quality

The Project's purified water will consistently meet all drinking water standards and environmental requirements. The concentrations of key water quality parameters were assessed during the NCPWF 30% design. Water quality of the NCPWF feed and individual process streams were predicted using supporting data from the NCDPWF, modeling, and applicable assumptions. The purified water quality produced by the NCPWF will comply with all state and federal primary and secondary drinking water requirements, Action and Notification Levels, priority pollutants, and RWQCB Basin Plan water quality objectives for Miramar Reservoir. As the design for the NCPWF has advanced toward its final stage, the water quality parameters have remained consistent with the 30% projections, with the exception of turbidity. The turbidity in the product water has increased as a result of the modified lime and carbon dioxide post-conditioning process.

Section 9 of this report provides purified water quality projections and a discussion of compliance with DDW and the RWQCB requirements.

1.9.1 Anticipated Purified Water Quality

Based on research initiatives and the NCPWF 30% Engineering Design Report (MWH/BC et. al., 2016), the anticipated purified water quality was determined for the following parameters:

- Constituents with primary Maximum Contaminant levels (pMCLs);
- Constituents with secondary Maximum Contaminant Levels (sMCLs);
- Constituents with Notification Levels;
- Priority pollutants;
- Basin Plan objectives (e.g., TDS, nitrogen and phosphorus); and
- Other relevant constituents (e.g., microbial pathogens, Total Organic Carbon (TOC) and constituents listed in the Unregulated Contaminants Monitoring Rule (UCMR), constituents of emerging concern (CECs), and chlorine residual).

Table 1-4 presents the engineering estimate of the purified water quality based on all supporting sources.

Table 1-4: Concentration of Key Parameters in Purified Water

Parameter	Units	UV/AOP Effluent		Finished Water[a]		
		Range	Median	Post-Conditioning	Post-Chlorination	Post-Dechlorination
pH[b]	-	4.1 – 5.0	4.3	7.5 - 8.5	7.5 - 8.5	7.5 - 8.5
Alkalinity[c]	mg/L as $CaCO_3$	2 – 15	8	>100	>100	>100
Turbidity[d]	NTU	0.01 - 0.08	0.03	5	< 5	< 5
Calcium[b]	mg/L as $CaCO_3$	4 – 4.4	4.2	92 - 146	92 - 146	92 - 146
Sodium[b]	mg/L	7 – 22	11	11	12 - 13	13 - 14
TOC[e]	mg/L	0.02 – 0.07	0.03	0.03	0.03	0.03
TDS[f]	mg/L	14 – 69	36	50 - 195	50 - 195	50 - 195
LSI[g]	-	-5.5 – -3.5	-4.7	0 – 0.5	0 – 0.5	0 – 0.5
Free Chlorine[h]	mg/L as Cl_2	1.0	1.0	1.0	1.5 – 4.0	ND (0.03)
Chloramines[h]	mg/L as Cl_2	0.7 – 1.5	1.0	1.0	1.0	ND (0.03)
Total Chlorine[h]	mg/L as Cl_2	1.7 – 2.5	2.0	2.0	2.5 – 5.0 [n]	ND (0.03) [n]
Bromide[i]	mg/L	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Bromate[j]	µg/L	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)
HAA5[k]	µg/L	1.5 - 5.3	3.3	3.3	3.3	3.3
TTHM[k]	µg/L	2 – 5	3.8	3.8	3.8	3.8
NDMA[l]	ng/L	2 – 12	ND (2)	ND (2)	ND (2)	ND (2)
1,4-dioxane[m]	µg/L	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)
Nitrate[c]	mg/L as N	0.52 – 1.12	0.75	0.75	0.75	0.75
Ammonia	mg/L as N	0.27 – 0.62	0.31	0.31	0.31	ND (0.03)
Total Nitrogen[c]	mg/L	0.8 – 1.7	1.1	1.1	1.1	0.8
Total Phosphorous[c]	mg/L	0.01	0.01	0.01	0.01	0.01

Note: Method reporting limit shown in parenthesis next to ND. Refer to Table 9-1 for comprehensive list of table footnotes

1.9.2 Compliance with Anticipated Title 22 Water Recycling Criteria

The purified water will be monitored to determine compliance with water quality standards contained in the Title 22 Water Recycling Criteria (CCR, 2014) for the following groups of constituents:

- Constituents with pMCLs and Action Levels;
- Constituents with sMCLs;
- Constituents with Notification Levels;
- Priority toxic pollutants;
- DDW-specified chemicals based on its review of the Title 22 Engineering Report, the augmented reservoir, and the results of the Source Control Program; and
- DDW- and RWQCB-specified indicator compounds (e.g., TOC).

1.9.3 Compliance with Basin Plan Requirements

The release of purified water into Miramar Reservoir will be regulated by the RWQCB through the issuance of an NPDES permit. The NPDES permit will include requirements and water quality standards that implement:

- Basin Plan policies and objectives (e.g., minerals including TDS, drinking water standards, and nutrients such as nitrogen and phosphorus);
- Water quality standards established within the CTR (40 CFR 131.38)(EPA, 2000b); and
- Applicable state and federal water quality plans and policies (e.g., chlorine residual).

1.10 Pathogenic Microorganism Control

The level of treatment required prior to discharge to Miramar Reservoir is 10-log, 9-log, and 10-log (10/9/10) for viruses, *Giardia* cysts, and *Cryptosporidium* oocysts (V/G/C), respectively. The Project will meet and surpass the necessary pathogen log reduction values (LRVs) for the SWA regulations through the use of multiple treatment processes at the NCWRP, NCPWF, and NCPW Pipeline (i.e., prior to dechlorination of the purified water). The SWA regulations specify pathogen reduction requirements for V/G/C, which must be achieved prior to release into the reservoir.

Section 10 of this report presents the proposed pathogen reduction credits for each treatment process and the surrogate performance limits to confirm pathogen reduction credits.

1.10.1 North City Water Reclamation Plant

The NCWRP consists of primary and secondary treatment processes followed by tertiary filtration. The pathogen reduction credits achieved through these processes are based on a comprehensive pathogen study conducted at the NCWRP. In November 2016, a protocol for that study was submitted to DDW. In October 2017, the results of the study were reviewed by the IAP to assist the City in determining appropriate approaches to granting LRVs. The City submitted the final report to DDW in December 2017, with recommendations based upon the IAP input. DDW provided comments on the final report and the results, and recommendations based upon DDW input is provided in Section 10.

The study results and recommendations based upon IAP input is provided in Section 10.

1.10.2 North City Pure Water Facility

The NCPWF treatment train consists of Ozone/BAC, MF, RO, UV/AOP, and chlorine disinfection. Each of the treatment processes serves as a barrier and represents a critical control point, which is a place in the treatment train (i.e., unit treatment process) that is designed specifically to reduce, prevent, or eliminate a human health hazard and for which controls exist to ensure the proper performance of the process. The critical control points are monitored using surrogate parameters to assess performance and ensure LRV credits are achieved. The NCPWF will be designed and operated based on the expected pathogen LRVs to be achieved by each process and the surrogate performance limits to confirm the associated pathogen reduction levels.

1.10.3 Pathogenic Microorganism Control Summary

A comprehensive critical control point framework and pathogen LRV credit strategy was developed for the Project. The Project treatment facilities will provide significantly more pathogenic microorganism control than the minimum levels required by the SWA regulations. The expected pathogen LRVs for each process and the total LRVs required are presented in Table 1-5. Continuous and regular monitoring of surrogate parameters used to determine LRVs will ensure that the NCWRP and NCPWF are protective of public health.

Table 1-5: Pathogen Log Reduction Expectations and Requirements

Pathogen	NCWRP[a]	Ozone/ BAC	MF	RO[b]	UV/ AOP	Pipeline Cl_2	Total Prior to Discharge to Reservoir	Required Prior to Discharge to Reservoir
Virus	0.7	6	0	2.5	6	6	21.2	10
Giardia	3.2	6	4	2.5	6	1	22.7	9
Cryptosporidium	0.9	1	4	2.5	6	0	14.4	10

[a] Subject to change upon additional pathogen monitoring
[b] RO credits based on Tier 1 and may exceed this value.

1.11 Miramar Reservoir

The City completed a limnology and water quality studies of Miramar Reservoir that assessed the overall ability of the reservoir to accept purified water at an average annual flow rate of 30 mgd under different operating scenarios and with a diffuser system to distribute the inflow of purified water throughout a large volume of the reservoir. Analyses were performed using three-dimensional hydrodynamic and water quality models to evaluate the dilution, mixing, and transport of purified water in the reservoir. Results of these studies predict the ability of the reservoir with the diffuser system to adequately mix, blend, and dilute the purified water inflow at nominal and low reservoir levels and at nominal and high withdrawal (outflow) rates. Section 11 of this report summarizes the limnology and water quality assessments of Miramar Reservoir.

1.11.1 Background on Reservoir Modeling

In 2015, the City initiated a comprehensive limnology and water quality study of Miramar Reservoir. The study evaluates the dilution, mixing, and transport of purified water in Miramar Reservoir under various future reservoir operating scenarios. That modeling effort used the same approach and three-dimensional hydrodynamic and water quality models as those used for earlier studies of San Vicente and Otay Reservoirs. The modeling setup, calibrations, and validation were vetted and approved by the North City Project IAP.

1.11.2 Study Objectives

The overall objective of the limnology and water quality studies is to answer the following four questions, each of which represents a possible operating scenario:

1. *Does Miramar Reservoir provide adequate mixing and blending of the purified water at an inflow rate of 30 mgd at nominal reservoir level?*
2. *Does Miramar Reservoir provide adequate dilution of the purified water at an inflow rate of 30 mgd at low reservoir level?*
3. *Does Miramar Reservoir provide adequate dilution of the purified water at a high outflow rate of 75 mgd (maximum outflow rate from Miramar Reservoir) at nominal reservoir level?*
4. *Does the purified water at an inflow rate of 30 mgd affect the water quality of the reservoir, specifically algal dynamics?*

1.11.3 General Approach

The limnology and water quality study of Miramar Reservoir was conducted under various anticipated operating conditions to support the Project. Previous modeling of the City's reservoirs used the Estuary Lake and Coastal Ocean Model (ELCOM) for hydrodynamics and the Computational Aquatic Ecosystem Dynamics Model (CAEDYM) for water quality. The models used in this study are AEM3D for hydrodynamics and CAEDYM for water quality. AEM3D is the newer version of ELCOM, which was used in the preliminary limnology study of Miramar Reservoir (WQS, 2016). Other than a few minor upgrades, AEM3D is very similar to ELCOM, including model inputs and outputs, and solution methodologies.

1.11.4 Model Calibration

The AEM3D model describes Miramar Reservoir's hydrodynamics and the movement of the water as it is influenced by wind, solar radiation, and inflows and outflows. AEM3D boundary conditions are set based on the reservoir's morphology and the structure of inlets and outlets. During calibration, AEM3D model parameters were adjusted based on real-world data on inflow, outflow, solar radiation, and wind speed and wind direction so that the model output matched real world measurements of temperature and salinity throughout Miramar Reservoir.

The CAEDYM model was calibrated by comparing the simulation results with measured in-reservoir field data for water quality parameters, including dissolved oxygen, nutrients, chlorophyll α, and pH.

1.11.5 Model Validation

A total of four model validation studies have been performed on the ELCOM and CAEDYM models for the City's reservoirs. In 2012, two validation studies were performed at San Vicente Reservoir using real-world tracer studies done in the mid-1990s. Both validation studies, one during the winter and one during the summer, showed that the models accurately predicted the movement of the tracer in the reservoir. Two more validation studies were performed at Otay Reservoir in the spring and summer of 2014. Results of the Otay Reservoir and San Vicente Reservoir studies were reviewed with the IAP, which concluded that the ELCOM and CAEDYM models are adequately validated. Based on these successful efforts, the City considers the models validated for Miramar Reservoir because, when compared to San Vicente and Otay Reservoirs, it has no unique properties that would be expected to affect the validation.

1.11.6 Modeling Conditions

The modeling conditions used for the hydrodynamic study are:

- Two-year model runs using meteorological and hydrological data from 2013-2014;
- Average annual purified water inflow rate of 30 mgd (design value for the project), with daily inflow rates ranging from 23 mgd in (summer months) to 33 mgd (winter months);
- Two different reservoir outflow rates:
  - Nominal Outflow Rate of 30 mgd (nominal reservoir water withdrawal operating scenario) with the reservoir volume staying relatively constant by matching inflows and outflows.
  - Outflow Rate of 75 mgd (high rate reservoir water withdrawal operating scenario) with the reservoir's volume staying relatively constant by limiting the high outflow rate to a period of three days.
- A diffuser system to distribute the inflow throughout a large volume of the reservoir;
- Two reservoir operating levels:
  - Nominal reservoir level of elevation 706 ft, which corresponds to a water volume of approximately 5,500 AF;
  - Low reservoir level of elevation 696.6 ft, which corresponds to a water volume of approximately 4,275 AF; and
- One open outflow port on the reservoir outlet tower; for each model run, the highest available outlet was used, either Port # 4 (at elevation 696 ft) or Port #3 (at elevation 681 ft).

Using CAEDYM, two nutrient and algae modeling runs were performed for the purified water inflow rate of 30 mgd under the nominal reservoir level. One model run simulated the use of a bubble plume mixer, in order to assess its effectiveness in eliminating anoxia in the deep water. The nutrient and algae model runs were performed for a four-year period in order to investigate the longer-term effects of the purified water on Miramar Reservoir's water quality.

1.11.7 Model Run Results

Results of AEM3D (hydrodynamic) and CAEDYM (nutrient and algae) model runs based on the above conditions are presented in Section 11. Specific answers to the questions in the study objectives are:

1. ***Does Miramar Reservoir provide adequate mixing and blending of the purified water at an inflow rate of 30 mgd at nominal reservoir level?*** Yes, with the use of the diffuser system, Miramar Reservoir provides adequate mixing and blending of the purified water at an inflow rate of 30 mgd and a nominal reservoir level. The observed overall minimum dilution was 34.5, and is greater than the required dilution of 10:1 for a 24-hour tracer. The predicted minimum dilution at a 99.9 percent degree of confidence was 32.6, and meets the requirement.
2. ***Does Miramar Reservoir still provide adequate dilution of the purified water at an inflow rate of 30 mgd at low reservoir level?*** Yes, with the use of the diffuser system, Miramar Reservoir provides adequate mixing and blending of the purified water at an inflow rate of 30 mgd and a low reservoir level. The observed overall minimum dilution was 24.9, and is greater than the required dilution of 10:1 for a 24-hour tracer. The predicted minimum dilution at a 99.9 percent degree of confidence was 23.9, and meets the requirement.

3. ***Does Miramar Reservoir still provide adequate dilution of the purified water at a high outflow rate of 75 mgd at nominal reservoir level?*** Yes, with the use of the diffuser system, Miramar Reservoir provides adequate mixing and blending of the purified water at an inflow rate of 75 mgd and a nominal reservoir level. The observed overall minimum dilution was 35.0, and is greater than the required dilution of 10:1 for a 24-hour tracer.
4. ***Does the purified water at an inflow rate of 30 mgd affect the water quality of Miramar Reservoir, specifically algal dynamics?*** Yes, with the use of the diffuser system, the purified water will affect the water quality of Miramar Reservoir. The water quality study shows that a purified water inflow rate of 30 mgd is predicted to produce lower algal levels (i.e., lower surface chlorophyll α concentrations) and higher water clarity. The purified water inflow will gradually reduce algal levels and increase water clarity. In the calibrations, the two-year average chlorophyll α level is 0.42 µg/L; while the average chlorophyll α levels for the first two years were predicted to range from 0.24 µg/L to 0.30 µg/L for the future scenarios with various TP concentrations in the PW inflow. This is related to the generally low phosphorus concentrations in the purified water. Based on the nutrient data in the inflows, algal growth in Miramar Reservoir is expected to be limited by phosphorus.

1.11.8 Compliance with Dilution Criteria Using Selected Outlet Ports

The SWA regulations require that a 10:1 dilution of inflowing purified water, at the open outlet, must be continuously achieved. At the same time, the ability to selectively draft from different reservoir outlet levels is important for optimizing treatability at the Miramar DWTP. The hydrodynamic modeling shows that several outlet ports or combinations of ports achieve compliance with the 10:1 dilution criteria, allowing the City flexibility as to which outlet ports can be used.

Completed modeling scenarios demonstrate that certain outlet ports provide the required dilution with a 99 percent confidence level under various conditions of reservoir storage, inflow and outflow rates, and weather. These are expected to be approved “set and forget” ports. They are Port #4 at WSEL above 701 ft and Port #3 at WSEL between 696.6 and 701 ft.

Preliminary modeling of other port combinations show that 10:1 dilution can likely be achieved with a 99.9 percent confidence level. After completion of further hydrodynamic modeling and consultation with DDW, these will become approved “set and forget” options. These are Ports #1, #3, and #4 (all three open at the same time) and Ports #1, #2, #3, and #4 (all four open).

For other ports or port combinations, dynamic “in-the-moment” modeling can demonstrate the required dilution under a specific set of conditions. After consultation with DDW, the port(s) are expected to be approved for use under the specific modeled conditions.

The City may choose to complete a package of model scenarios for other ports to demonstrate that the 10:1 dilution is achieved with a 99.9 percent confidence level. After consultation with DDW, these would become approved “set and forget” options.

1.11.9 Mean Theoretical Hydraulic Retention Time

This is a reservoir augmentation project that benefits from the many advantages provided by retention of the purified water in the reservoir. The Project’s treatment, monitoring, and resiliency features have been enhanced to reduce the need for long reservoir mean hydraulic theoretical retention time requirements.

At an average reservoir withdrawal rate of 30 mgd and a typical reservoir volume of 5,600 AF, the theoretical average retention time of purified water in Miramar Reservoir will be at least 60 days. The reservoir volume and reservoir outflow rate are the two variables that determine retention time. The City will develop operational guidelines for Miramar Reservoir that will ensure compliance with the theoretical average retention time criteria of the SWA regulations. Section 11.9 has details of the measurements needed to demonstrate compliance.

1.12 Drinking Water Supply System

The Project will augment the City's drinking water supply system served by Miramar Reservoir, the Miramar DWTP, and the associated water distribution system. Operated by the City's PUD, the Miramar DWTP currently treats imported supplies from the Metropolitan Water District of Southern California that are delivered to the City via the SDCWA Aqueducts. The Project will convey purified water produced by the NCPWF to Miramar Reservoir, where it will be stored and used as source water for the Miramar DWTP. The two water sources, imported water and stored purified water from Miramar Reservoir, will be delivered to the Miramar DWTP independently and mixed upon entering the Miramar DWTP. In the unlikely event that purified water cannot be used, the alternative water supply source is imported water, which can be delivered directly to the Miramar DWTP.

Figure 1-12 is a conceptual illustration of the major aqueducts and pipelines in the City's existing drinking water supply system.

1.12.1 Drinking Water Source Waters

Imported water is currently delivered directly to the Miramar DWTP, or stored first in Miramar Reservoir before being pumped to the Miramar DWTP. With implementation of the Project, purified water will be introduced directly to and stored in Miramar Reservoir. These two water sources, imported water delivered through the SDCWA system and purified water stored in Miramar Reservoir, will be independently delivered to the Miramar DWTP and mixed, upon entering the Miramar DWTP.

Imported water quality depends upon the relative composition of imported water, which is a blend of water from the Colorado River Aqueduct and water from Northern California via the State Water Project. With the Project, water quality in Miramar Reservoir will largely reflect the characteristics of the purified water source, exhibiting low concentrations of TDS, total suspended solids (TSS), hardness, and alkalinity.

Table 1-6 presents a comparison of the water quality of both source waters – imported water and purified water.

Table 1-6: Water Quality Comparison of Imported Water and Purified Water

Parameter	Imported Water Average (Range) 2014 – 2016	Purified Water[a] Average or Median (Range)
Alkalinity, mg/L as $CaCO_3$	123 (95-140)	125 (100-145)
Calcium, mg/L	68 (42-76)	120 (92-146)
Chloride, mg/L	92 (80-102)	11 (5-25)
pH, pH units	8.0 (7.2-8.5)	8.0 (7.5-8.5)
Sulfate, mg/L	219 (123-253)	5 (4-10)
TDS, mg/L	587 (409-657)	130 (50-195)
Turbidity, NTU	0.52 (0.24-1.7)	0.60 (0.45-0.75)
TTHMs, µg/L	27 (2-66)	3.8 (2.0-5.0)

[a] Values are based on five years of NCDPWF testing, source water investigations, literature sources, and modeling.

1.12.2 Drinking Water Treatment Plant

The Miramar DWTP operation is governed by a set of compliance goals based on Safe Drinking Water Act requirements. The plant must comply with the Maximum Contaminant Levels (MCL) for drinking water as promulgated by the EPA. The Miramar DWTP's historic performance has been outstanding as indicated by the water quality data summary presented in Table 1-7.

Table 1-7: Miramar DWTP Historic Performance

Parameter	Unit	Goal	Goal Type	Miramar DWTP Effluent 2014 through 2016 Average (Range)
Turbidity	NTU	0.3	Primary MCL	0.06 (0.04-0.20)
Turbidity	NTU	0.1	Miramar DWTP treatment goal	
Total turbidity removal	Percent	80	Miramar DWTP permit requirement	88 (57-96)
Virus log removal value	log	4	MCL/Surface Water Treatment Rule (SWTR)	>10- log
Giardia log removal value	log	3	MCL/SWTR	>6-log

The Project will modify the Miramar DWTP's source water supply (a blend of imported water and purified water) and require operational adjustments to address changes in water quality. In 2015, a bench-scale study was conducted to assess potential impacts of the blended source water quality changes at the Miramar DWTP and associated training of City operators regarding any operational changes identified during this study. Study findings demonstrated that treatability was remarkably robust for all test conditions and purified water blended with imported water can be successfully coagulated and filtered. The bench-scale study revealed the importance of properly conditioning the purified water at the NCPWF to mitigate stability and corrosion issues. A pilot study to refine and verify potential operational changes has been completed. A final report for the pilot study results was submitted in April 2018 and will be provided to DDW.

1.12.3 Drinking Water Distribution System

The current Miramar Service Area includes the zones supplied via the Miramar DWTP and SDCWA Connections 10, 11, 14, and 15 and drinking water delivered to the City of Del Mar. Figure 1-11 is a map illustrating the Miramar Service Area, which area includes all hydraulic zones north of I-8. The City can also serve the southern portions of the Miramar Service Area from the Alvarado DWTP. Monthly variations in daily demand flow between peak and low months vary from year to year, but follow a predictable pattern, with higher demand occurring in the summer and lower demand occurring in the winter. The Miramar Service Area average daily demand for the five-year period between 2012 and 2016 is just less than 89 mgd.

A bench-scale pipe loop study is underway to develop a thorough understanding of potential impacts of the blended water source and determine whether possible corrosion and leaching of harmful metals may have to be mitigated. Results of the pipe loop study will be used to modify the Miramar DWTP's operations to accommodate the source water blend (imported and purified waters) and establish a chemical equilibrium that helps prevent pipe corrosion and metal leaching in the distribution system. A final report for the pipe loop study is expected to be complete in August 2018 and will be provided to DDW.

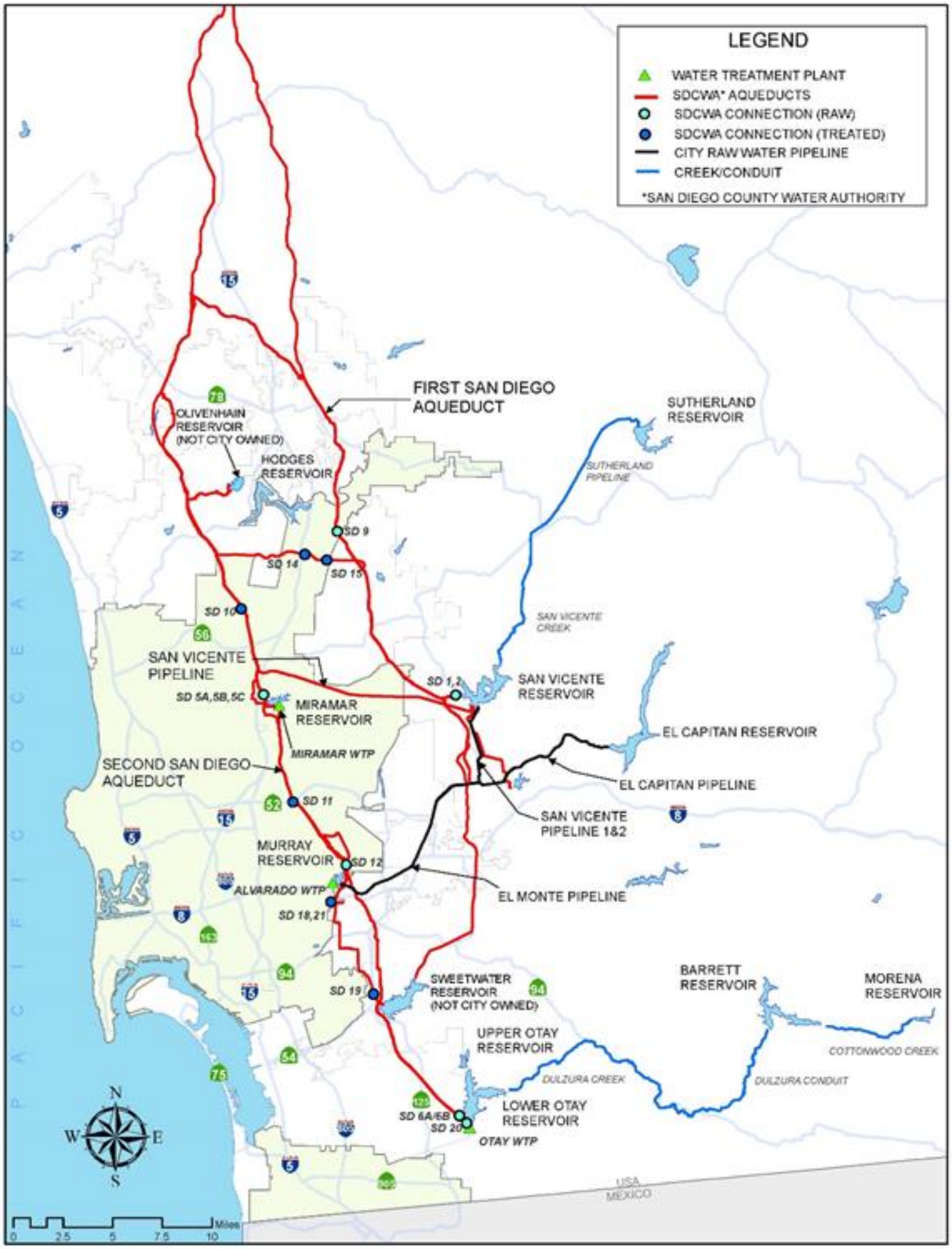


Figure 1-12: Conceptual Illustration of City of San Diego Drinking Water System

1.13 Reliability Features

A framework for potable reuse safety has been developed based on the following four "Rs": Reliability, Redundancy, Robustness, and Resilience (Pecson et al., 2015). The overarching umbrella concept is reliability, which can be achieved by two different strategies, failure prevention (achieved through redundancy and robustness) and failure response (achieved through resilience). The Project incorporates these features, including overall reliability, failure prevention for pathogens and chemicals, failure response at Project facilities (NCWRP, NCPWF, NCPW Pump Station and Pipeline, [including the NCPW Dechlorination Facility], Miramar Reservoir, and Miramar DWTP), continuous on-line monitoring, control limits at critical control points, system-wide alarms, and operational responses. This diversity of strategies is illustrated on Figure 1-13.

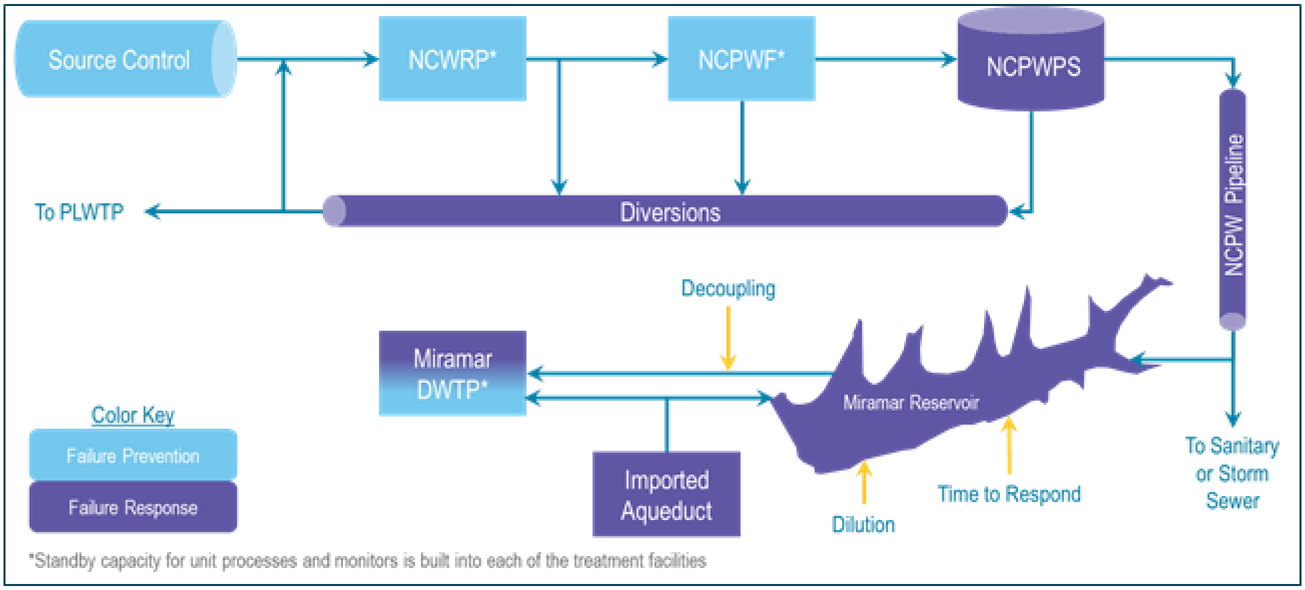


Figure 1-13: Reliability Features of the North City Project

Through the enhanced source control, treatment, and monitoring provided through the NCWRP and NCPWF, it is anticipated that the failure prevention features alone will suffice to ensure a high degree of system reliability. The rigor of the failure prevention approach should minimize the need for additional failure response. Nevertheless, the Project will be implemented with significant failure response features, including multiple diversion points for off-spec (non-compliant) water, as well as response time, dilution, and decoupling of Miramar Reservoir. The ability to switch to the alternative supply source rapidly (i.e., 100 percent imported water), provides additional failure response that also ensures that the Miramar DWTP will continue to produce safe drinking water for its service area. Along with effective and defined operational strategies, numerous features ensure a high degree of reliability for the Project. Section 13 of this report elaborates on the multiple reliability features of the Project.

1.13.1 Reliability

The Project will incorporate all four components of reliability, balancing failure prevention and failure response in different combinations while maintaining equivalent degrees of public health protection. This viewpoint is supported by the California State Expert Panel, which stated: "*Two major options have been proposed to fulfill the core functions of the environmental buffer in DPR systems, either by providing additional treatment redundancy and/or by adding engineered storage with a defined holding time prior to release into the drinking water supply distribution system.*" (Olivieri et al. 2016).

1.13.2 Failure Prevention: Redundancy and Robustness

Redundancy (use of measures beyond minimum requirements) and robustness (use of multiple and diverse barriers) will provide consistent, continuous protection against pathogens and chemical contaminants. The strategies to protect against these two contaminant groups must consider the exposure required to cause health effects. Pathogens pose the most acute threat with infections occurring after as little as a single exposure; therefore, the Project must place a premium on providing consistent and continuous protection against pathogens. More flexibility can be permitted for chronic constituents because their effects are manifested over longer, often over a lifetime, of exposure.

Redundancy. Use of redundant treatment processes allows the overall treatment train to provide a buffer so that an excursion or deviation from normal operating conditions, or a malfunction or failure in one unit process, does not cause the system as a whole to fail to meet specifications. The NCWRP and NCPWF will provide redundancy in treatment well beyond the minimum SWA requirements.

In addition to barriers provided at the NCWRP (secondary treatment and tertiary filtration), the NCPWF and NCPW Pipeline also provide robustness by using five additional distinct and diverse protection barriers (Ozone/BAC, MF, RO, UV/AOP, and chlorine disinfection) to reduce the risk of a major failure significantly. The probability of multiple barriers in the proposed advanced water treatment train failing simultaneously drops to fractions of a second per year, further enhancing the strength of the failure prevention strategy. Each of the pathogen barriers will be monitored continuously by on-line devices using a critical control points approach.

Robustness. The key to effective chemical control is robustness. The NCPWF is designed with a robust number of distinct barriers operated by different mechanisms, allowing the combined effect of the overall treatment train to provide excellent protection against all of the known chemical contaminants. The use of diverse treatment processes listed above also provides increased protection against emerging and “unknown” chemicals. Furthermore, redundancy is provided to ensure that multiple barriers are in place to control acute chemicals (e.g., nitrate, nitrite, and perchlorate).

1.13.3 Failure Response: Resilience

Resiliency is built into the entire Project. Continuous monitoring and response procedures at the NCWRP, NCPWF, and NCPW Pipeline (including the NCPW Dechlorination Facility) allow for rapid implementation of any corrective action that may be required. Resiliency features at Miramar Reservoir, which serve as an environmental buffer, include response time, dilution, and decoupling (the ability of the purified water source to be separated from the Miramar DWTP). Redundancy and robustness are also provided by the Miramar DWTP, which further increases the degree of treatment provided to address upstream excursions or failures. Resiliency in operational responses will be achieved through development of an Operation Plan (OP). Finally, to facilitate effective and reliable Project operation, an operator-friendly, color-coded response and communications plan will be used, which grades corrective actions based on the severity of the treatment excursion or failure. An overview of that plan is illustrated on Figure 1-14.

1.14 Response and Notification Plan and Contingency Plan

Project features have been incorporated and tools will be provided to ensure proper response and notification in the event of a treatment malfunction or failure. The Project will be equipped with state-of-the-art control and monitoring equipment, which will facilitate operation of the facility by highly trained operations staff to produce a purified water supply that is reliably protective of public health. That same equipment will allow for the early detection of any treatment degradation and the ability to take pro-active actions to address treatment issues as they arise.

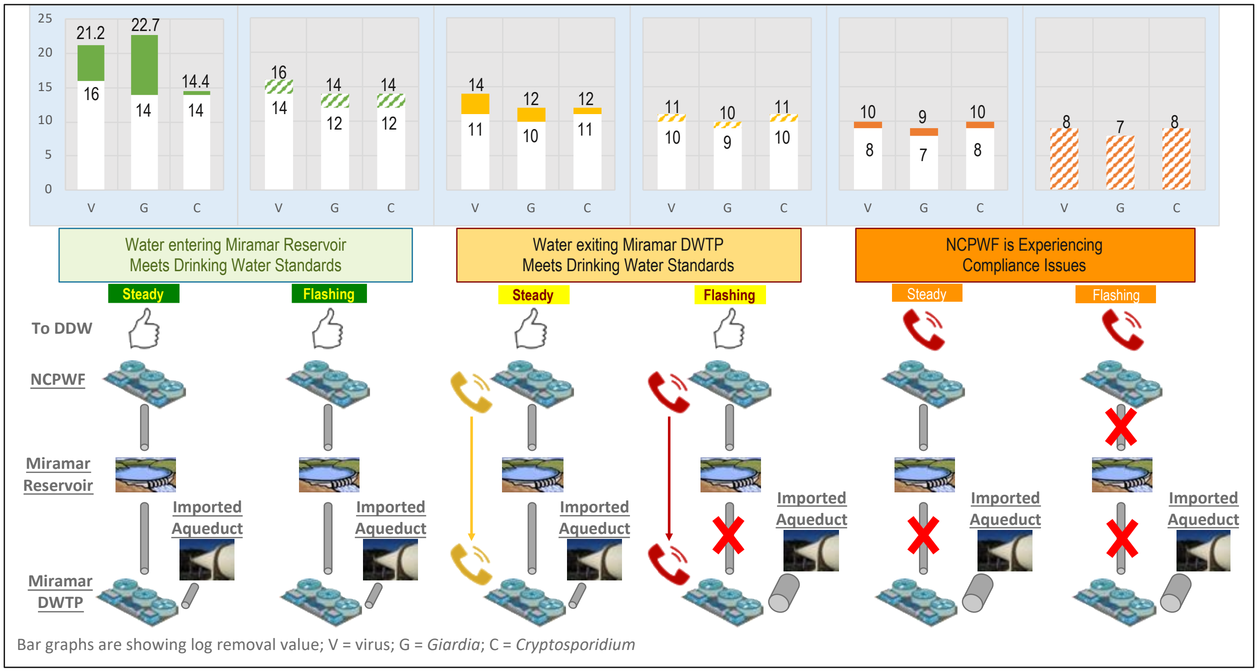


Figure 1-14: Graded Response Plan with Alarms and Responses

An OP, specific to the North City Project ("North City Project OP"), will be developed for the facilities that details Standard Operating Procedures (SOPs) for normal and emergency conditions. If the purified water does not meet permit requirements, pathogen reduction performance, or advanced treatment criteria based on on-line monitoring parameters (e.g., conductivity removal through RO, UV dose, and other critical control points), the purified water has four options; it can be: (1) redirected to the PLWTP, (2) returned to the head of the NCWRP, (3) diverted from the NCPW Pipeline to drain to a nearby sewer or storm drain rather than being discharged to Miramar Reservoir, or (4) isolated within Miramar Reservoir. Responses and notifications will be implemented as the operating conditions transition from normal to compromised conditions. Additionally, the contingency plan will be activated to ensure that the raw source water for the Miramar DWTP can be switched from a blend of purified water and imported water to entirely imported water, if necessary. Imported water is available as a normal and suitable alternative raw water source for the Miramar DWTP. Section 14 of this report summarizes the various elements associated with the Project's response, notification and contingency plans to ensure full and continued protection of public health.

1.14.1 Enterprise Control Strategy

The Project consists of a linear system, comprising multiple treatment and conveyance facilities that are all interconnected. Recognizing that the interrelated nature of these facilities requires that the Project be operated as a holistic enterprise, an Enterprise Level Control Strategy was developed to serve as a roadmap for the more detailed control plans and designs of Project facilities. This approach ensures that the controls associated with the processes and devices are properly coordinated and consistent with the overarching strategy.

1.14.2 Interface with Water and Wastewater Operations

The City's Wastewater Treatment and Disposal Division within the System Management and Operations Branch of the PUD will be initially responsible for O&M of the following North City Project elements: the Morena Pump Station and Pipeline, NCWRP, NCPWF, NCPW Pump Station and Pipeline, and NCPW Dechlorination Facility. With the implementation of the Program's second phase, it is anticipated that a new

Pure Water Division will be created and assume responsibility for the NCPWF, NCPW Pump Station and Pipeline, and the NCPW Dechlorination Facility. The Wastewater Treatment and Disposal Division will also continue to operate and maintain the existing wastewater pump stations (Pump Station 64 and Penasquitos Pump Station) that convey raw wastewater to the NCWRP. The O&M of the Miramar Reservoir Pump Station and Miramar DWTP will continue to be the responsibility of the Water Operations Division, which is also part of the PUD's System Management and Operations Branch.

Project operations will be coordinated through various standing meetings. The North City Project OP and more detailed SOPs will guide day-to-day activities and ensure proper coordination of O&M activities. Communication systems will link all Project facilities to enable real-time monitoring by all Operations staff.

1.14.3 Response and Notification Plan

City staff will follow the SOPs, equipment O&M manuals, and the North City Project OP for operation of the NCWRP, NCPWF, and NCPW Pump Station and Pipeline. These documents will include plans and procedures for normal operation, preventive maintenance, membrane cleanings, equipment failures, power outages, source water control upsets, NCWRP upsets or changes in performance, NCPWF upsets or changes in performance, challenges with conveyance systems, operations of Miramar Reservoir, and the Miramar DWTP.

The Project's Response and Notification Plan is based on three operating scenarios for the system, which have been designated a color as follows: normal operating scenario (green), compromised operating scenario (yellow), and failing operating scenario (orange). Each operating scenario is further subdivided into either a steady or flashing color category, indicating the level of urgency of the responses required. The Response and Notification Plan corresponding the various operational conditions is presented in Table 1-8.

Table 1-8: Response and Notification Plan for the NCPWF

Condition	NCPWF Response	Miramar DWTP Notification	Miramar DWTP Response	DDW and the RWQCB Notification	Contingency
Green Steady	Standard operator response to address any treatment performance issues	N/A[a]	N/A	N/A	N/A
Green Flashing	Enhanced operator response to improve treatment performance	N/A	N/A	N/A	N/A
Yellow Steady	Enhanced operator response to improve treatment performance	NCPWF alerts Miramar DWTP of reduced, but acceptable level of treatment	N/A	N/A	N/A
Yellow Flashing	Further enhanced operator response to improve treatment performance	NCPWF alerts Miramar DWTP to use alternative source water	Miramar DWTP discontinues using water from Miramar Reservoir	N/A	Miramar DWTP uses only imported water

Continues on next page...

Condition	NCPWF Response	Miramar DWTP Notification	Miramar DWTP Response	DDW and the RWQCB Notification	Contingency
Orange Steady	Urgent operator response to improve treatment performance	NCPWF alerts Miramar DWTP to use alternative source water	Miramar DWTP discontinues using water from Miramar Reservoir	City notifies DDW and RWQCB that permit limits are jeopardized and alternative source water is in use	Miramar DWTP uses only imported water
Orange Flashing	Discontinue purified water flow to Miramar Reservoir	NCPWF alerts Miramar DWTP to use alternative source water	Miramar DWTP discontinues using water from Miramar Reservoir	City notifies DDW and RWQCB notified that purified water discharge to Miramar Reservoir has been discontinued and alternative source water is in use	Miramar DWTP uses only imported water

[a] Not applicable, meaning no response or notification is needed.

1.14.4 Contingency Plan

An extensive Contingency Plan will be developed as part of the development of the North City Project OP. The Contingency Plan will include measures to be taken to ensure the availability of an alternative raw water source (imported water from the SDCWA Aqueducts) for the Miramar DWTP in the event of process and control upsets triggered by equipment failure or loss of power.

In the unlikely event the NCPWF purified water does not meet the permit requirements so that Miramar Reservoir can no longer be used as a source of water supply to the Miramar DWTP, the NCPWF will alert the Miramar DWTP to use an alternative water source, from SDCWA's raw water aqueduct system. This alternative will ensure the continued delivery of an acceptable raw water for treatment at the Miramar DWTP and distribution in the plant's service area.

1.15 Monitoring and Reporting Program

The proposed compliance Monitoring and Reporting Program (MRP) for the Project is designed to satisfy requirements specified in the SWA regulations set forth by DDW and the Basin Plan objectives established by the RWQCB in anticipation of the permit requirements to be issued by the RWQCB. It is anticipated that the MRP for the expanded NCWRP and NPR water use will be unchanged from the existing NCWRP permit. The compliance sampling locations and constituents monitored, specified in the Project's MRP, are based on SWA regulations, the Water Quality Control Plan for the San Diego Basin, EPA's CTR requirements, and EPA's National recommendations. Section 15 of this report outlines the MRP proposed for the North City Project.

1.15.1 Advanced Treatment Criteria

The Project will use a well-oxidized recycled municipal wastewater (tertiary treated water) produced by the NCWRP as the feed water source for the NCPWF. To demonstrate proper continuous full advanced treatment, at least one surrogate or operational parameter for the RO and AOP processes will be continuously monitored and recorded in accordance with the SWA regulations. Continuous monitoring of either electrical conductivity (EC) or TOC on the combined RO permeate stream will be used to indicate RO process integrity. For the AOP system, two surrogate and operational parameters will be continuously monitored to demonstrate AOP performance: UV/AOP (influent ultraviolet light transmittance) and UV dose for each reactor. These operational parameters will be monitored continuously to demonstrate that at least 0.5 log reduction of 1,4-dioxane is achieved.

1.15.2 Pathogenic Microorganism Control

The City will monitor the performance of individual treatment processes to demonstrate achievement of total pathogen reduction levels of at least 10 log virus, 9 log *Giardia* cysts, and 10 log *Cryptosporidium* oocysts reduction, thereby, verifying the performance of each treatment process's ability to achieve its credited LRV and contributing to the total LRVs required. Overall pathogenic microorganism credits will be achieved through the following treatment processes and demonstrated using the following corresponding surrogate parameters and/or calculations:

- ***NCWRP Treatment***
  - Ammonia in aeration basin effluent
  - SRT
  - Turbidity of the combined filter effluent
  - TOC of the combined filter effluent
- ***NCPWF Ozone Treatment***
  - CT calculated using temperature corrected truncated extended integration
- ***NCPWF MF Treatment***
  - Calculated based on pressure decay tests (PDT)
- ***NCPWF RO Treatment***
  - Tier 1: Calculation of strontium reduction
  - Tier 2: Calculation of TOC reduction
  - Tier 3: Calculation of EC reduction
- ***NCPWF AOP Treatment***
  - Feed UV transmittance
  - UV dose
- ***NCPW Pipeline Chlorination Treatment***
  - CT calculated using chlorine residual, temperature, and pH

1.15.3 Purified Water Quality Characteristics for Compliance

Purified water will be monitored as it leaves the NCPWF at the NCPW Pump Station to satisfy pre-established compliance requirements to protect public health and designated beneficial uses of Miramar Reservoir. For regulatory compliance established by the Project permit requirements, the purified water will be monitored for constituents governed by Title 22 criteria for SWA using recycled water and Basin Plan water quality objectives.

The City will assess purified water at the regulatory-prescribed frequency for constituents with pMCL, Actions Levels, sMCL, Notification Levels, Basin Plan-Specified Water Quality Objectives; CTR Standards; and those classified as Priority Toxic Pollutants. Furthermore, the City will monitor the chemicals and indicated compounds that DDW and the RWQCB specify based on their review of this Title 22 Engineering Report.

1.15.4 Discharge Characteristics for Compliance

The Project will comply with the NPDES permit to be issued by the RWQCB that will include requirements for compliance with a statewide policy established by the SWRCB for chlorine residual. The water quality will be monitored for chlorine residual immediately downstream of the NCPW Dechlorination Facility prior to release into Miramar Reservoir.

1.15.5 Augmented Reservoir Characteristics for Compliance

The flow rate of purified water released into Miramar Reservoir will be continuously metered and recorded. The quality of the water in the reservoir will be monitored on a monthly basis in accordance with the SWA regulations. In addition to the parameters specified by DDW, the RWQCB will likely establish other reservoir water monitoring requirements that assess conformance with Basin Plan objectives and beneficial uses, which are expected to focus on biostimulation.

1.15.6 Reporting

Monthly reports will be submitted to the RWQCB and DDW in compliance with the Project permit. An annual report, prepared by an engineer licensed in California and experienced in the fields of wastewater treatment and public water supply, will be submitted to the RWQCB and DDW. Every five years from the date of the initial approval of the Title 22 Engineering Report, the City will update the Title 22 Engineering Report to address any changes and submit the report to the RWQCB and DDW.

1.16 North City Project Operation Plan

A framework has been developed for the North City Project's OP. More detailed information about the actual facilities will be available after the final designs are completed and construction nears completion. Technical specifications and process control descriptions from the construction contract documents and associated shop drawing submittals for the installed equipment will be used to develop the detailed North City Project OP. The current framework is based primarily on the NCWRP 10% Engineering Design Report (MWH/BC, 2016b) and NCPWF 30% Engineering Design Report (MWH/BC et al., 2016). Final designs for these facilities, the Morena Pump Station and Pipeline, and the NCPW Pump Station and Pipeline are underway. Detailed information about the installed equipment will be known during the construction phase. Operation of these new water reclamation and pure water facilities will be paired with the operation of two existing facilities, Miramar Reservoir and Miramar DWTP to complete the OP.

The North City Project OP will also provide for an operational ramp-up, which will follow successful completion of the contractor commissioning and system-wide testing activities. Section 16 of this report outlines the preliminary framework for the North City Project OP and proposed operational ramp-up approach.

1.16.1 Summary of the North City Project OP

The North City Project OP will comply with the requirements set forth in the SWA regulations. The purpose of the OP will be to support the goal of optimizing the facilities operations in order to produce exceptional quality purified water at the targeted volumes to supplement existing water supplies. The OP will describe the operation of all Project components under normal, challenging, or emergency operating conditions, and will include operating procedures, response and action plans, communication plans, and monitoring and reporting requirements. The North City Project OP will also include a detailed staffing plan with descriptions of operator duties, qualifications, certifications, work schedules, and training programs. This OP will be updated as needed to be representative of current operation, maintenance, and monitoring practices as actual experience with the Project facilities provides "lessons learned" and supports changes in documentation.

1.16.2 Contractor Commissioning and System-wide Test

All Project facilities will go through a rigorous contractor commissioning process prior to the City issuing a Notice of Completion to individual construction contractors. Specific contractor commissioning requirements will be detailed in the final design and construction documents that are currently under development.

Following contractor commissioning of all individual facilities and prior to the start of regular operations (i.e., prior to treatment of purified water at the DWTP), the City will perform a system-wide test to verify proper functioning of all interconnections and system-wide control functions. Because the system-side test will involve all Project facilities, including the delivery of purified water to Miramar Reservoir, the City will notify DDW in advance of this test and isolate the Miramar DWTP from the reservoir during that time.

1.16.3 Operational Ramp-Up

The City's proposed operational ramp-up consists of three stages, each with incremental increases in flow deliveries to Miramar Reservoir and criteria to elevate confidence in the overall operations prior to full-scale implementation. The three operational ramp-up stages are presented in Table 1-9, which lists the average flowrate and tentative duration of each stage. The initiation and completion of each stage will be based on pre-defined, DDW-approved checklists that validate proper Project operations.

Table 1-9: Operational Ramp-up Staging Flowrates and Durations

Operational Ramp-up Stage	Stage 1	Stage 2	Stage 3
Average Purified Water Flow to Miramar Reservoir	7.5 mgd	15 mgd	30 mgd
Duration[a]	90 days	90 days	90 days

[a] Durations are tentative. If targets are met, City will submit checklist with supporting data to DDW and go to next stage without meeting with DDW.

As illustrated on Figure 1-15, the operational ramp-up period will feature multiple sampling locations to develop treatment train profiles, enhanced monitoring, pathogen reliability demonstration, and determination of the fraction of purified water in Miramar Reservoir and Miramar DWTP during each stage. The ability to decouple Miramar Reservoir will also be tested during the operational ramp-up.

Advancement from one staging step to the next will depend on achieving the operating targets as confirmed by enhanced water quality monitoring during the ramp-up period, and written approval by DDW. At the end of Stage 3, a full report summarizing the Project operation and monitoring results will be submitted to DDW and the RWQCB.

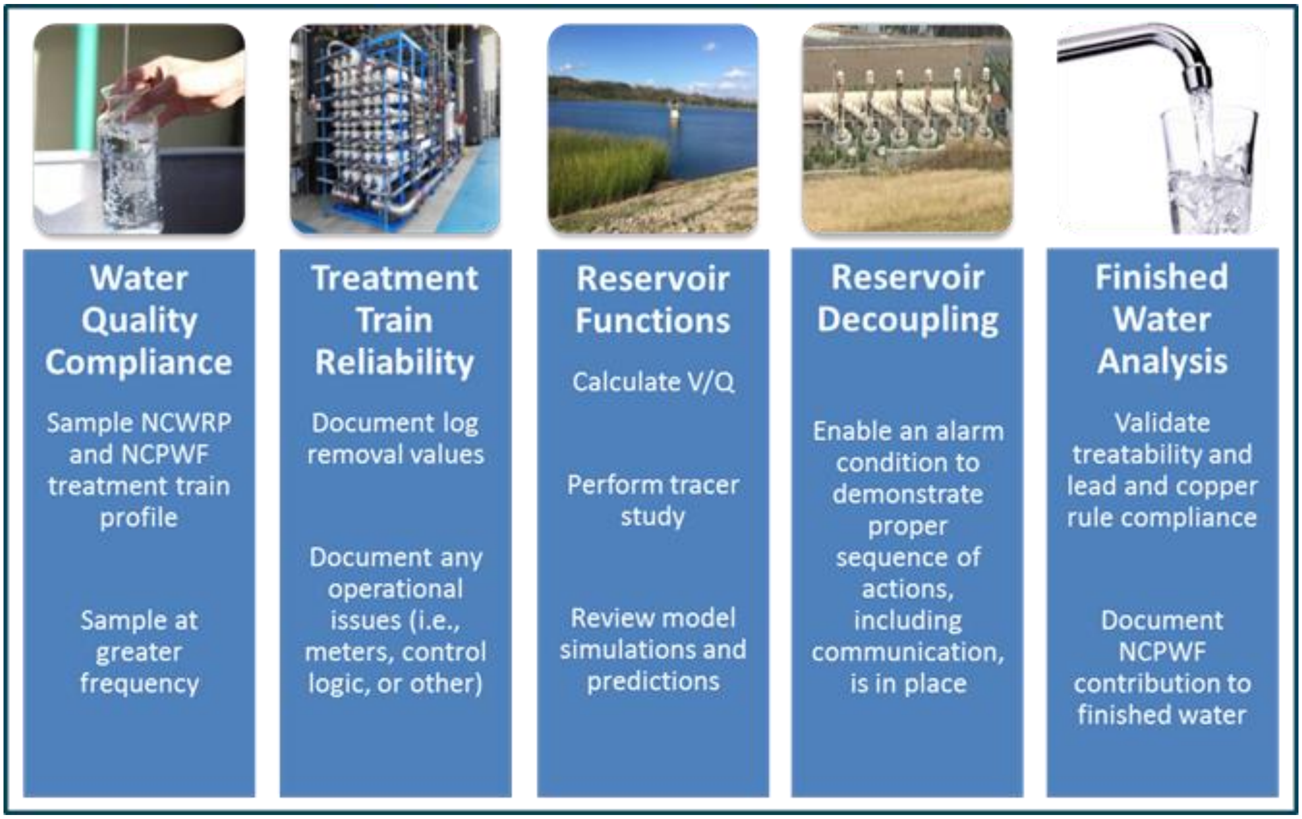


Figure 1-15: Proposed Criteria for Operational Ramp-up

1.16.4 Handling of Off-spec Water

Off-spec water is defined as any final effluent leaving the NCPWF that does not meet the requirements for discharge to Miramar Reservoir. In the very unlikely event that off-spec water is produced at the NCPWF, three options have been developed to provide the City with the operational flexibility to dispose of the off-spec water by closing the valve at the NCPW Dechlorination Pipeline and draining the NCPW Pipeline to the:

1. NCPWF Waste Discharge Pipeline, which would convey the off-spec water to the NCWRP or to the PLWTP; or
2. Existing Carrol Canyon Trunk Sewer, which would convey the off-spec water to the PLWTP; or
3. Existing storm drain near the NCPW Dechlorination Facility, which would be subject to compliance with RWQCB requirements.

In addition to the above-mentioned proposed configurations for the temporary offloading or disposal of off-spec water in the NCPW Pipeline, the City continues to explore other possible engineering solutions to assist with permanent offloading of the PLWTP.

1.17 Operation & Maintenance Readiness Plan

The City developed the North City Pure Water Operations & Maintenance Readiness Master Plan ("O&M Readiness Plan"), which involved a thorough assessment of the resources that will be required to operate and maintain the Project facilities. The O&M Readiness Plan:

- Describes the staff positions and associated responsibilities and qualifications required to operate and maintain the Project facilities;
- Defines the organizational structure and plan for integrating the Project staff into the City's existing water and wastewater O&M organization;
- Includes a preliminary staff hiring plan with a schedule by position; and
- Establishes the anticipated level of certification and type of training required for Project staff.

Section 17 of this report describes the planning effort undertaken by the City to assess and identify the O&M needs associated with the North City Project.

1.17.1 Background

The O&M Readiness Plan was developed by an organized Working Group comprising key City O&M staff from the PUD Wastewater, Water, and Laboratory divisions. The Working Group's goal was to develop recommendations to help ensure safe, reliable operation of the Project. These recommendations were then presented to the PUD Leadership for approval.

1.17.2 North City Pure Water O&M Organization

In order to select the North City Pure Water O&M Organization's structure and determine where it should be incorporated within the City's existing O&M organization, the Working Group completed a thorough alternative analysis by which a recommended organizational structure was determined. The analysis yielded a recommendation to add the North City Pure Water Organization within the City's existing Wastewater Division under a Program Manager as an interim phase, with the Pure Water Organization becoming a separate division as the next phase of the Program is initiated. In a later review session with senior management, it was determined that the more effective staffing approach is to have the Pure Water organization be its own separate division under a Deputy Director from the start. Under this current organizational structure, the North City Project facilities are assigned into divisions as presented in Table 1-10.

Table 1-10: North City Project Facilities Divisions

Pure Water Division	Existing Wastewater Division	Water
✓ NCPWF ✓ NCPW Pump Station and Pipeline ✓ NCPW Dechlorination Facility	✓ Morena Pump Station ✓ NCWRP	✓ Reservoir Infrastructure ✓ Miramar DWTP

1.17.3 Staffing Requirements and Full Time Equivalents

The staffing requirements are based, in part, on data gathered from O&M of the 1-mgd NCDPWF, which comprises the same processes that will be included in the full-scale NCPWF. These data were verified against the staffing requirements for Orange County Water District's Groundwater Replenishment System.

The NCPWF will be continuously manned, 24-hours per day/seven-days per week by at least three operators, one of which will possess a Grade III Wastewater Operator or Grade 4 Water Operator with Advanced Water Treatment (AWT) 3 Certification. The Pure Water Treatment Superintendent will have a Grade V Wastewater Certification or a Grade 5 Water Certification and an AWT 5 Certification. Upwards of 30 full-time equivalents will be needed to operate and maintain the NCPWF, NCPW Pump Station and Pipeline, and NCPW Dechlorination Facility. It should be noted that this organizational plan may be adjusted depending on future needs and personnel, and future certification requirements mandated by the SWRCB.

The Project will require more than ten new water quality and laboratory staff, and approximately ten additional full-time equivalents to accommodate the additional workload associated with the Morena Pump Station and Pipeline and expanded NCWRP.

1.17.4 Job Classifications and Certifications

The draft responsibilities and required certifications and training for each position in the North City Pure Water O&M Organization have been developed. The City has been involved in the planning of a new AWT Certification Program through participation in the SWRCB Advisory Group on Feasibility of Developing Criteria for Direct Potable Reuse and a collaborative effort led by the California Urban Water Agencies.

All NCPWF operations staff will be trained at the NCDPWF, prior to commissioning of the NCPWF. It is envisioned that this training will include both classroom and practical, hands-on training. The City is in the process of developing a comprehensive curriculum for that training program.

1.17.5 Hiring Plan

The O&M Readiness Plan includes a preliminary hiring plan with a schedule for filling positions. While the hiring plan is still a draft and subject to revision, the City recognizes that it is imperative to ensure that the appropriate staffing resources are hired and trained in time for the construction, commissioning, and start of the Project facilities.

1.18 Technical, Managerial, and Financial Capacity

In accordance with the 1996 federal Safe Drinking Water Act, California enacted requirements for public water systems to demonstrate to DDW that water suppliers possess adequate technical, managerial, and financial (TMF) capacity to “assure the delivery of pure, wholesome, and potable drinking water” (CDHS/SWRCB, 1996). The City, as a water supplier proposing a SWA potable reuse project, submits applicable TMF information in support of this North City Project for review by DDW.

While specific TMF requirements have yet to be adopted by DDW for potable reuse system operations, Section 18 of this report summarizes the City’s capacity using DDW’s TMF Assessment Form for Potable Water Systems.

1.18.1 Technical Capacity

The City has successfully operated water reclamation facilities for over three decades. The City has also undertaken potable reuse applied research for the last 13 years. The initiation of an operator training program at the NCDPWF five years prior to start-up of the Project forms a strong technical foundation for the Project. This experience is a testament to the City’s technical ability to implement and operate the North City Project. The City’s technical capacity, combined with the inclusion of an unprecedented number of state-of-the art treatment processes and fail-safe features in the Project, reduces the risk to public health to an insignificant level.

1.18.2 Managerial Capacity

The City has long demonstrated the capacity to proficiently manage public systems providing water, wastewater, and water recycling service to approximately 2.2 million people. The City intends to leverage the experience of its existing leaders and the established structure and best practices already in place to manage the North City Project. The City currently owns and operates all existing components of the Project (NCWRP, Miramar Reservoir, and Miramar DWTP) and will own and operate all new components of the Project (Morena Pump Station and Pipeline, expanded NCWRP, NCPWF, NCPW Pump Station and Pipeline, and NCPW Dechlorination Facility). The Project will not change any water rights.

1.18.3 Financial Capacity

All wastewater, recycled water, and drinking water revenues generated by the City are kept in funds that are separate from other City funds, including the General Fund. Those revenues can only be used to cover costs associated with the operation, maintenance, and improvements of the wastewater, recycled water and drinking water systems, as well as to replenish various related reserve funds (e.g., Emergency Operating Reserve, Secondary Purchase Reserve, Rate Stabilization Fund Reserve, Emergency Capital Reserve, and Pension Stabilization Reserve). The City's financial processes are well established and allow for separate budgeting, tracking, and control of water and wastewater expenditures; and operating and capital improvements expenditures.

The City has well established fiscal standards through the City Charter and Council Policies, and the City's PUD has a strong financial position. The City approved a water rate increase plan for a five-year period in November 2015 with the completion of a cost of service study.

The PUD has determined that the costs for the Pure Water Program will be allocated between the Sewer and Water funds in the following way:

- All capital and operational costs related to facilities for the conveyance and treatment of wastewater through secondary treatment will be borne by the PUD's Metropolitan Wastewater Utility Enterprise Fund (including the 12 Participating Agencies); and
- All capital and operational costs related to treatment and conveyance of process water post-secondary treatment will be borne by the Water Utility Enterprise Fund.

The total capital cost to build the North City Project is estimated at approximately $1.1 to 1.3 billion (in 2016 dollars). Funding for the North City Project will come from a variety of sources available to the City.

The City is committed to storing appropriate funding each year to ensure the continued maintenance and timely replacement of all Project assets. This funding will be secured through the City's annual operating budget. Funding for the replacement of equipment (e.g., periodic replacement of membrane filters, RO units and UV lamps) will be secured through the PUD's Operating or Capital Improvement Program (CIP) budget. The PUD will use the vendor or manufacturer recommended replacement schedule and the continuous assessment of the equipment's operating condition as a basis for planning the long-term funding of all required equipment replacements. Sufficient funds are available in the Emergency Operations Reserve and the Emergency Capital Reserve for unforeseen equipment expenses, such as complete replacement of MF or RO membranes.

2. Project Overview

The North City Project, illustrated on Figure 2-1, is the first phase of the Pure Water Program. The Project is scheduled to be operational by 2021 and is designed to augment the City's Miramar Reservoir with approximately 30 mgd (33,600 AFY) of purified water.

The Project involves diverting additional untreated municipal wastewater to the NCWRP via the Morena Pump Station and Pipeline. The permitted capacity of the NCWRP will be modified to enable production of tertiary treated water for the NCPWF and satisfy NPR water demands supporting both potable and non-potable reuse. Wastewater treated at the expanded NCWRP will be transferred via the Tertiary Treated Water Pump Station and Pipeline and further treated at the NCPWF to produce a safe, high-quality, sustainable source of water to supplement existing water supplies. From the NCPWF, purified water will be conveyed to Miramar Reservoir via the NCPW Pump Station and Pipeline. Miramar Reservoir is a source of supply to the Miramar DWTP, which provides drinking water to the northern portion of the City's service area.

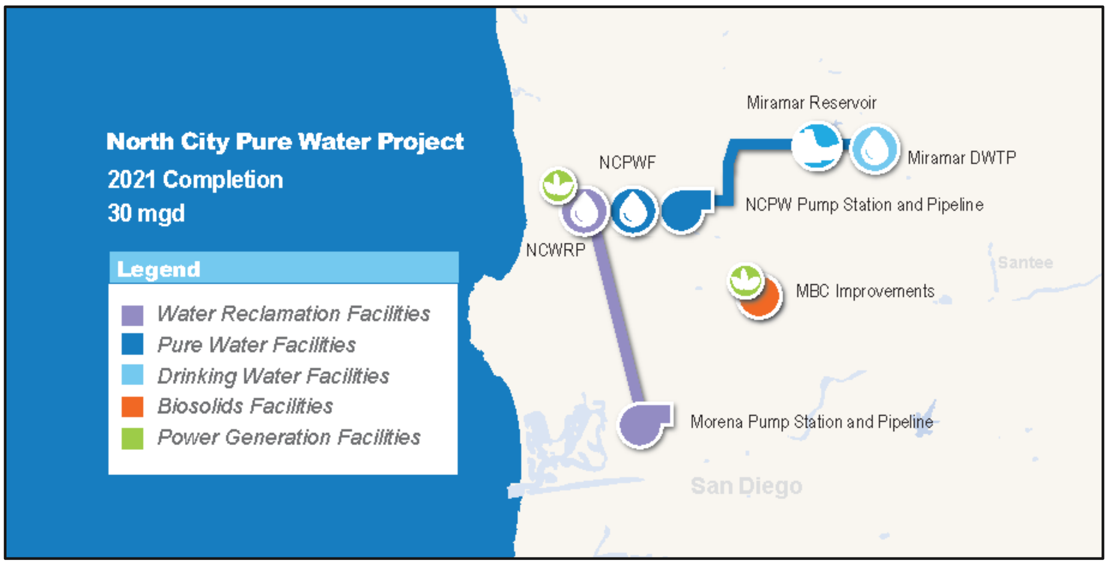


Figure 2-1: North City Pure Water Project Schematic

This section presents the following overview of the North City Project Title 22 Engineering Report:

- Purpose of the Title 22 Engineering Report;
- Background;
- Project participants;
- Project development and supporting activities;
- Public outreach;
- IAP;
- Environmental compliance; and
- Project goals.

2.1 Purpose of the Title 22 Engineering Report

This Title 22 Engineering Report provides information about the City's North City Project, which is part of the Pure Water Program. It describes the framework for the City's plan for compliance with CCR's Title 22 Water Recycling Criteria (CCR, 2018 in progress) and SWA regulations. This report is prepared in compliance with the aforementioned regulatory requirements for review by DDW.

The purpose of this report is to: (1) request approval from DDW for the North City Project and to form the basis for the RWQCB to issue a new NPDES permit for the Project, (2) request approval from DDW for modifying the NCWRP and to form the basis for the RWQCB to issue a new or amended master water recycling permit for the NCWRP, and (3) request approval from DDW and form the basis of the water supply permit amendment to use the Miramar Reservoir, as augmented with Pure Water, as a source of supply in the City of San Diego's drinking water system.

2.2 Background

The City is implementing the North City Project – the first phase of the City's Pure Water Program – as an integrated water supply and wastewater management project. When completed, the Project will provide up to 30 mgd (33,600 AFY) of purified water to augment Miramar Reservoir. As a result, both wastewater flows to the PLWTP and discharges of treated effluent to the ocean will be reduced by about half. The planned operational start-up date for the Project is late 2021.

The City has long endeavored to diversify and enhance its existing water supply. In January 2004, the San Diego City Council authorized a comprehensive evaluation of all viable options to maximize the use of recycled water. While evaluating options for increasing the beneficial use of recycled water through the Water Reuse Study (City, 2006), the City found that the strategy of augmenting a local reservoir with purified water both "maximizes the use of the available recycled water supply" and provides the "lowest overall unit cost" of the reuse strategies evaluated.

Following the 2006 Water Reuse Study, the following key activities and milestones led to the inception of the Pure Water Program:

- The City submitted a "Proposal to Augment San Vicente Reservoir with Purified Recycled Water" for regulatory review in 2012 (City, 2012a). The 2012 Concept Report proposed supplementing San Vicente Reservoir with up to 13.4 mgd (15,000 AFY) of purified water. That concept was conditionally approved by DDW on September 7, 2012 (CDPH, 2012);
- The City collaborated with environmental and Metro Joint Powers Authority (JPA) stakeholders to develop options for maximizing water recycling and minimizing the PLWTP ocean discharges in the Recycled Water Study (City, 2012b);
- The City further confirmed the need to develop additional local water supply sources as a means of providing reliability and protection from water supply shortages. The City's 2012 Long-Range Water Resources Plan (City, 2013a), indicated that even with aggressive conservation efforts, the City will need approximately 25 percent more water by 2035 than what was required in 2010;
- The City implemented the Demonstration Project (City, 2013b), and demonstrated that potable reuse through San Vicente Reservoir Augmentation would be feasible;
- The City Council directed staff to identify options to maximize potable reuse based on the Demonstration Project Report (City, 2013b); and

- The City worked with environmental stakeholders to develop a potable reuse strategy to reduce ocean discharges as part of its 2015 PLWTP NPDES permit application. This effort resulted in the development of a phased approach for the Pure Water Program that would ultimately produce approximately 83 mgd of pure water by 2035 to augment surface water reservoir(s) in the region.

The original implementation plan for the Pure Water Program envisioned 15 mgd of purified water production by 2023, 30 mgd by 2027, and 83 mgd by 2035. The original plan only contemplated the augmentation of San Vicente Reservoir for the initial phase. As the Program continued to develop and the State's regulatory process evolved, the scope of the initial phase was increased to 30 mgd and a different reservoir option (Miramar Reservoir) was considered. To further assess the regulatory feasibility of Miramar Reservoir, the City submitted a "Concept Proposal Report for the Miramar Potable Reuse Project" to DDW on November 2, 2015 (City, 2015a). Miramar Reservoir was ultimately selected as the reservoir to which purified water will be conveyed.

SWA with purified water in California falls under the regulatory authority of DDW and the RWQCB. In addition to the water recycling regulations, the Project must comply with the RWQCB Basin Plan (RWQCB, 2012).

The Project is presented in this Title 22 Engineering Report for DDW's review and approval as the first step towards securing a permit for the Project from the RWQCB.

2.3 Project Participants

The Project is being sponsored and implemented by the City. With a population of approximately 1.4 million as of January 1, 2016, and a land area of 342 square miles, San Diego is the eighth largest city in the nation, and the second largest city in California by both population and land area. The City operates under a "Strong Mayor" form of government, whereby the Mayor is the Chief Executive Officer and has direct oversight over the City's operating functions and departments, with the exception of the City Council, Personnel, City Clerk, Independent Budget Analyst, Ethics Commission, City Attorney, and City Auditor.

The City owns San Diego's water, wastewater, and recycled water systems and operates those systems through the City's PUD. No other agencies are involved in the O&M of those City-owned systems. Similarly, no other agencies will be involved in the O&M of the conveyance and treatment facilities associated with the Project.

2.3.1 City Public Utilities Department Organization

The mission of the PUD is to provide reliable water utility services that protect the health of the City's communities and the environment. The PUD provides drinking water and wastewater collection, treatment and disposal services to all San Diego residents. Along with providing wastewater services within the City, the PUD also transports, treats, and disposes of the wastewater from 12 other cities and sanitation districts. In addition to supplying more than 290,000 metered service connections within its own incorporated boundaries, the City conveys and sells drinking water to the City of Del Mar, the Santa Fe and San Dieguito Irrigation Districts, and the California American Water Company, which, in turn, serves the Cities of Coronado and Imperial Beach, and portions of South San Diego.

The Mayor has operational authority over the City organization and appoints managers and directors who are charged with the operations of the various departments; therefore, the PUD ultimately reports to the Mayor through the City's Deputy Chief Operating Officer. The Director of Public Utilities oversees the PUD.

The PUD comprises the following branches and associated divisions:

- ***System Management and Operations Branch.*** Water System Operations, Wastewater Treatment & Disposal, Engineering and Program Management, Asset Management, and Systems Management & Operations;
- ***Distribution and Collection Branch.*** Wastewater Collection, Water Construction & Maintenance, and Distribution & Collection;
- ***Pure Water and Quality Assurance Branch.*** Employees Services & Quality Assurance, Environmental Monitoring & Technical Services, Pure Water Program, and Pure Water Operations;
- ***Business Support Branch.*** Finance & Information Technology, Customer Service, and Long Range Planning & Water Resources; and
- ***Department Management Branch.*** Strategic Support Services, External Affairs, and External Water Policy.

2.3.2 San Diego Water System

The San Diego water system operated by the PUD extends approximately 400 square miles, including areas outside of the City. Total water deliveries are on the order of 200 mgd (224,000 AFY), which includes water delivered through the City's system (i.e., within the City), plus water wholesaled to several neighboring agencies. The City's water system consists of nine source water reservoirs, three water treatment plants, 48 water pump stations, 32 treated water storage facilities, and over 3,200 miles of water transmission and distribution pipelines.

On average, about 85 percent of the City's drinking source water supply is imported water purchased from the SDCWA; the remaining 15 percent is rain runoff captured in local reservoirs. The City is the largest of SDCWA's 24 member agencies, accounting for 38 percent of its water sales. The SDCWA, in turn, gets most of its imported water from the Metropolitan Water District of Southern California, which delivers water to 26 public water agencies and is the largest wholesale water agency in the nation. The Metropolitan Water District of Southern California imports water from the Colorado River via the Colorado River Aqueduct and from the Sacramento-San Joaquin River Delta in northern California through the State Water Project.

To offset potable water demands, the PUD also operates a recycled water treatment and distribution system. The City's two water reclamation plants produce an average of 11 mgd of NPR water, 7 mgd of which is distributed over an 80 square-mile area within the City, while 4 mgd is wholesaled to neighboring agencies. This NPR water is used primarily for outdoor irrigation and industrial cooling.

2.3.3 San Diego Wastewater System

Along with providing wastewater collection and conveyance services within the City, the PUD treats and disposes of the wastewater from 12 other participating agencies, whose wastewater flows account for about one-third of the wastewater processed by the City. As such, the San Diego wastewater system consists of two separate systems, the Municipal Wastewater System and Metropolitan Wastewater System.

The Municipal Wastewater System consists of the infrastructure needed to collect and convey the wastewater generated by residences and businesses within the City to the Metropolitan Wastewater System. Serving a 330 square-mile area with a population of 1.4 million people, the Municipal Wastewater System includes 250,000 connections to the City sewer lines, 2,900 miles of City sewer lines, over 55,000 sewer manholes, and 84 wastewater pump stations.

The Metropolitan Wastewater System conveys, treats, and disposes of the wastewater from the City and 12 other cities and districts (referred to as Participating Agencies) from a 450 square-mile area with a population of over 2.2 million (includes a population of 1.4 million within the City of San Diego). In 2015, this regional system processed an average of 155 mgd of wastewater. The PLWTP remains the mainstay of that system, processing slightly more than 85 percent of the total wastewater flow.

The Metro Wastewater JPA is a coalition of the municipalities and special districts that share in the use of the City's Metropolitan Wastewater System. Representatives from each of the 12 Participating Agencies serve as an advisory body to the San Diego City Council on the operation of the Metropolitan Sewerage System. The Participating Agencies are the cities of Chula Vista, Coronado, Del Mar, El Cajon, Imperial Beach, La Mesa, National City, and Poway; the Lemon Grove Sanitation District; the Otay Water District; the Padre Dam Municipal Water District; and the County of San Diego (on behalf of the Winter Gardens Sewer Maintenance District, and the Alpine, Lakeside, Spring Valley and East Otay Mesa Sanitation Districts).

2.4 Project Development and Supporting Activities

The City began evaluating opportunities for water reclamation and indirect potable reuse in the 1990s. The implementation of the existing NCWRP was one of the original efforts towards this goal and has been producing and delivering recycled water to customers for landscape irrigation and industrial use since 1997. In 2004, the San Diego City Council called for a Water Reuse Program to evaluate options for increasing the use of the City's recycled water. Figure 2-2 illustrates a timeline of the various initiatives and milestones that led to the development of the Pure Water Program.

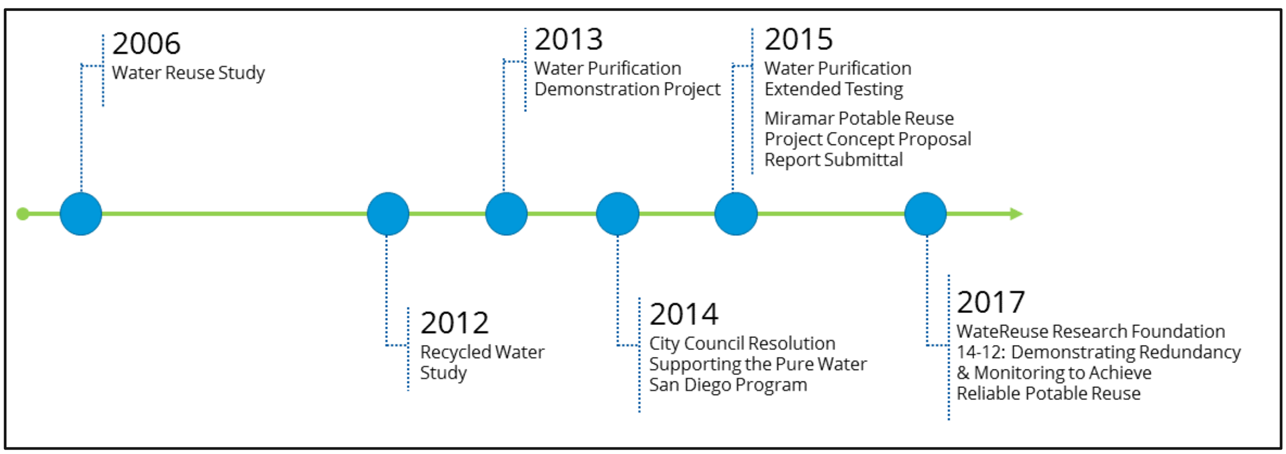


Figure 2-2: Pure Water Program Timeline

The first phase of the Water Reuse Program was the Water Reuse Study (City, 2006). The objective of the study was to conduct an impartial, balanced, comprehensive, and science-based study of recycled water opportunities to meet current and future water needs. The study conducted research on the health effects of water reuse options and incorporated public participation during the process. Based on the information presented in the Water Reuse Study, a stakeholder group determined that the preferred option for maximizing use of the City's recycled water supply would be to augment existing supplies in the City's San Vicente Reservoir with recycled water.

The Recycled Water Study (City, 2012b) built on the findings of the Water Reuse Study by developing and evaluating alternatives to maximize system-wide (Metropolitan Sewerage System) water recycling, reduce flows to the PLWTP, and identify locations around the City where potable reuse facilities could be implemented. Stakeholders that participated in the Recycled Water Study included local environmental organizations, Metro Wastewater JPA, and SDCWA.

The Demonstration Project was the second phase of the Water Reuse Program. The NCDPWF was used to demonstrate, to DDW and the public, the feasibility of converting recycled water into purified water for reservoir augmentation, and ultimately treatment and distribution as drinking water. The Demonstration Project was designed to substantiate regulatory and economic feasibility and assess public acceptability of a full-scale potable reuse project. The Demonstration Project components, which helped form the basis for the North City Project, included the following:

- Operated, tested, and monitored a 1 mgd demonstration-scale treatment facility, referred to in this report as the NCDPWF (formerly referred to as the advanced water purification facility);
- Convened an IAP to provide expert peer review and feedback;
- Conducted hydrodynamic studies of San Vicente Reservoir;
- Proposed a regulatory framework for a full-scale reservoir augmentation project;
- Performed an energy and cost analysis;
- Performed a pipeline alignment study; and
- Conducted an education and outreach program.

In April 2013, the Demonstration Project Report (City, 2013b) was unanimously adopted by the San Diego City Council. The report included the results of the demonstration-scale testing, reservoir studies, and public outreach. The Demonstration Project also included the findings of the Limnology and Reservoir Detention Study (FSI, 2012) that evaluated the feasibility of blending purified water with imported water supplies in San Vicente Reservoir.

In April 2014, the San Diego City Council approved a formal resolution supporting the Pure Water Program's planning efforts with an enlarged concept. It was envisioned that approximately 100 mgd of wastewater would be diverted from the PLWTP to future advanced water purification facilities that would produce approximately 83 mgd of purified water to augment local reservoirs and the City's water supplies, while reducing flows directed to the PLWTP. The resolution called for the implementation of the Pure Water Program to avoid having to expand and upgrade the PLWTP and, at the same time, increase local water supplies. Using an incremental approach, three Program phases were envisioned at that time to achieve the desired 83 mgd of purified water:

1. North City facilities producing 15 mgd of purified water for San Vicente Reservoir by 2023;
2. South Bay facilities producing 15 mgd of purified water for Otay Reservoir by 2027; and
3. Central Area facilities producing 53 mgd of purified water for San Vicente Reservoir by 2035.

On November 18, 2014, the San Diego City Council voted unanimously to approve the start of Program implementation efforts.

More recently, a number of studies have been conducted at the NCDPWF to assess issues related to potable reuse implementation. Following the Demonstration Project, extended testing was carried out for 22 months to evaluate an Ozone/BAC pretreatment process. That testing concluded in January 2015. The goal of the additional pretreatment step was to:

- Enhance reliability through treatment redundancy and robustness, and
- Evaluate whether it would provide sufficient resilience to reduce or eliminate the need for dilution in a reservoir.

The extended testing demonstrated the effectiveness of the Ozone/BAC pretreatment to control CECs, TOCs, and pathogens, as well as to improve the performance of the downstream processes, including both MF and RO. Additionally, data have been collected to demonstrate reliable potable reuse through WateReuse Research Foundation (WRRF) 14-12 Study (entitled: Demonstrating Redundancy and Monitoring to Achieve Reliable Potable Reuse). This testing at the NCDPWF assessed how a combination of treatment redundancy and enhanced monitoring can reliably achieve potable reuse treatment objectives without the need for an environmental buffer (WRRF, 2017 in publication). WRRF 14-12 Study quantified the reliability of the treatment train to protect public health through the evaluation of a year-long testing program that included on-line monitoring of each of the critical barriers in the treatment train. The results of that effort demonstrated that treatment and monitoring can ensure reliability while reducing the need for dilution and decreasing the time required to detect and respond to failures, while providing greater control over pathogens, chemicals, and aesthetic concerns.

Limnology studies were prepared for San Vicente Reservoir that assessed the ability of the reservoir to accept various rates of purified water at different inlet locations under diverse operating scenarios (WQS, 2015). A three-dimensional hydrodynamic and water quality model was used to evaluate the dilution, mixing, and transport of the purified water in the reservoir. The results of the model included determining the transport and mixing of purified water in the reservoir, evaluating various potential inlet locations, and assessing nutrient concentrations and algal growth. Similar limnology studies and hydrodynamic modeling evaluations were prepared for Otay Reservoir (WQS, 2018b in progress). While following through on the work at San Vicente and Otay Reservoirs, the focus of the limnology studies shifted in 2015 to Miramar Reservoir.

Beginning in March 2015, the concept of expanding the NCPWF (formerly known as the North City Advanced Water Purification Facility) to produce 30 mgd of purified water and discharging to either San Vicente Reservoir or Miramar Reservoir was evaluated with the goal to accelerate the initial phase of the Program, while realizing some cost efficiencies. While both North City reservoir options would be equally protective of public health, results of a thorough alternative analysis revealed that Miramar Reservoir option would offer a number of benefits, including reduced impacts to the community and environment, greater schedule certainty, increased long-term operational flexibility, ability to have all new facilities within City limits, and realization of cost savings.

The Miramar Potable Reuse Project Concept Proposal Report (City, 2015a) was submitted to DDW for review in November 2015. Since then, the City has met regularly with DDW and the RWQCB and proceeded with preliminary and final design of the following facilities:

- Morena Pump Station and Pipeline;
- NCWRP Expansion;
- NCPWF;
- NCPW Pump Station and Pipeline; and
- Miramar DWTP Improvements.

The Pure Water Program is a multi-year effort to use water purification technology to produce a clean and safe water supply for the region. The investment in new water sources can reduce the dependence on imported water and increase water supply reliability, and improve resilience during times of water shortage. Culminating years of planning, studies, and development, the North City Project is the initial phase of the Pure Water Program.

2.5 Public Outreach

Public outreach has long been a part of the City's various water recycling efforts and Pure Water Program. Ongoing informational meetings and tours are used to continue educating San Diego residents about the Project. Section 3 describes the background and current activities of the City's outreach program that have helped forge a bond with stakeholders and increase support for the Project.

2.6 Independent Advisory Panel

Development of the Project has been guided by an IAP. The City contracted with the National Water Research Institute to form the IAP and coordinate its meetings and activities. The IAP consists of a group of independent experts convened to provide specialized peer review of the technical, scientific, and regulatory aspects of the Project. IAP meetings have been held periodically since 2004 in response to the Project's development:

- Water Reuse Study (2004-2006);
- Water Purification Demonstration Project (2009-2013); and
- Pure Water Program (2014-2017).

The IAP currently comprises ten members from academia, scientific, and engineering fields with expertise in water reuse-related areas, microbiology, limnology, toxicology, treatment and process engineering, facilities operations, regulatory criteria, public health, and environmental health. Two IAP Subcommittees were formed to address limnology and the NCDPWF. To support the Limnology Subcommittee, a Limnology Working Group was formed, which consisted of two IAP members and project staff assigned to vet the details of the reservoir studies. Members of the full IAP and subcommittees are listed in Appendix A along with their areas of expertise and periods of participation. IAP membership has been modified from time to time as the Project evolved and depending upon the availability of individual experts.

A summary of the meetings of the full IAP, Limnology Subcommittee, and NCDPWF Subcommittee held to date is presented in Appendix B. Reports on findings and recommendations of the various IAP meetings are available upon request from the National Water Research Institute or the City.

2.7 Environmental Compliance

The Program Environmental Impact Report for the Pure Water Program (State Clearinghouse No. 2014111068) was completed and certified by the San Diego City Council in October 2016 (City, 2016a) for compliance with the California Environmental Quality Act. This report outlined potential environmental impacts associated with the implementation of all Pure Water Program projects to create 83 mgd of purified water. A project-level joint California Environmental Quality Act and National Environmental Policy Act document is currently being prepared for the Program's first phase which will produce 30 mgd of purified water. The Notice of Preparation to prepare an Environmental Impact Report for the Project was released on August 4, 2016. The Notice of Intent to prepare an Environmental Impact Statement was published in the Federal Register by the Bureau of Reclamation on August 5, 2016. A public draft of the Project's Environmental Impact Report and Environmental Impact Statement was released in the summer of 2017.

2.8 Project Goals

The Pure Water Program is designed to address the following two considerable water challenges faced by the City:

Lack of Local Control Over the City's Water Supply. 85 percent of the City's water is imported from the Colorado River or California State Water Project. These imported water supply sources serve the City, as well as many other regional entities, that are upstream of the San Diego. This lack of local control makes San Diego's water supply more vulnerable to water shortages, climate change, uncertain supply allocations, and natural disasters. The cost of imported water is also rising, having more than doubled in the last ten years.

Unique Regulatory Arrangement for the PLWTP. The continued operation of the City's main wastewater treatment plant using advanced and CEPT depends upon the renewal of a Clean Water Act Section 301 (h) (40 CFR 125.57, 1972 and amendments) modified permit every five years.

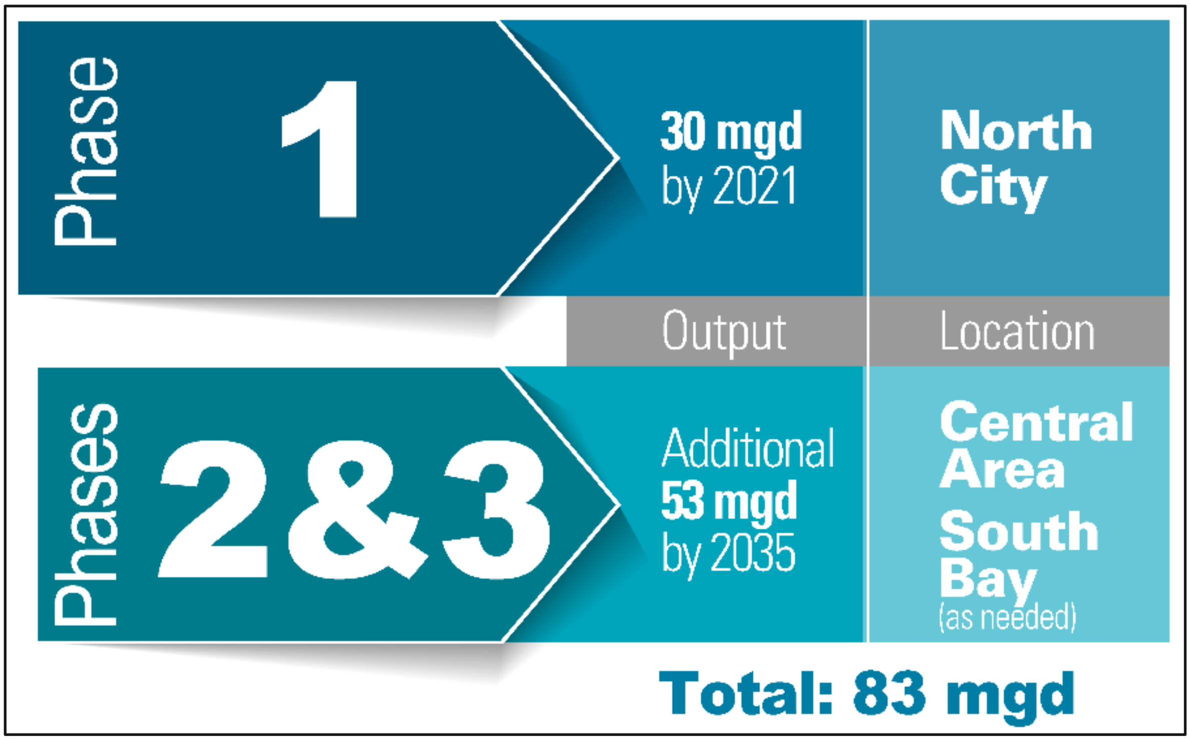


Figure 2-3: Pure Water Program Phases

The Pure Water Program, as illustrated on Figure 2-3 and in Table 2-1, is a phased, multi-year program that provides an integrated solution to the City's water supply and wastewater management challenges. The Program will ultimately produce one-third of San Diego's water supply, while significantly reducing both flows to the PLWTP and further bolstering the concept of secondary equivalency. The Program offers a cost-effective investment for San Diego's water needs by providing a reliable, sustainable, locally controlled water supply by using proven technology to produce safe, high-quality drinking water.

Table 2-1: North City Project Goals and Objectives

Goals	Objectives
Water Supply	Diversify San Diego's water supply portfolio
	Provide a reliable, sustainable water supply that addresses San Diego's vulnerability vis-a-vis water shortage, climate change, reduced supply allocations, or natural disasters
	Increase San Diego's water independence
	Supports the City Council Comprehensive Policy for a Sustainable Water Supply in San Diego (City, 2011a)
	Conform to the "Reasonable and Beneficial Use Doctrine" set forth in the California State Constitution (California Constitution, Article 10, Section 2, 1976) and California Statutes (California Statutes, Water Code Section 100, 1943 and amendments) by acknowledging the value of recycled water and reasonable use of the State's limited water supplies
Wastewater Management	Reduce the amount of treated wastewater discharged to the ocean by approximately half
	Eliminate the need for upgrades to the PLWTP
	Support the secondary equivalency concept approach at the PLWTP to protect the ocean environment
	Support the terms of the PLWTP permit
	Conform to the Pure Water Program commitments to stakeholders, which call for offloading wastewater flows to the PLWTP and increasing water recycling and potable reuse

3. Public Outreach

The Pure Water Program continues to implement a comprehensive program outreach plan. Effective program-level outreach helps inform San Diegans about the Program and how it addresses San Diego's water and wastewater challenges, and project-specific outreach provides community stakeholders within Project areas valuable information.

3.1 Background

Since 2010, a variety of outreach activities have been employed to educate the public about the safety and reliability of the water purification process and how the Program will address both San Diego's water and wastewater challenges. The outreach activities have included the development of educational materials, speakers' bureau presentations to various community groups and organizations, a public tour program of the City's NCDPWF, engagement via social media platforms, in-person stakeholder interviews, participation in water industry conferences, and youth outreach activities.

Public support for adding purified water to the drinking water supply has increased from a low of 26 percent in 2004, to 73 percent in 2015, which represents an increase of nearly 50 percent (Rea & Parker, 2015).

3.2 Outreach Activities

3.2.1 Comprehensive Education and Outreach Plan

An outreach plan completed in 2014 identified the variety of outreach strategies, activities, and informational materials necessary to ensure audiences knew about and were engaged in the Program. The key messages included:

- The Program provides a safe, reliable, and cost-effective drinking water supply;
- The Program provides a locally-controlled, drought-proof water supply; and
- The Program uses proven technology and is environmentally friendly.

It was concluded that the most effective and efficient way to achieve the goal of informing San Diego residents about the water purification process was through focusing communication efforts on community leaders and stakeholder groups or organizations. Audiences for the outreach program were numerous and included local business, environmental, civic, and community leaders from all areas in the City, including its multicultural communities; members of community planning groups and neighborhood councils; elected officials at all levels of government; media representatives; special interest groups such as seniors, the public health community, students, and religious leaders; and PUD staff.

3.2.2 Educational Outreach Materials and Tools

Informational materials and tools were developed to explain and disseminate information about the Program and the science behind water purification. These materials were tailored to the interests of multiple audiences and were made available in a variety of formats including both print and electronic versions. The materials were created to appeal to multicultural and age-specific audiences and were translated into other languages (Spanish and Vietnamese). To ensure that all aspects of the Program were easily understandable, informational materials were distributed or available at all outreach activities (presentations, tours, and community events). These materials were also posted to the Program website.

Materials including facts and frequently asked questions sheets, brochures, Pure News e-newsletters, e-updates, presentations, and videos have provided objective information about the Program in easy-to-read and understandable language. Most recently, a new fact sheet and web page were developed that provides an overview of the North City Pure Water Project that will be designed, constructed, and operational by 2021. Additionally, a short informational video that provides an overview of the Program and how it will be implemented was created and is now hosted on the Program website and YouTube page. Support cards have also been used at all outreach activities and are designed to allow interested parties, community leaders, tour guests, and presentation participants to provide their contact information and level of interest in the Program. Pure News e-newsletters and e-updates are sent to more than 6,000 stakeholders throughout the year.

3.2.3 Community Events

One effective way to engage and inform members of the public about the Program is through participation at free community events throughout the City. These events vary from science expositions to festivals and community fairs. At an informational booth, educational materials are distributed, program details are discussed, and contact information from booth visitors is collected to continually build a database of interested parties for future outreach. Since 2010, the Program has hosted informational booths at more than 180 events and reached more than 24,000 community members.

3.2.4 Facility Tours

Free public tours of the City's 1 mgd NCDPWF have been in place since June 2011. This facility is where the public can visit to see and learn about the multi-barrier water purification process utilized to convert recycled wastewater into purified water. The NCDPWF was designed so that tour participants can view the water purification equipment first hand and follow the path through the processes, from the treatment first step to the end result - the purified water. Tour attendees have included elected officials, school classes, Girl Scout troops, civic and community groups, professional organizations, multicultural groups, and interested individuals. More than 14,000 people have toured the facility to date. NCDPWF tours were most recently provided for International Water Association Conference attendees in July 2017. This was the first time the conference was held in the U.S.

3.2.5 Youth Outreach

Reaching out to youth has been incorporated in many aspects of the outreach program. Elementary and high school classes, Boy Scout dens, Girl Scout troops, and home-schooled children regularly tour the NCDPWF. Many higher education groups also tour the facility, including water treatment, engineering, law school, and medical school classes. In addition to the tours, the speaker's bureau made presentations about the Program to elementary and high school classes. Tours, events, and presentations catered to youth have engaged thousands.

In November 2017, the City partnered with Carollo Engineers and the Fleet Science Center Better Education for Women in Sciences and Engineering (BE WiSE) Program to hold a workshop for aspiring female scientists and engineers. More than 30 middle and high school students attended the workshop and toured the NCDPWF. Female engineers from the City and Carollo Engineers discussed their careers in water and answered questions from workshop attendees. In fall 2017, more than 300 students participating in the FIRST LEGO League robotics competition toured the NCDPWF as part of their research to develop a project that helps solve a water supply challenge.

In spring of 2016, the City worked with the San Diego Unified School District to host "Media Days" for local high school students enrolled in the schools' broadcasting and journalism programs. Approximately 100 high schoolers toured the NCDPWF over two days and were given the task of preparing a news package or newspaper article with a unique and interesting angle that reports on the Program's components and benefits for San Diego. As part of Media Days, the students also attended educational workshops where they learned about careers in journalism and water, as well as storytelling and photography tips.

The City has also partnered with the San Diego Coastkeeper and Think Blue to develop an interactive lesson about the Program to include in San Diego Unified School District's existing 5th grade science class curriculum, "Stewardship: Water Education for Lifelong Leadership (SWELL)." This lesson has been used to teach hundreds of elementary school students about potable reuse as illustrated on Figure 3-1. Additionally, a patch program was launched for Girl Scout troops who participate in an interactive presentation about the Program and then tour the NCDPWF to see the water purification technology. In 2015, a partnership was established with the Energy Coalition to assist with developing a lesson plan about the energy and water nexus for 5th grade students throughout California. This included the development of videos of City staff talking about their "green" careers and participation in local events.

Figure 3-1: Students Participating in the SWELL Project

3.2.6 University of San Diego Partnership

To ensure the continued success of the Program's outreach efforts, the City invited the University of San Diego communication studies department classes in fall of 2014 and 2015, and spring of 2016, to participate in a hands-on effort to help enhance the City's public outreach and education strategy. The students worked in teams to develop communication tools such as videos, infographics, social media hashtags, and additional communication recommendations targeting young adults, mothers, and multicultural communities.

The City developed a short survey for the students to use to determine the public's knowledge about local water sources, recycled water, and to find out what information influences public perception. Based on the results of the surveys, each team of students created communication tools to engage their target audience about the Program.

At the end of the semester, each team presented their communication tools to a panel of judges that included community leaders. Each group provided recommendations for how to best educate the public about the City's Program.

The City received more than 400 surveys, ten variations of public-service announcement videos, infographics, and social media hashtags to consider incorporating into the Program outreach efforts. The City's partnership with the University of San Diego classes received University of San Diego's 2015 Innovation in Community Engagement Award.

Figure 3-2: University of San Diego Students Touring the NCDPWF

3.2.7 Pure Water Day Open House

On October 21, 2017, more than 500 members of the public attended the second annual open house event at the NCDPWF. The event included NCDPWF tours, tastings of the purified water, an interactive Kid Zone and passport handout, tours of the North City Waterwise Garden, and a succulent planting station. Informational booths provided attendees with the opportunity to learn about the next steps for the Program, including the design and construction of the Project's treatment and conveyance facilities that will ultimately provide one-third of San Diego's water by 2035.

The NCDPWF hosted a record 21 tours over five hours. Guests walked through the facility where they met tour guides at each treatment barrier and saw the technology up close. At the end of the tour, participants had the opportunity to taste the purified water and share their thoughts on camera at the video testimonial station.

Kid Zone activities included educational games, face painting, an obstacle course, and more. After tasting the purified water, guests were able to plant and take a succulent home in their biodegradable Pure Water tasting cup. A passport handout encouraged attendees to participate in all of the event's activities. Participants showed their completed passports at the passport booth to earn a souvenir and take a Polaroid photo.

3.2.8 Social Media and Online Engagement

Social media sites provide effective opportunities to reach new audiences and maintain contact with existing interested parties. An active social media presence is maintained on Facebook, Twitter, Instagram, and YouTube. The pages are updated and monitored on a daily basis, which includes responding to public comments to keep followers engaged. Some of the tactics used to keep followers engaged on social media have included a selfie contest during water awareness month, #ThirstyThursdays, which encouraged questions about water, and a #WaterSchool that asked trivia questions about San Diego's water.

More than 85,000 people have visited purewatersd.org to view fact sheets, frequently asked questions, newsletters, e-blasts, program-related media clips, social media links, videos, event schedules, and other Program information, as well as sign up for tours and presentations.

3.2.9 Media

Reaching out to all San Diegans through all forms of media helps raise awareness about the Program. The City maintains positive working relationships with members of the media and works diligently to keep them accurately informed about the water purification process and status of the Program. Since 2010, more than 800 media articles, television broadcasts, blogs, and newsletters featured San Diego's water purification efforts in national, local, and online media.

3.2.10 Speakers Bureau

An active speaker's bureau program is a vital component of public outreach. Reaching out to civic, business, and community groups and their leaders through speaking engagements has several benefits. It provides a way to reach community leaders and their constituent audiences at the same time. Providing speaking engagements at existing meeting locations adds to audience receptivity. Knowledgeable speakers provide face-to-face opportunities for audience members to ask questions and learn more about the Program in a familiar setting. Speaking engagements have provided an opportunity to measure audience understanding and receptivity, learn more about their concerns, and obtain important feedback that can aid in more effective future outreach efforts.

Project-specific outreach efforts continue for the proposed Morena Pump Station and Pipelines and NCPW Pump Station and Pipeline. These efforts included 26 presentations to more than 500 community members in 2017 at community planning groups, town councils, and civic associations within the Project areas.

To date, more than 530 presentations have been provided about the Program to more than 17,000 people.

3.3 Stakeholder/Partner Communications

Sharing educational information about the Program has helped form relationships with stakeholders and to develop an enhanced network of contacts. Once identified, stakeholders are contacted to participate in one-on-one stakeholder interviews, schedule group presentations, place Program information in their relevant publications, and tour the NCDPWF. All of the stakeholders were added to the interested parties' database so they can continue to receive regular email updates about the Program.

Local residents, community groups, environmental organizations, and local businesses support the Program. To date, more than 3,600 San Diegans have pledged their support for the Program and 32 formal support letters have been written by community stakeholders including community groups, environmental organizations, and local businesses.

The City also has developed a list of nearly 7,800 interested parties, stakeholders, and supporters who are kept informed on the progress of the Program through quarterly e-newsletters and e-updates.

3.3.1 Pure Water Working Group

The City formed the Pure Water Working Group to provide diverse viewpoints and input on the City's efforts to provide a safe, reliable, and sustainable drinking water supply for San Diego. An invitation to join the Working Group was sent to a diverse group of stakeholders, including representatives from community planning groups, businesses, city council district offices, non-profit environmental organizations, and community leaders.

The Working Group member organizations include:

- Asian Business Association of San Diego
- Asian Pacific American Coalition
- BIOCOM
- The Building Industry Association of San Diego
- San Diego Building Owners and Managers Association
- City 10
- City of San Diego Community Planners Committee
- City of San Diego, Council District 1
- City of San Diego, Council District 3
- City of San Diego, Council District 4
- City of San Diego, Council District 6
- City of San Diego, Council District 7
- City of San Diego, Council District 8
- City of San Diego, Council District 9
- Coastal Environmental Rights Foundation
- CONNECT San Diego
- Food and Beverage Association of San Diego
- Greater San Diego Association of Realtors
- Greater San Diego Regional Chamber of Commerce
- Hospital Association of San Diego and Imperial Counties
- Industrial Environmental Association
- League of Women Voters
- JPA
- Navy / Navy Region Southwest
- Qualcomm
- San Diego Audubon Society
- San Diego Coastkeeper
- San Diego County Apartment Association
- San Diego County Taxpayers Association
- San Diego County Medical Society
- San Diego Gas and Electric
- San Diego Regional Chamber of Commerce
- San Diego Regional Economic Development Corporation
- San Diego State University
- San Diego Unified Council of Parent-Teacher Associations
- Sharp HealthCare
- Surfrider Foundation San Diego Chapter
- University Community Planning Group
- Urban League of San Diego County
- Water Reliability Coalition

The Working Group serves as a forum for gaining input and feedback from stakeholders who represent the PUD's customers and broad community interests. The Working Group met eight times during 2014, the year the group was formed, and continues to meet on a periodic basis. A report detailing their key recommendations and observations was developed and is available on the City website at www.purewatersd.org/stakeholders. The input gained from the working group has helped enable the City to advance a well-thought-out, comprehensive potable reuse implementation plan.

3.3.2 Stakeholder Interviews

The City coordinates one-on-one and in small group stakeholder interviews to provide information about the Program and gather opinions about it, as well as performs follow-ups as needed to answer questions. Following the interviews, the relationships with the community leaders and their organizations are reinforced in several ways, including provisions of information requested during the interview, sharing of template articles for inclusion in their organizational outreach materials, encouragement to host a speaker's bureau presentation, and invitation to tour the NCDPWF. To date, 329 stakeholder interviews have been conducted.

Stakeholders include federal elected officials, Native American tribes, utility agencies, faith-based groups, multicultural organizations, community councils, civic and business associations, and a number of organizations in the fields of agriculture, environmental organizations, real estate, construction, health care, military, education, and hospitality.

3.3.3 Multicultural Outreach

Participation in multicultural community events such as the Chinese New Year Food and Cultural Fair, San Diego Black Nurses Association Health Expo, and Fiesta del Sol have helped ensure that residents of various cultural and ethnic backgrounds are informed about the Program. Additionally, in-person presentations are provided to multicultural businesses and community groups, and one-on-one stakeholder interviews are conducted with the leaders of such groups. Outreach materials are available in multiple languages. To date, more than 164 stakeholder interviews have been conducted with the leaders of multicultural groups in San Diego and 35 in-person presentations have been made to multicultural audiences.

3.3.4 Pure Stone Partnership

In March 2017, the Pure Water Program partnered with Stone Brewing Company to brew *Stone Full Circle Pale Ale* using purified water from the NCDPWF. The event marked the first time a commercial brewery had brewed beer with 100% advanced treated recycled water. Mayor Kevin Faulconer and Pat Tiernan, COO of Stone Brewing, kicked off the Pure Stone event by pouring the first pints of sustainably-brewed beer. More than 200 City leaders and elected officials gathered at Stone Brewing World Bistro & Gardens in Liberty Station to hoist a glass and taste the beer for themselves.

The partnership's shared commitment to sustainability and ingenuity helped the City cement its reputation as a leader in potable reuse nationwide. To recognize the significance of the partnership, Mayor Kevin Faulconer presented a proclamation that declared March 16 "Pure Stone Day." The partnership received the 2017 Public-Private Partnership Award from the Water Reliability Coalition for increasing awareness of the safety and reliability of potable reuse. The event was covered by more than 80 local, national, and international media outlets.

3.3.5 Ongoing and Planned Activities

The City continues to implement the outreach activities detailed in this report and has either completed or is planning to move forward with the following new initiatives:

- Provide presentations to all community planning groups, civic associations, and town councils within the Project areas;
- Maintain an interactive Project map on the website that provides information on the purpose, location, and current status of each Project facility, along with any potential community impacts during construction;
- Arrange tours of the NCDPWF with new City Councilmembers and elected officials;
- Initiate a Pure Water Champions Program that will identify community advocates who will be profiled on the Program website, social media platforms and newsletter, and help increase awareness of the Program via sharing of social media and newsletter content, encouraging others to tour the NCDPWF;
- Host tours for local media outlet representatives at the NCDPWF;
- Engage and inform members of the local medical community about the Program;

- Expand Facebook advertising to promote social media engagement and awareness of the Program;
- Build on relationships with local media representatives, bloggers, and specialty reporters to increase community awareness;
- Engage and inform San Diego Unified School District to create new partnerships and garner support from education; and
- Identify and invite key stakeholder organizations to tour the NCDPWF and host a board meeting at NCDPWF.

In closing, the City's outreach effort will be ongoing and engaging throughout the course of the Program, moving toward more focused efforts as the design of individual Project facilities are further developed.

4. Regulatory Requirements

The California Water Code supports and encourages recycled water use:

- Section 13510: *"It is hereby declared that the people of the state have a primary interest in the development of facilities to recycle water containing waste to supplement existing surface and underground water supplies and to assist in meeting the future water requirements of the state."*
- Section 13560: *"The Legislature finds and declares … the use of recycled water for indirect potable reuse is critical to achieving the state board's [SWRCB] goals for increased use of recycled water in the state...."*

Additionally, in 2009, the SWRCB adopted Resolution 2009-0011, "Policy for Water Quality Control for Recycled Water" ("Recycled Water Policy") (SWRCB, 2009). The Resolution sets a mandate for increasing the use of recycled water by 200,000 AFY by 2020 and an additional 300,000 AFY by 2030, with a goal of replacing the use of potable water with recycled water for appropriate NPR water uses (e.g., landscape irrigation), thereby allowing potable water supplies to be conserved for potable uses.

The North City Project is an indirect potable reuse project that aims to produce purified water for augmentation of Miramar Reservoir, which stores source water for the Miramar DWTP. As a potable reuse and SWA project, the Project will be regulated by various state laws.

4.1 Water Recycling and Potable Reuse in California

Water recycling and potable reuse in California fall under the jurisdiction of the SWRCB. Within the SWRCB, two organizations are responsible for protecting public health and the environment with respect to water: (1) DDW, and (2) the RWQCB. DDW regulates public drinking water systems and is responsible for developing regulations for recycled water. The RWQCB develops and enforces water quality objectives and implementation plans to protect the beneficial uses of the state's waters. There are nine Regional Boards that were created under the Porter-Cologne Water Quality Control Act in 1970. Locally, the San Diego RWQCB serves Region 9 (San Diego County and small portions of Orange, Imperial, and Riverside Counties) and is responsible for regulatory permitting and enforcement. With respect to water reclamation, DDW and the RWQCB work together under the terms of the 1996 Memorandum of Agreement (CDHS/SWRCB, 1996) to review, approve, permit, and monitor water recycling and potable reuse projects.

The Title 22 Water Recycling Criteria (CCR, 2014) regulate recycled water production and use, establishing water quality standards, and treatment reliability requirements. The permit requirements are based on Title 22 Criteria, project-specific conditions of approval received from DDW, as well as:

- Water quality standards established in the updated Water Quality Control Plan for the San Diego Basin ("Basin Plan") (RWQCB, 2014);
- Water quality standards for inland surface waters set forth in the CTR (40 CFR 131.38/EPA, 2000a); and
- Chlorine residual requirements (SWRCB, 2006).

4.1.1 Groundwater Replenishment

Groundwater replenishment with recycled water began in 1962, and six projects are currently in operation using surface (spreading) and subsurface (injection) applications. Numerous other indirect potable reuse groundwater recharge projects are being planned or nearing implementation. Prior to 2014, groundwater recharge using recycled water was regulated on a case-by-case basis. Final regulations for groundwater replenishment using recycled water were adopted on June 18, 2014 (CCR, 2014), establishing Title 22 Criteria for obtaining approval and permitting planned Groundwater Replenishment Reuse Projects.

4.1.2 Surface Water Augmentation

SWA is defined in California Water Code, Chapter 7 entitled "Water Reclamation" as:

- Section 13561(d): *" 'Surface water augmentation' means the planned placement of recycled water into a surface water reservoir used as a source of domestic drinking water supply."*

SWA using recycled water as indirect potable reuse has not yet been implemented in California. Uniform water recycling criteria for SWA are in development by DDW in accordance with California Water Code Section 13562.

Although planned SWA is new, NPR applications and indirect potable reuse via groundwater replenishment have long histories in California. Common direct, NPR applications for recycled water applications include:

- Landscape irrigation;
- Agricultural irrigation;
- Industrial uses;
- Urban NPR uses; and
- Recreational and environmental uses.

Applicable regulatory requirements to protect public health are described in Section 4.2, and regulatory requirements to protect receiving waters and the environment are described in Section 4.3.

Between the issuance of Draft SWA Regulations for public review in July 2017 and the adoption of proposed SWA regulations by the SWRCB in March 2018, which are described below, the California Legislature approved and the Governor signed Assembly Bill No. 574 on October 6, 2017. Assembly Bill 574 is an act amending Sections 13560 and 13561 of the California Water Code (CWC, 2017) by establishing new terminology for potable reuse:

- Direct potable reuse; and
  - Raw water augmentation
  - Treated drinking water augmentation
- Indirect potable reuse
  - Groundwater recharge
  - Reservoir water augmentation

With the approval of Assembly Bill 574, the term "surface water augmentation" was changed to "reservoir water augmentation" and redefined to mean "the planned placement of recycled water into a raw surface water reservoir used as a source of domestic drinking water supply for public water system or into a constructed system conveying water to such a reservoir."

In this Engineering Report for the Project, the term SWA shall be interchangeable with and have the same meaning as "reservoir water augmentation."

4.2 Regulatory Requirements to Protect Public Health

On March 6, 2018, the SWRCB adopted Resolution No. 2018-0014 approving proposed SWA Regulations (SWRCB, 2018).

By way of background, DDW developed the Draft SWA Regulations to comply with California Water Code Section 13562 that required the SWRCB to adopt uniform water recycling criteria for surface water augmentation by the end of 2016, if an Expert Panel reviewed the concept and made the finding that the proposed regulations would adequately protect public health. The proposed regulations were assessed by an external scientific peer review (independent from the Expert Panel) and an Expert Panel. The scientific peer review evaluating scientific portions of the regulations was completed on June 10, 2016. The Expert Panel adopted the finding that the proposed SWA criteria would adequately protect public health on October 31, 2016. Following a period of review by the Office of Administrative Law, DDW issued Draft SWA Regulations (SWRCB DDW, 2017) for public comment on July 21, 2017. The SWRCB held a public hearing on the draft regulations on September 7, 2017, and the deadline for submitting comments was on September 12, 2017. The SWRCB received 21 comment letters from a variety of entities. DDW staff responded to the comments and prepared the proposed SWA regulations dated October 31, 2017, for consideration by the SWRCB. The proposed SWA regulations were adopted by the SWRCB with the passage of Resolution No. 2018-0014 on March 6, 2018 (SWRCB, 2018). The adopted SWA regulations have been submitted to the Office of Administrative Law for review, approval, and filing with the Secretary of State. .

The SWA regulations set forth criteria for two parts of Title 22, Division 4, of the California Code of Regulations:

- Chapter 3 "Water Recycling Criteria"; and
  - Article 1 "Definitions"
  - Article 5.3 "Indirect Potable Reuse: Surface Water Augmentation"
- Chapter 17 "Surface Water Treatment"
  - Article 9 "Indirect Potable Reuse: Surface Water Augmentation"

The SWA regulations contain provisions that apply to the Project. Several of the water recycling provisions are somewhat general in nature. They include a plan for corrective actions and notification procedures; documenting technical, managerial, and financial capability; treatment process demonstration; compliance monitoring; wastewater treatment performance; recognition of directives to suspend and subsequent authorization to resume augmentation of the reservoir; and acknowledgement of written reporting requirements. Other water recycling provisions are more technically focused: advanced treatment criteria, wastewater source control, pathogenic microorganism control, water quality requirements and monitoring, and reservoir monitoring. Surface water treatment provisions set forth requirements for amending the drinking water supply permit, conducting public hearings, and operation of the augmented reservoir. Collectively, these provisions comprise the SWA regulations and are described below. (If any differences between the interpretation presented herein and the adopted SWA regulations are apparent, the Final Regulations, shall prevail.)

The following provides a summary of the SWA regulations that were approved by the SWRCB in Resolution No. 2018-0014 (SWRCB, 2018). Detailed requirements can be found in the Chapters and Articles of the Title 22, Division 4, referenced above.

4.2.1 General Requirements (Section 60320.301)

4.2.1.1 Joint Plan

Prior to augmentation of a reservoir with recycled water, the project sponsor (for the Project, the City of San Diego) must submit a Joint Plan for implementation of the project to DDW and the RWQCB. In general terms, the project sponsor(s) in the Joint Plan include the water recycling agency and the drinking water supply agency; these may be separate entities, or as in the Project's case, the City is both the water recycling agency and drinking water supply agency. The Joint Plan establishes who is responsible for the project and describes corrective actions in the event that recycled water has been delivered to a reservoir that fails to meet designated water quality requirements and notification procedures for operational changes that may affect the recycled water quality.

4.2.1.2 Technical, Managerial, and Financial Capability

The project sponsor must submit to DDW and the RWQCB information demonstrating that it possesses adequate technical, managerial, and financial ability to implement and operate the project in compliance with the SWA requirements.

4.2.1.3 Demonstration Prior to Operation

Prior to augmentation of a reservoir with recycled water, the project sponsor must demonstrate to DDW and the RWQCB that the treatment processes are installed and can be operated in a manner to achieve their intended purpose. A protocol for this demonstration shall be included in this Engineering Report.

4.2.1.4 Compliance Monitoring

If the project sponsor fails to monitor the project to demonstrate compliance with the SWA requirements, this provision allows DDW or the RWQCB to determine if the project is in compliance based on available data.

4.2.1.5 Wastewater Agency

All recycled municipal wastewater used for a SWA project must be from a wastewater management agency that is in compliance with effluent limits or water quality requirements set forth in its RWQCB permit.

4.2.1.6 Suspension of Operation

If a project fails to meet the SWA requirements or is directed by DDW or the RWQCB to suspend augmenting a reservoir with recycled water, the water recycling agency shall not resume augmenting the reservoir until it receives written authorization to do so from DDW or the RWQCB.

4.2.1.7 Reporting

The project sponsor (water recycling agency or drinking water agency) shall submit written reports to DDW and the RWQCB.

4.2.2 Advanced Treatment Criteria (Section 60320.302)

The entire volume of recycled water must continuously receive full advanced treatment prior to delivery to the augmented reservoir. Full advanced treatment is defined as treatment of oxidized wastewater using RO and AOP that meet the SWA criteria.

For RO, there are specific requirements related to membrane rejection, recovery, applied pressure, and permeate sodium chloride and TOC.

To monitor process performance and when the integrity of the RO membranes is compromised, the project sponsor must propose at least one form of continuous monitoring (e.g., conductivity, TOC, or other parameter), as well as the associated surrogate or operational parameter limits and alarm settings indicating that integrity has been compromised. A report shall be submitted to DDW and the RWQCB during the initial operation documenting performance of the RO process.

For AOP, challenge or spiking tests shall be conducted to demonstrate that the AOP process has been designed and can be operated to achieve greater than or equal to 0.5-log (69 percent) reduction of 1,4-dioxane. A plan shall be submitted to DDW for review and approval specifying at least one surrogate or operational parameter that can be continuously monitored to indicate whether the AOP is achieving the minimum 0.5-log reduction of 1,4-dioxane. The SWA criteria also specify that a report be submitted to DDW and the RWQCB documenting the performance of the full-scale AOP process and an assessment of the efficacy of the surrogate or operational parameters to indicate sufficient reduction in 1,4-dioxane is achieved.

Monitoring of the full advanced treated recycled water is required for constituents having MCLs and Notification Levels. For the first 12 months of operation, monitoring shall be conducted monthly and, if no results exceed an MCL or Notification Level, then quarterly monitoring may be approved. If the full advanced treated recycled water exceeds a drinking water MCL or Notification Level, follow-up actions shall be taken per requirements established in Sections 60320.312 and 60320.320.

4.2.3 Lab Analyses (Section 60320.304)

Analyses for contaminants with primary or secondary MCLs must be performed using drinking water methods by a laboratory certified by the SWRCB. Analyses for other chemicals shall use methods described in the project's Operation Plan.

4.2.4 Wastewater Source Control (Section 60320.306)

Recycled municipal wastewater used for a SWA project must be from a wastewater management agency that administers a comprehensive source control program that includes: (1) an assessment of the fate of contaminants specified by DDW and the RWQCB through the wastewater and recycled water systems; (2) monitoring and investigations of sources of DDW and RWQCB-specified contaminants; (3) an outreach program to industrial, commercial, and residential communities for the purpose of managing and minimizing the discharge of chemicals at the source; and (4) a current inventory of chemicals and contaminants that may be discharged into the sewer system.

4.2.5 Pathogenic Microorganism Control (Section 60320.308)

The treatment system must be designed and operated to achieve designated minimum reduction levels of three types of pathogens: (1) enteric viruses, (2) *Giardia* cysts, and (3) *Cryptosporidium* oocysts. As presented in Table 4-1, required minimum pathogen LRVs are dependent upon the dilution and mean theoretical hydraulic retention time provided by the augmented reservoir. The required total minimum LRVs is the sum of the LRVs achieved by each treatment process, beginning with raw wastewater through full advanced treatment. If the reservoir provides less than 100:1 dilution, then an extra LRV of enteric V/G/C is required of the treatment train. If the reservoir provides a retention time less than 180 days, then an extra LRV of enteric V/G/C is required of the treatment train.

The treatment train must be operated to continuously achieve a total LRV for V/G/C equal to or greater than the minimum requirements. Compliance is determined by on-going monitoring using the pathogenic microorganism of concern or a microbial, chemical, or physical surrogate parameter that has been verified to indicate the treatment process performance to achieve its credited LRV. If the total LRVs drop below minimum required values by 2-log or more for each pathogen indicating that a failure has occurred, the project must cease augmenting the reservoir with recycled water. Failure is defined as the treatment system's inability to meet the pathogen reduction criteria for longer than four consecutive hours or more than a total of eight hours during any seven-day period. Failures must be reported to DDW and the RWQCB.

Table 4-1. Pathogen Reduction Requirements

Minimum Dilution in Reservoir[a]	Minimum Retention Time in Reservoir (Θ) (days)[b]	Minimum LRV V/G/C	Failure/Shutdown LRV V/G/C
100:1	>180	8-7-8	< 6-5-6
10:1	>180	9-8-9	<7-6-7
100:1 or 10:1	60 < Θ < 180	DDW may increase LRV requirements	Subtract 2-log from minimum LRV requirement
100:1	60 < Θ < 120	Add 1-log = 9-8-9	Subtract 2-log from minimum LRV requirement = 7-6-7
10:1	60 < Θ < 120	Add 1-log = 10-9-10	Subtract 2-log from minimum LRV requirement = 8-7-8

[a] Dilution is based on the volume of water withdrawn from the reservoir as specified in Section 64668.30(c) and described below.
[b] Θ is the mean theoretical hydraulic retention time determined as specified in Section 64668.30(b) and described below.

Dilution. The volume of recycled water that was delivered to the reservoir during any 24-hour period relative to the volume of water withdrawn from the augmented reservoir. Tracer studies and hydrodynamic modeling are required to demonstrate that the reservoir provides the required dilution at all times under all operating conditions.

Retention. The number of days calculated by dividing the volume of water in the reservoir at the end of each month by the total outflow of water withdrawn from the reservoir during that corresponding month.

The SWA regulations allow for a project sponsor to apply for an alternative minimum mean theoretical hydraulic retention time that is equal to or greater than 60 days and less than 180 days. Sometimes referred to as "the gap," DDW may, upon its review of the project, require that the treatment train provide additional LRVs. If approved by DDW, an alternative minimum mean theoretical hydraulic retention time range between 60 and 120 days requires at least 1-log additional reduction of each pathogen beyond the requirements established by the dilution criteria.

4.2.6 Advanced Treatment Criteria for the North City Pure Water Project

For projects providing a minimum of 10:1 dilution, but not less than 100:1 dilution, and between 60 and 120 days retention in the augmented reservoir, the treatment train must provide at least 1-log additional LRV for each pathogen for the dilution and retention time criteria (2 logs total). The treatment train shall provide a total of at least 10-log reduction of enteric virus, 9-log reduction of *Giardia* cyst, and 10-log reduction of *Cryptosporidium* oocyst (10-9-10 LRV V/G/C). The treatment train must consist of at least three separate treatment processes for each pathogen. While the extra treatment process need not be unique, it shall be independent (Section 64668.30(c)(2)). A separate treatment process may be credited with no more than 6-log reduction per pathogen, and at least three of the processes must each be credited with no less than 1-log reduction for each pathogen (Section 60320.308(a)(2)). In this case, the project shall discontinue delivery of recycled water to the reservoir if the treatment train fails to achieve 8-log reduction of enteric virus, 7-log reduction of *Giardia* cyst, or 8-log reduction of *Cryptosporidium* oocyst (8-7-8 LRV V/G/C). These conditions apply to the Project.

4.2.7 Regulated Contaminants and Physical Characteristics Control (Section 60320.312)

Samples (grab or 24-hour composite) of recycled water must be collected and analyzed quarterly for compliance with drinking water standards:

- Inorganic chemicals with primary MCLs;
- Radionuclides;
- Organic chemicals with primary MCLs;
- Disinfection byproducts; and
- Lead and copper (action level).

Samples (grab or 24-hour composite) of recycled water must be collected and analyzed at least annually for constituents with sMCLs.

Section 60320.312 provides specific guidance on confirmation sampling for exceedances of pMCLs, sMCLs, Action Levels, and upper limits, monitoring at increased frequency following an exceedance, establishing a schedule for completion of corrective actions, and reporting requirements.

4.2.8 Additional Chemical and Contaminant Monitoring (Section 60320.320)

Samples of recycled water must be collected and analyzed quarterly for:

- Priority toxic pollutants specified by DDW based on its review of this Engineering Report (chemicals listed in 40 CFR Section 131.38 "Establishment of numeric criteria for priority toxic pollutants for the State of California"); and
- Chemicals specified by DDW based on its review of this Engineering Report, results of the augmented reservoir monitoring, and results of the source wastewater assessment.

Section 60320.320 provides specific guidance on confirmation sampling for exceedance of Notification Levels. Quarterly monitoring of the chemicals listed in Section 60320.320 may be reduced to annually upon receiving DDW's approval based on its review of the most recent two years' of results.

Recycled water shall be monitored annually for indicator compounds specified by DDW or the RWQCB based on review of the following: (1) this Engineering Report, (2) inventory of chemicals used by industries in the sewershed developed as part of the source wastewater control program, (3) an indicator compound's ability to characterize the performance of the treatment processes for removal of chemicals, and (4) the availability of a test method for a chemical.

Detection of a chemical or contaminant specified in Section 60320.320 in the recycled water shall be reported to DDW and the RWQCB by the end of the quarter following the detection. If so directed by DDW or the RWQCB, the project sponsor shall monitor the recycled water delivered to the augmented reservoir for the detected chemical or contaminant.

4.2.9 Operation Plan (Section 60320.322)

Prior to augmentation of the reservoir with recycled water, the project sponsor must submit an Operation Plan to DDW and the RWQCB for review and approval. At a minimum, the Operation Plan shall describe the operations, maintenance, analytical methods, monitoring necessary for the project to meet regulatory requirements, and reporting of monitoring results to DDW and the RWQCB. The Operation Plan must be representative of the current operations, maintenance, and monitoring of the project and updated as appropriate.

The Operation Plan shall identify an on-going training program that demonstrates that the personnel operating and overseeing the project have received training in the following three areas: (1) proper operation of the treatment processes, (2) the California Safe Drinking Water Act and its implementing regulations, and (3) potential adverse health effects associated with the consumption of drinking water that does not meet California drinking water standards.

Operation of the project shall be conducted in a manner such that the recycled water delivered to the augmented reservoir provides optimal reduction of all chemicals and contaminants, including microbial contaminants, regulated contaminants, and additional specified chemicals.

Within six months following the first year of operation of optimizing the treatment processes, the project sponsor shall update the Operation Plan to include any changes in operational procedures. Furthermore, anytime thereafter operations are optimized that result in a change in operations, the Operation Plan shall be updated. The updated Operation Plan shall be submitted to DDW and the RWQCB for review.

4.2.10 Augmented Reservoir Monitoring (Section 60320.326)

Monitoring shall commence prior to augmenting the reservoir with recycled water. The water recycling agency and public drinking water agency utilizing the reservoir shall identify monitoring locations in the reservoir for review and approval by DDW. The monitoring locations must be representative throughout the volume of the reservoir and include water quality at:

- Conditions across the horizontal extent of the reservoir surface;
- Each level in the reservoir corresponding to depths from which water may be withdrawn; and
- The reservoir’s epilimnion and hypolimnion.

The project sponsor shall collect and analyze monthly samples at the above locations in the reservoir for at least 24 months for:

- sMCLs and upper limits;
- TOC;
- Total nitrogen;
- Escherichia coli (E. coli)

- Total coliform bacteria;
- Temperature;
- Dissolved oxygen;
- Chlorophyll α;
- Total and dissolved phosphorus; and
- Other chemicals and contaminants specified by DDW based on its review of this Engineering Report and source wastewater control program assessment.

Monthly monitoring must continue for the above constituents for at least the initial 24 months following startup of augmentation of the reservoir with recycled water. This on-going monitoring shall also include chemicals and contaminants specified by DDW based on its review of the project operations and recycle water quality monitoring, as well as reservoir locations and frequencies specified by DDW.

After this initial 24-month period of operation, the project sponsor may apply to DDW for approval of reduced on-going monitoring; however, on-going reservoir monitoring shall be conducted at least annually.

4.2.11 Reporting (Section 60320.328)

The project sponsor must submit an annual report by July 1st to DDW and the RWQCB, as well as each public water supply agency using the augmented reservoir. The report shall be prepared by a licensed California engineer who is experienced in the fields of wastewater treatment and public water supply. The annual report shall include:

- Summary of the project's compliance with the monitoring and regulatory requirements;
- Any violations, noting the date, duration, nature of the violation, and corrective actions, including any suspension(s) of delivery of recycled water to the reservoir;
- Any detections of monitored chemicals or contaminants, and observed trends in the reservoir monitoring results;
- Description of any changes in operation of the treatment processes or facilities;
- Description of any anticipated changes in the project;
- Estimated quantity and quality of recycled water to be delivered to the reservoir in the coming year, as well as the quantity of recycled water delivered to the reservoir during the previous three years; and
- Summary of source wastewater control measures taken and status of the wastewater management agency permit compliance.

Every five years from the date of the initial approval of this Engineering Report, the project sponsor must update the report to address any project changes and submit the report to DDW and the RWQCB. The update must address any anticipated increases in deliveries of recycled water to the reservoir and a description of the project's ability to comply with the regulations.

4.2.12 Alternatives (Section 60320.330)

The project sponsor may use an alternative to the requirements of the regulations if it demonstrates to DDW that the proposed alternative provides an equivalent or better level of performance with respect to the efficacy or reliability of removal of contaminants of concern to public health, and provides at least the same level of public health protection. Such a demonstration shall include review of the results by an independent scientific advisory panel that has been approved by DDW and includes a toxicologist, a limnologist, an engineer licensed in California with at least three years of experience in wastewater treatment and public drinking water supply, a microbiologist, and a chemist.

Written approval from DDW is required prior to implementation of any alternative. DDW or the RWQCB may require that the project sponsor hold a public hearing on the proposed alternative, providing information to and soliciting comments from the public.

4.2.13 Application (Section 64668.05)

For public drinking water suppliers using a reservoir that is augmented with recycled water as a source of water supply, this section links the Surface Water Treatment criteria to the Water Recycling criteria.

4.2.14 General Requirements and Definitions (Section 64668.10)

Definitions in the Surface Water Treatment criteria refer to and are the same as those in the Water Recycling criteria.

Prior to using the augmented reservoir, the public water supply agency must submit an application for a new or amended domestic water supply permit and have an approved joint plan with the water recycling agency as required in Section 60320.301. The public water supply agency must revise its emergency plan and operations plan to include elements of the joint plan and a means of providing an alternative source of domestic water supply, a DDW-approved treatment procedure or other actions to be taken that will ensure a reliable water supply in the event that the augmented reservoir water has been degraded, cannot be used or treated to meet drinking water standards, or receives recycled water not in compliance with the SWA requirements.

The drinking water supply agency must demonstrate to DDW and the RWQCB that it has sufficient control over the augmented reservoir to ensure compliance with the SWA regulations. Furthermore, the drinking water supply agency shall notify DDW if it becomes aware that the water recycling agency has failed its permit requirements.

4.2.15 Public Hearings (Section 64668.20)

The public water supply agency must facilitate at least three public hearings held by DDW before using a reservoir augmented with recycled water as a source of domestic water supply. The public water supply agency shall work with the water recycling agency to develop information for the public hearings including these items: project description, identification of the wastewater source, descriptions of the treatment processes, monitoring and contingency plans, and anticipated DDW and RWQCB permit provisions for the project. The information for the public hearings shall be approved by DDW and available for public review at least 30 days prior to the hearings. Section 64668.20 specifies requirements for the public notifications.

4.2.16 Augmented Reservoir Requirements (Section 64668.30)

The augmented reservoir shall have been in operation as an approved surface water supply source for at least five years (unless approved by DDW for at least two years) to establish a baseline record of its water quality.

As noted above in Section 4.2.5, the reservoir shall provide a minimum mean theoretical hydraulic retention time approved by DDW such that, in combination with dilution, the project achieves the required pathogenic microorganism reduction values presented in Table 4-1. Any additional treatment needed to achieve the required LRVs that correlate with the minimum mean theoretical hydraulic retention time and dilution provided by the reservoir are not required to be a unique treatment process from other processes in the treatment train. For reservoir augmentation, the minimum retention time shall be initially 180 days and thereafter at least 60 days based on the volume of water stored in the reservoir at the end of the month divided by the volume of water withdrawn from the reservoir during the month. (See Section 4.2.5.)

The public water supply agency must conduct tracer studies and hydrodynamic modeling of the reservoir prior to augmenting the reservoir with recycled water to demonstrate that it complies with the dilution requirements at all times under all operating conditions. Section 4.2.5 above discusses the dilution requirements for the augmented reservoir. The relationship between dilution, retention time, and pathogen reduction requirements is presented in Table 4-1. A tracer study utilizing an added tracer must be initiated within the first six months of the project startup. The public water supply agency shall submit a plan for the tracer study to DDW for review and approval. DDW may require additional tracer studies at any time to verify compliance with the SWA requirements.

Prior to initiating a change in operation that may impact the hydraulic characterization of the reservoir, the public water supply agency shall notify DDW and demonstrate that the previous tracer study or hydrodynamic modeling remains valid for the changed condition, or if requested by DDW, conduct a new tracer study demonstrating compliance.

The public water supply agency shall utilize an independent scientific advisory panel, unless directed otherwise by DDW, to be convened for review of the hydraulic characterization of the reservoir, including tracer studies and hydrodynamic modeling. The independent scientific advisory panel shall be approved by DDW and include at a minimum a limnologist experienced with hydrodynamic modeling of surface water reservoirs or a limnologist and an individual with such modeling experience. DDW shall attend independent scientific advisory panel meetings and discussions.

The project sponsor shall develop and submit a plan for DDW's review and approval describing the actions to be taken to assess and address potential impacts of advanced treated recycled water as a raw water source for the drinking water treatment plant and distribution system. The plan shall address:

- Maintaining chemical and microbial stability in the drinking water distribution system as increasing fractions of advanced treated recycled water may change the drinking water quality;
- Maintaining the drinking water treatment plant's treatment process effectiveness as increasing fractions of advanced treated recycled water may change the reservoir water quality;
- Assessments to be performed to maintain the aforementioned criteria prior to and during operation of the project; and
- Outcomes of the above assessments that would be reported to DDW.

4.3 Regulatory Requirements to Protect Receiving Waters

The RWQCB will regulate the discharge of purified recycled water to Miramar Reservoir through waste discharge requirements pursuant to the California Water Code and an NPDES permit issued pursuant to the federal Clean Water Act under authority delegated by the EPA (RWQCB, 2011; RWQCB, 2013). The NPDES permit will establish purified water concentration standards that implement:

- State and federal water quality standards for Miramar Reservoir established by the RWQCB and EPA within the Basin Plan;
- Statewide standards for inland surface waters that have been imposed by EPA within the CTR; and

- Statewide policies established by the SWRCB for chlorine residual.

4.3.1 Basin Plan Requirements

The Basin Plan establishes designated beneficial uses for receiving waters, water quality standards to protect the beneficial uses, and implementation policies for achieving compliance with the standards. The Basin Plan establishes the following beneficial uses for Miramar Reservoir:

- Municipal water supply and industrial service supply;
- Contact and non-contact recreation (water contact recreation is limited to fishing from the shore or a boat);
- Warm freshwater habitat;
- Wildlife habitat; and
- Hydropower generation.

To protect the designated beneficial uses of Miramar Reservoir, the Basin Plan establishes water quality standards for:

- Mineral constituents such as TDS, chloride, sulfate, manganese, iron, boron, and fluoride;
- Constituents with state and federal primary drinking water standards; and
- Nutrient constituents (total nitrogen and total phosphorus [N:P]).

4.3.1.1 Mineral Constituents

Table 4-2 presents the Basin Plan surface water quality objectives for mineral constituents within Miramar Reservoir. The RWQCB will implement the Basin Plan standards presented in Table 4-2 by establishing effluent concentration standards within the NPDES permit that regulates the purified water discharge to Miramar Reservoir.

Table 4-2: Basin Plan Surface Water Objectives for Mineral Constituents – Miramar Reservoir

Parameter	Concentration[a] (mg/L, unless otherwise noted)
TDS	500
Chloride	250
Sulfate	250
Percent sodium	60%
Iron	0.3
Manganese	0.05
Boron	0.75
Fluoride	1.0

[a] Basin Plan surface water quality objectives not to be exceeded more than 10 percent of the time. Basin Plan surface water quality objectives have been adopted by EPA as federal surface water standards subject to the protection of the federal Clean Water Act.

4.3.1.2 Application of Drinking Water Standards to Miramar Reservoir

To protect municipal supply uses, the Basin Plan also imposes state and federal primary drinking water standards on waters stored in Miramar Reservoir. Thus, while DDW applies primary and secondary drinking water standards to the final potable supply produced by the Miramar DWTP, the RWQCB's NPDES permit will apply the state and federal primary and secondary drinking water concentration standards to the purified water being discharged into Miramar Reservoir.

4.3.1.3 Nutrient Standards

To ensure that biostimulation effects do not adversely impact beneficial uses, the Basin Plan establishes the following region-wide objectives and requirements governing nutrients:

- Numerical concentration objectives for total phosphorus;
- Provisions that natural ratios of N:P are identified and upheld; and
- A narrative objective that concentrations of nitrogen and phosphorus, by themselves or in combination with any other nutrient, shall be maintained at levels below those that stimulate algae and emergent plant growth.

The Basin Plan numerical objectives for nutrients that are applicable to Miramar Reservoir are presented in Table 4-3. To implement the Basin Plan nutrient objectives, it is anticipated that the RWQCB will implement a purified water concentration standard for total phosphorus of 0.025 mg/L. Since phosphorus is readily removed by advanced treatment, it is projected that the purified water discharge to Miramar Reservoir will contain total phosphorus concentrations of less than 0.01 mg/L, which will comply with this numerical standard by a comfortable margin. Complying with the 0.025 mg/L phosphorus standard will also ensure compliance with the Basin Plan narrative objective that prohibits discharges from causing adverse algae or emergent plant growth.

Table 4-3: Basin Plan Nutrient Objectives – Miramar Reservoir

Type of Receiving Water	Concentration[a] (mg/L)	
	Total Phosphorus	Total Nitrogen
Discharges to Miramar Reservoir	0.05[b]	See note[c]
Within Miramar Reservoir	0.025[b]	See note[c]

[a] Basin Plan surface water quality objectives not to be exceeded more than 10 percent of the time. Basin Plan surface water quality objectives have been adopted by EPA as federal surface water standards subject to the protection of the federal Clean Water Act.

[b] Threshold total phosphorus shall not exceed 0.05 mg/l in any stream at the point where it enters any standing body of water, nor 0.025 mg/L in any standing body of water.

[c] The Basin Plan does not establish analogous concentration values for total nitrogen, but requires that natural ratios of N:P are to be identified through monitoring and upheld. In the absence of data, the Basin Plan specifies that a N:P ratio of 10:1 is to be used.

As presented in Table 4-3, the Basin Plan does not establish analogous concentration standards for total nitrogen, but instead requires that natural ratios of N:P are identified and upheld. The Basin Plan further specifies that a 10:1 N:P ratio is to be used in the absence of data.

Using a "limited nutrient" approach, the City will be able to control biostimulation by maintaining Miramar Reservoir phosphorus concentrations at near-zero levels. Through this management approach, the City will be able to ensure that Miramar Reservoir N:P ratios are sustained at high levels (two orders of magnitude or more). Thus, while historic N:P ratios in Miramar Reservoir have exceeded 10:1, under the proposed reservoir management approach, the purified water discharge is projected to result in significantly increased reservoir N:P ratios.

In correspondence dated February 7, 2013, the RWQCB's acknowledged that this "limited nutrient" compliance approach should be feasible, and that NPDES concentration standards for nitrogen for a purified water discharge to a reservoir could be based on managed (e.g., controlled) reservoir N:P ratios (RWQCB, 2013). While the 2013 RWQCB correspondence addressed San Vicente Reservoir, the limited nutrient approach should be even more applicable to Miramar Reservoir, where surface runoff contributions are significantly more controlled and limited. Given that a purified water discharge to Miramar Reservoir should allow the reservoir N:P ratio to be sustained at two orders of magnitude or more, it is anticipated that the RWQCB will be able to establish a long-term average purified water nitrogen concentration standard for Miramar Reservoir that is in the order of 2 mg/L as total nitrogen. In early January 2017, the City submitted a "Proposed Approach: Compliance with Basin Nutrient Objectives" report (City, 2016b) to the RWQCB. The report summarizes the approach proposed by the City for demonstrating that phosphorus and nitrogen concentrations of 0.025 mg/L and 2 mg/L, respectively, are consistent with the nutrient water quality objectives established by the RWQCB in the Basin Plan.

4.3.2 California Toxics Rule

The EPA's CTR establishes statewide standards for inland surface waters of California within Title 40, Section 131.38 of the Code of Federal Regulations (40 CFR 131.38/EPA, 2000b). CTR standards (Appendix C) have been established for the protection of aquatic habitat and public health. Because CTR standards for toxic constituents are more stringent than corresponding drinking water standards, the CTR concentration limits (rather than drinking water standards) will govern NPDES concentration limits established by the RWQCB for the discharge of purified water to Miramar Reservoir.

The CTR standards can be achieved by establishing a mixing zone, within which the CTR standards would not apply. Should the RWQCB wish to establish a mixing zone or dilution credit, they must do so in accordance with the SWRCB CTR implementation policies (SWRCB, 2000). The RWQCB's 2013 concept approval for a purified water release to San Vicente Reservoir (RWQCB, 2013) indicated that the RWQCB may establish CTR mixing zones and dilution credits on a case by case basis. In Miramar Reservoir, mixing zone dimensions and dilution credits may be established by the RWQCB on the basis of the hydrodynamic mixing characteristics provided by the diffuser and distribution inlet. Miramar Reservoir inlet facilities and mixing hydrodynamics are discussed within Section 6.3.2.9 and Section 11. To date, the RWQCB has not indicated that they plan to establish a mixing zone for the purified water release to Miramar Reservoir. If they do not, the City of San Diego intends to comply with the CTR standards at a monitoring point designated by the RWQCB. In the future, the City may apply for a mixing zone or dilution credit based on hydrodynamic modeling studies and assessments of decay rates, with results acceptable to the RWQCB.

4.3.3 Chlorine Residual

Although the CTR does not establish a standard for chlorine residual, the EPA has established national criteria for chlorine residual concentrations to protect freshwater aquatic life (EPA, 2014). The SWRCB (SWRCB, 2006) proposed that the EPA criteria be established as a statewide standard but, to date, the draft chlorine residual standards have not been implemented. The draft statewide chlorine standards currently being considered by the SWRCB would require that dischargers reduce chlorine residual in discharges to receiving waters to as close to zero as practicable. Pending approval of statewide standards for chlorine residual, the SWRCB (SWRCB, 2014) has implemented the EPA criteria maximum concentration water quality criteria presented in Table 4-4 for current statewide NPDES permits governing discharges to surface waters from drinking water systems. It is anticipated that such a standard would also apply to any purified water discharged to Miramar Reservoir.

Table 4-4: National Recommended Water Quality Criteria for Chlorine

Parameter	National Recommended Water Quality Criteria[a] (concentration in µg/L)	
	Criteria Maximum Concentration[b]	Criteria Continuous Concentration[c]
Chlorine Residual	19[d]	11

[a] National recommended water quality criteria per EPA, (2014) for the protection of aquatic freshwater life.

[b] Criteria maximum concentration is the highest concentration to which aquatic life can be exposed for a short period of time without deleterious effect.

[c] Criteria continuous concentration is the highest concentration to which aquatic life can be exposed for four days without deleterious effect.

[d] This 19 µg/l criterion has been established as an NPDES effluent concentration limit in the SWRCB general NPDES permit (Order WQ 2014-0194-DWQ) that regulates discharges of potable water to surface waters (SWRCB, 2014).

5. Source Wastewater

The source water for the Project is municipal wastewater from the northern portion of the City of San Diego Metropolitan Sewerage System, which encompasses the existing NCWRP sewershed and new Morena Pump Station sewershed. This section provides the following three details about the wastewater source: (1) sewershed description including maps and associated collection facilities, (2) raw wastewater characteristics based on historical data, and (3) summary of the City's IWCP.

The City administers and enforces a Source Control Program for the entire Metropolitan Sewerage System that is already more comprehensive than other federal industrial pretreatment programs because of the PLWTP's modified NPDES permit. In lieu of secondary treatment at the PLWTP, the City provides enhanced source control to protect public health and the environment, and to protect the quality of recycled water.

5.1 Sewershed Description

A detailed map of the Metropolitan Sewerage System, which collects and treats wastewater from the City and 15 other nearby cities and districts represented by 12 Participating Agencies, is illustrated on Figure 5-1. Serving a population of over 2.2 million, the Metropolitan Sewerage System covers approximately 450 square miles and treats an average of 150 mgd of wastewater (annual average of the last three years). Participating Agencies include:

- Cities of Chula Vista, Coronado, Del Mar, El Cajon, Imperial Beach, La Mesa, National City, and Poway;
- Lemon Grove Sanitation District;
- Otay Water District;
- Padre Dam Municipal Water District; and
- County of San Diego on behalf of the Winter Gardens Sewer Maintenance District, and the Alpine, Lakeside and Spring Valley Sanitation Districts.

The PUD Wastewater Collection Division manages, operates, and maintains the wastewater collection system within the City boundaries, which comprises more than 2,900 miles of sewer lines and 84 wastewater pump stations. The City operates three wastewater treatment facilities and one biosolids treatment facility:

- The PLWTP has an existing average rated capacity of 240 mgd. Treated plant effluent is discharged to the Pacific Ocean via the Point Loma Ocean Outfall;
- The NCWRP has an existing average rated capacity of 30 mgd. The plant produces disinfected tertiary-treated recycled water for landscape irrigation and industrial use. Any excess effluent is discharged to the ocean through the PLWTP. The NCWRP expansion to be completed as part of this Project is described in Section 6.2.2;
- The South Bay Water Reclamation Plant (WRP) has an existing average rated capacity of 15 mgd. The plant produces disinfected tertiary-treated recycled water for non-potable use. Any excess secondary effluent is discharged to the Pacific Ocean via the South Bay Ocean Outfall; and
- MBC features two treatment operations: 1) thickening and digestion of raw solids generated at the NCWRP; and 2) dewatering of wet biosolids from the PLWTP and NCWRP with liquid removed from the biosolids (centrate) returned to the sewer for treatment at the PLWTP.

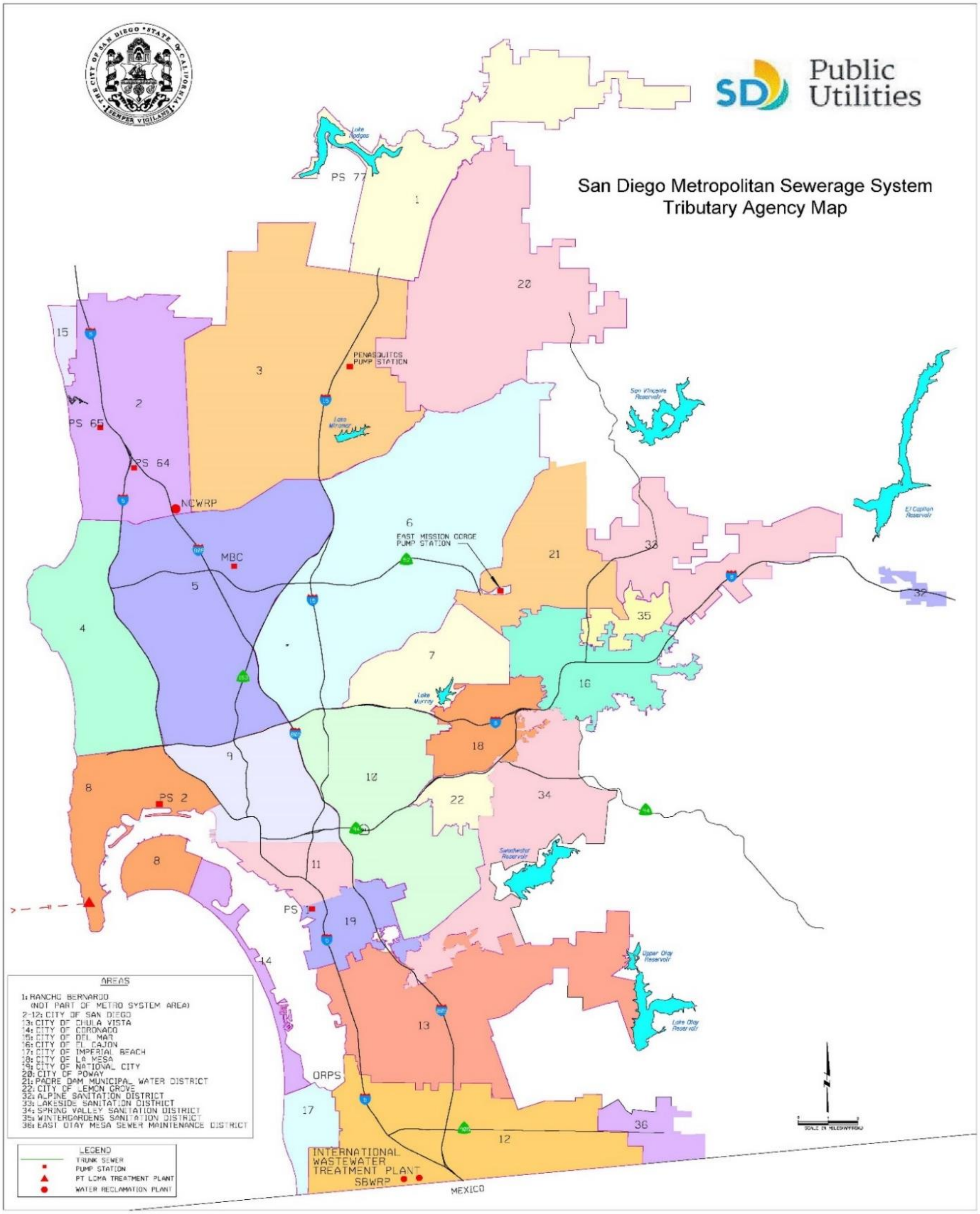


Figure 5-1: San Diego Metropolitan Sewerage System Tributary Agency Map

The Project sewersheds comprise the existing NCWRP sewershed and the new Morena Pump Station sewershed. The Project will collect, treat, and reuse wastewater from these two regional collection areas in the Metropolitan Sewerage System, as illustrated on Figure 5-2.

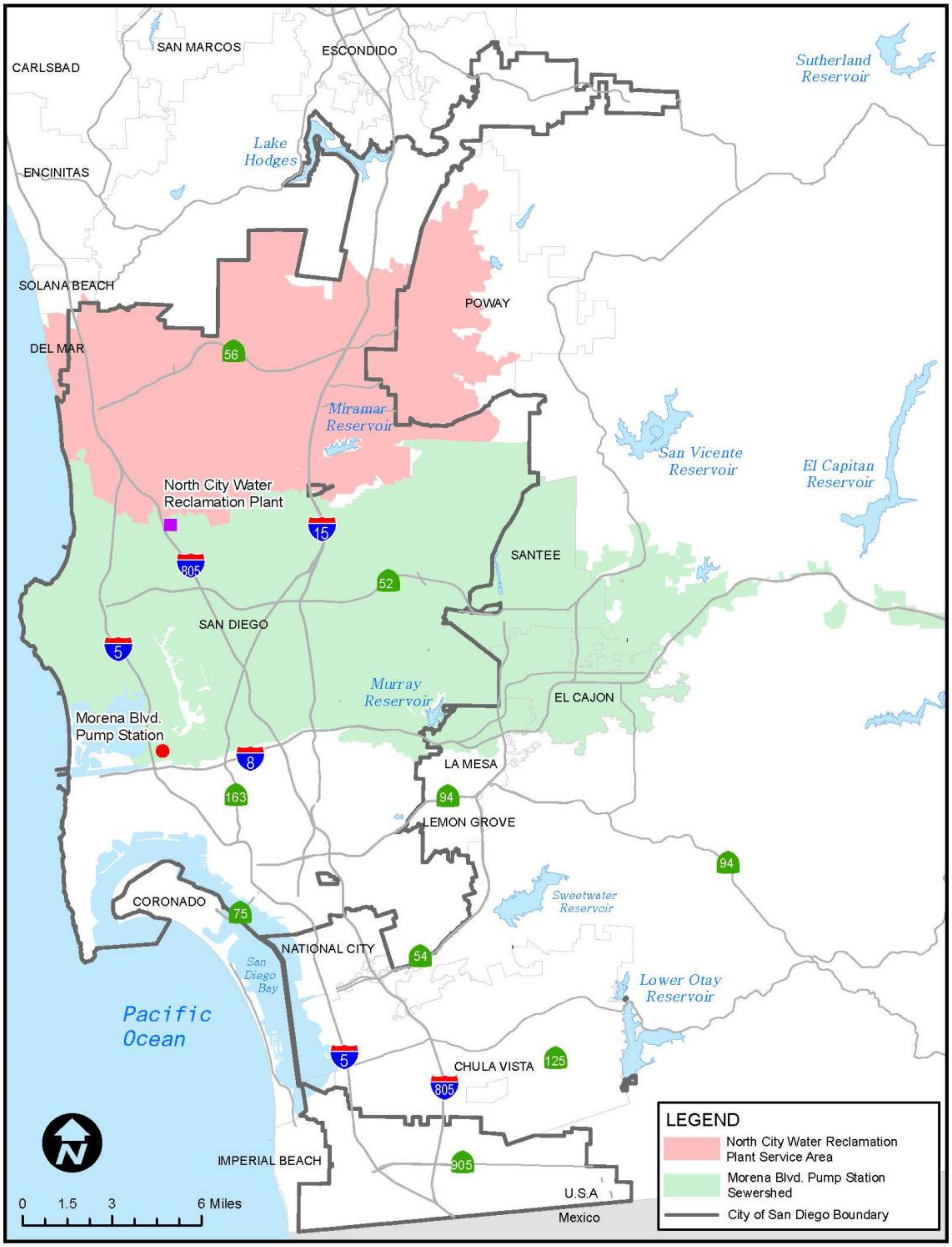


Figure 5-2: NCWRP and Morena Pump Station Sewersheds

The locations of the trunk sewers, pump stations, treatment facilities, and ocean outfalls in the Metropolitan Sewerage System are illustrated on Figure 5-3. Pump Station 77 conveys all wastewater flows from Area 1 (as illustrated on Figure 5-1) to the Hale Avenue Treatment Plant, which is owned and operated by the City of Escondido.

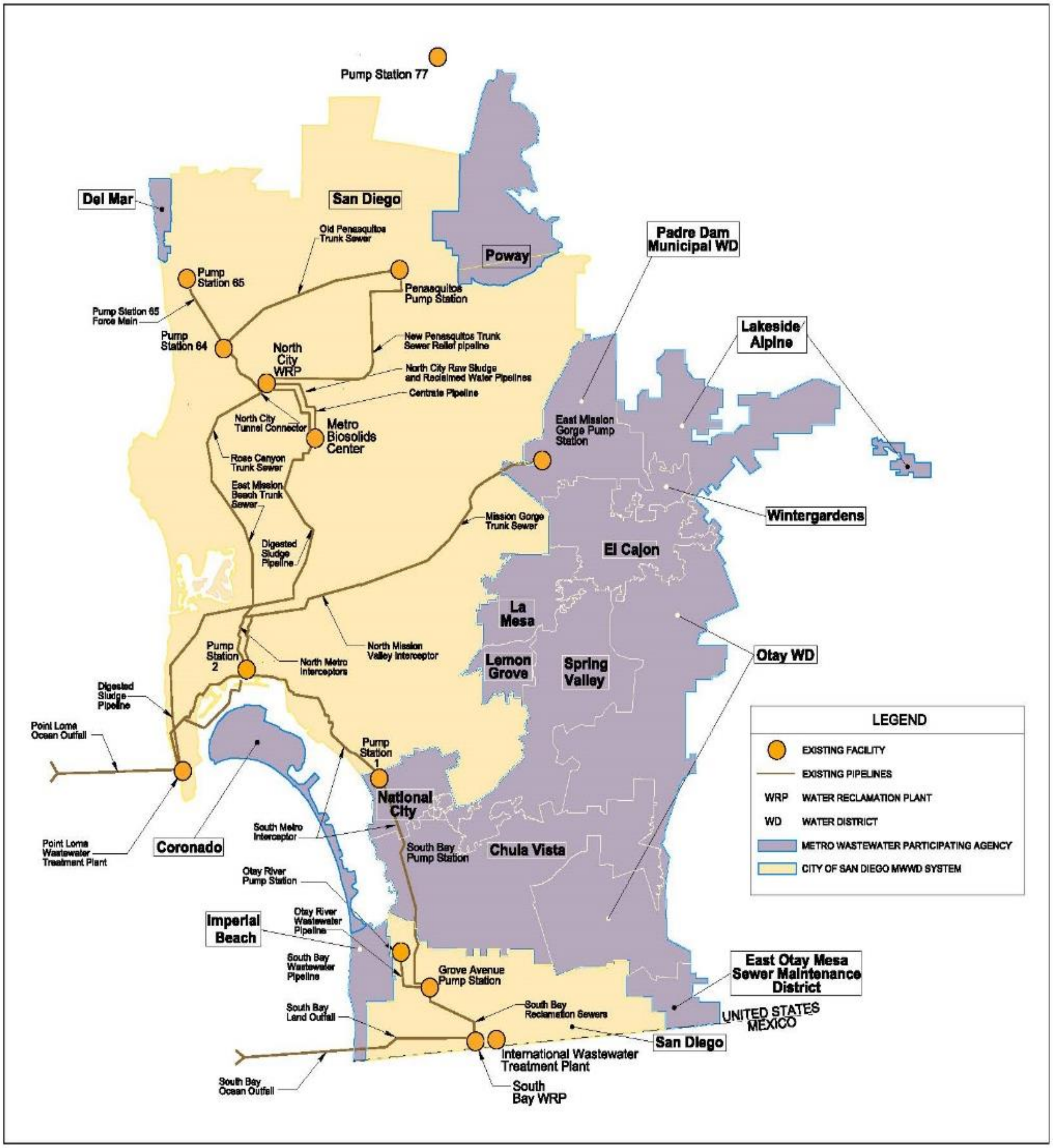


Figure 5-3: Metropolitan Sewerage System Facilities Map

5.1.1 Existing NCWRP Sewershed

Table 5-1 presents the general areas that contribute wastewater to the existing NCWRP sewershed. Four pump stations convey wastewater to the existing NCWRP: (1) Penasquitos Pump Station, (2) Pump Station 64, (3) Pump Station 65, and (4) Del Mar Pump Station. The existing NCWRP wastewater pumping and conveyance system is illustrated schematically on Figure 5-4 with approximate average flows. Since 2011, the NCWRP has operated as a scalping plant, treating on average 16 mgd of wastewater to supply existing NPR water demands and diverting the remaining wastewater flow (about 9 mgd of raw wastewater plus secondary return flow) to the PLWTP.

Table 5-1: Sewershed Areas Tributary to the Existing NCWRP

Area[a]	Sewershed Area Description
2	City of San Diego
3	City of San Diego
15	City of Del Mar[b]
20	City of Poway

[a] See map areas on Figure 5-1.

[b] Area 15 flows will be redirected away from the Metropolitan Sewerage System in the future.

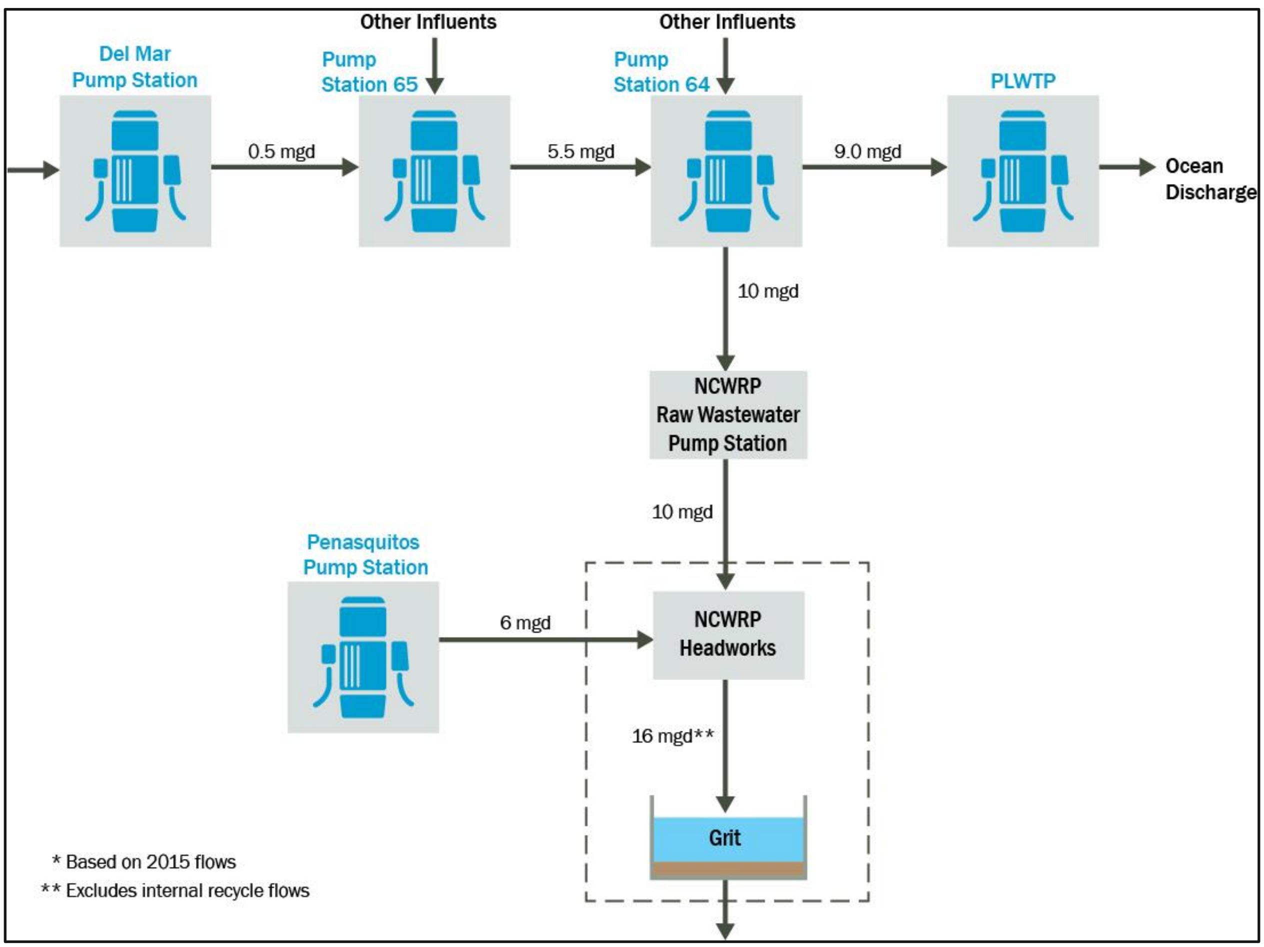


Figure 5-4: Existing NCWRP Wastewater Flows, Pump Stations, and Pipelines

Municipal wastewater from the four areas tributary to the existing NCWRP sewershed is primarily from residential and commercial customers. As of August 15, 2016, a total of 292 industries are located in the existing NCWRP sewershed. Presented by class in Table 5-2, 113 of these industries are required to have permits (Classes 1, 2, and 3), and the remaining 179 industries are not required to have permits (Classes 4C, 4, and 5) because they have little or no discharge to the Metropolitan Sewerage System. Of the dischargers with permits, 61 are research and development companies and five are pharmaceutical manufacturers. The remaining 47 permitted industries cover over 20 different industry types, including membrane manufacturers, breweries, hospitals, health services facilities, fabricated metal products, electronic equipment manufacturers and machinery, and transportation equipment manufacturers. The total industrial flow within the NCWRP sewershed is approximately 0.5 mgd, which is about 3 percent of the existing average NCWRP sewershed flow of 16 mgd. Besides these currently permitted industries, over 100 more research and development facilities are under evaluation for potential future permits.

Table 5-2: Industrial Permits By Class in the Project's Sewershed

Class	Description	NCWRP Sewershed[a]	Morena Pump Station Sewershed[a]	Total Expanded NCWRP Sewershed[a]
Dischargers with Permits				
1	Categorical Industrial Users (CIU) (subject to Federal Pretreatment Standards)	16[b]	14[b]	30[b]
2	Targeted Industrial Sectors with toxics, but not CIUs	1[b] / 89[c]	9[b] / 90[c]	10[b] / 179[c]
3	Targeted Industrial Sectors with conventional pollutants	4[b] / 3[c]	4[b] / 16[c]	8[b] / 19[c]
Subtotal of dischargers with permits		113	133	246
Dischargers Not Required to Have Permits				
4C	CIUs (federally regulated) process generates wastewater, but no discharge to the sewer	13	12	25
4	Class 2 Industrial Users with flows less than 25 gallons per day (gpd) and Class 3 Industrial Users with flows less than 2,500 gpd	136	991	1,127
5	Dry and no potential for discharge	30	112	142
Subtotal of dischargers not required to have permits		179	1,115	1,294
Total		292	1,248	1,540

[a] Industrial dischargers as of 8/15/2016
[b] Significant Industrial Users (SIUs) have discharges greater than 25,000 gpd or 5 percent of the plant flow (see Section 5.3.1.5.b).
[c] Non-SIUs

5.1.2 Morena Pump Station Sewershed

With implementation of the Project, the NCWRP will treat wastewater from the Morena Pump Station sewershed in addition to wastewater from the existing NCWRP sewershed, with the exception of flows from the Del Mar Pump Station (Area 15), which will be directed away from the NCWRP sewershed. A total annual average daily flow rate of about 52 mgd will be treated at the expanded NCWRP. The flow contributions for the expanded NCWRP sewershed is illustrated on Figure 5-5 and include:

- 20 mgd from Pump Station 64 (the original 10 mgd from the existing NCWRP sewershed, plus an additional 10 mgd that was originally going to the PLWTP);
- 6 mgd from Penasquitos Pump Station, which is a part of the existing NCWRP sewershed; and
- 26 mgd from the new Morena Pump Station sewershed.

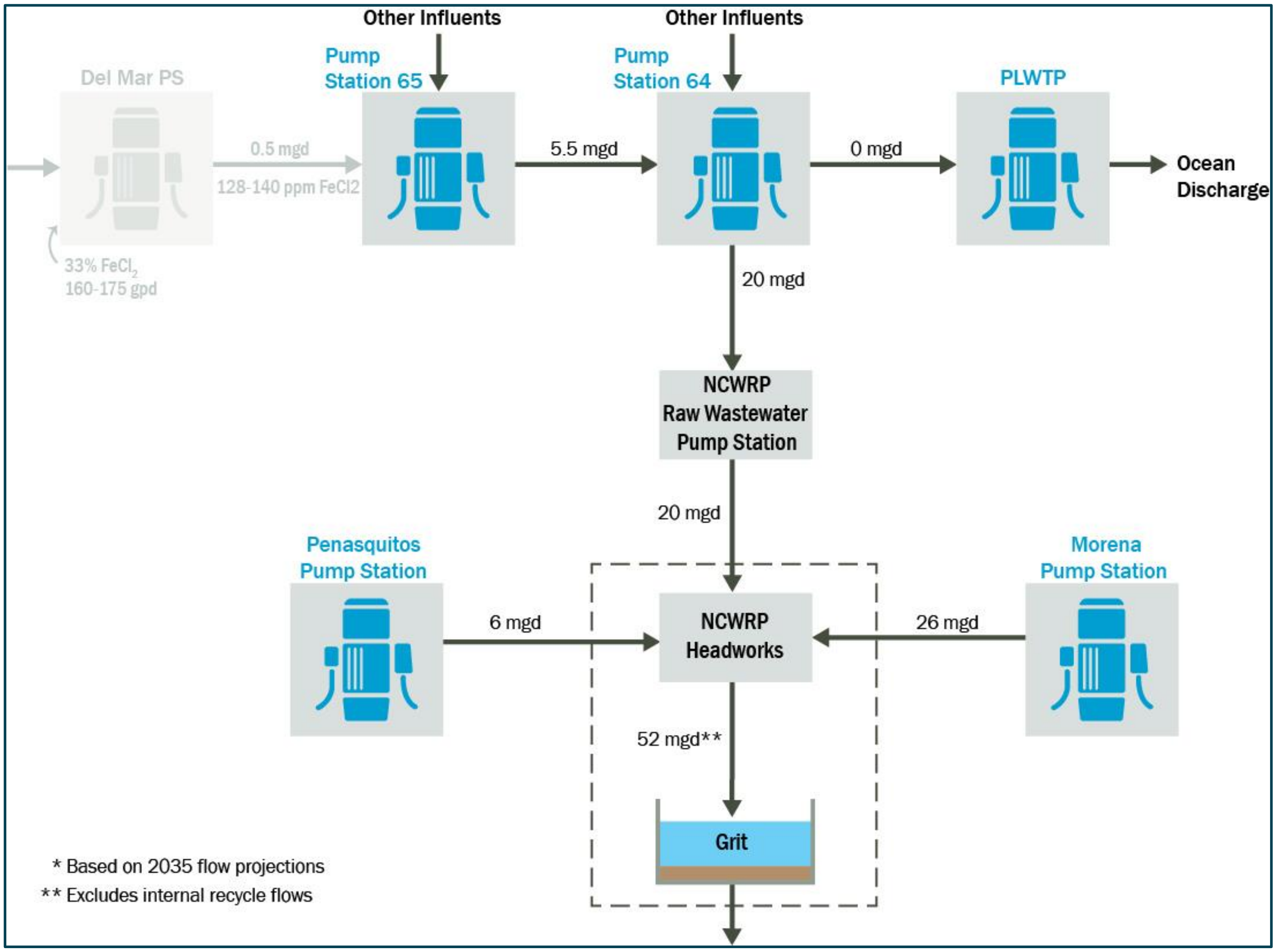


Figure 5-5: Expanded NCWRP Wastewater Flows, Pump Stations, and Pipelines

Table 5-3 presents the areas of the Metropolitan Sewerage System that contribute wastewater to the new Morena Pump Station sewershed. On average, approximately 26 mgd will be diverted to the expanded NCWRP from the Morena Pump Station sewershed. The Morena Pump Station and Pipeline are described in Section 6.2.1. The ten areas that are tributary to the new Morena Pump Station will contribute municipal wastewater chiefly from residential and commercial customers.

Table 5-3: Sewershed Area Tributary to the Morena Pump Station

Area[a]	Sewershed Area Description
4	City of San Diego
5	City of San Diego
6	City of San Diego
7	City of San Diego
10	City of San Diego
16	City of El Cajon
18	City of La Mesa
21	Padre Dam Municipal Water District
32	Alpine Sanitation District (County of San Diego)[b]
35	Winter Gardens Sanitation District (County of San Diego)[b]

[a] See map areas on Figure 5-1.
[b] These sewersheds were separate sewer districts prior to 2011.

As of August 15, 2016, a total of 1,248 industries are in the Morena Pump Station sewershed. Presented by class in Table 5-2, the Morena Pump Station diversion will add wastewater from 133 industries with discharge permits (Classes 1, 2, and 3) to the NCWRP raw wastewater. An additional 1,115 industries are not required to have permits (Classes 4C, 4, and 5) because they have little or no discharge to the Metropolitan Sewerage System. Of the 133 permitted industries, one is a pharmaceutical manufacturing facility and 14 are research and development facilities. The remaining 118 permitted facilities cover over 50 different industry types, including a large university, a Marine Corps Air Station, hospitals, health services facilities, metal products fabricators, equipment manufacturers, auto dealerships and repair facilities, car washes, construction dewatering, and groundwater remediation sites. The total current regulated industrial flow within the Morena Pump Station sewershed is approximately 1 mgd, which is less than 4 percent of the annual average 26 mgd flow proposed for diversion. This 1 mgd of regulated industrial flow comprises about 0.5 mgd of construction groundwater flows and about 0.5 mgd of industrial wastewater flows. In addition to these currently permitted industries, approximately 40 other research and development facilities are under evaluation for potential future permits.

Table 5-4 compares the industrial discharges with significant flows in the existing NCWRP sewershed with those in the Morena Pump Station sewershed. Table 5-5 presents industrial contributions from the existing NCWRP sewershed and the new Morena Pump Station sewershed, as well as the resulting expanded NCWRP sewershed.

Table 5-4: Industries with Significant Flows by Standard Industrial Classification[a]

Type of Industry[b]	Existing NCWRP Sewershed	Morena Pump Station Sewershed
Research and development	61	14
Pharmaceutical manufacturers	5	1
Membrane manufacturers	3	-
Breweries	4	2
Hospitals and health services facilities	3	26
Fabricated metal products	4	14
Electronic equipment manufacturers	8	10
Machinery and transportation equipment manufacturers	3	11
Primary metal industries	1	4
Universities and Colleges	-	2
Marine Corps Air Station	-	1
Auto repair and car washes	2	18
Groundwater remediation and dewatering	1	22
Total	95	125

[a] SIUs have flows greater than 25,000 gpd or 5 percent of the plant flow (see Section 5.3.1.5.b)

[b] Industrial discharge permits as of 8/15/2016. Industrial discharge permits are subject to change and are regularly updated.

Table 5-5: Industrial Discharge Flowrates

Industrial Contribution[a]	Existing NCWRP Sewershed	Morena Pump Station Sewershed	Total Expanded NCWRP Sewershed
Industrial wastewater flows (average)	0.5 mgd	0.5 mgd	1.0 mgd
Construction groundwater flows (average)	-	0.5 mgd	0.5 mgd
Total as percent of total average wastewater flow[b]	3.1 percent	3.8 percent	2.9 percent

[a] Industrial discharges as of 8/15/16

[b] Total average municipal wastewater flows (See Figures 5-4 and 5-5):

Existing NCWRP sewershed = 26 mgd

Morena Pump Station sewershed = 26 mgd

Total Expanded NCWRP sewershed = 52 mgd

5.2 Raw Wastewater Characteristics

The following section describes the raw wastewater characteristics, both historic and projected.

5.2.1 Historic NCWRP Influent Flows and Loads

A review of historical data from May 5, 2011, through December 31, 2014, was performed. The NCWRP began treating a relatively constant flow rate of approximately 16 mgd in May 2011, to minimize the amount of treated water that is sent back to the PLWTP (i.e., recycled water produced at the NCWRP, but not reused). Table 5-6 presents historical influent flow rates for four averaging periods. The influent flow rates do not currently vary significantly because the NCWRP is now being operated as a scalping plant, treating a near-constant flow rate.

Table 5-6: Historical NCWRP Influent Flows

Averaging Period	Influent Flows (mgd)					
	2011[a]	2012	2013	2014	2015	2016
Average Annual	16.5	16.4	15.3	15.6	16.8	15.8
Peak Day	21.0	24.7	22.8	21.0	22.3	19.8

[a] The 2011 influent flow dataset includes flows from 5/5/2011–10/31/2011. For 2012, 2013, 2014, 2015, and 2016, the dataset includes flows from the full calendar year (1/1–12/31).

Table 5-7 and Table 5-8 present a summary of the concentrations during the different averaging periods for biological oxygen demand (BOD) and TSS and the calculated peaking factors for each year. The NCWRP will be treating near-constant flow rates and influent loading variability will be due to influent concentration variations.

Table 5-7: Historical NCWRP Influent BOD Concentrations

Averaging Period	Influent BOD Concentrations (mg/L)					
	2011[a]	2012	2013	2014	2015	2016
Average Annual	251	268	271	286	315	326
Peak Day	438	383	445	526	533	570

[a] The 2011 dataset includes concentrations from 5/5/2011–10/31/2011. For 2012, 2013, 2014, 2015, and 2016, the dataset includes concentrations from the full calendar year (1/1–12/31).

Table 5-8: Historical NCWRP Influent TSS Concentrations

Averaging Period	Influent TSS Concentrations (mg/L)					
	2011[a]	2012	2013	2014	2015	2016
Average Annual	273	288	293	320	329	353
Peak Day	431	443	446	574	610	754

[a] The 2011 dataset includes concentrations from 5/5/2011–10/31/2011. For 2012, 2013, 2014, 2015, and 2016, the dataset includes concentrations from the full calendar year (1/1–12/31).

Composite influent BOD and TSS samples are collected daily at the NCWRP. Influent concentrations have increased, which may be attributed to water conservation. At the time pre-design was initiated (April 2015), the highest influent BOD and TSS concentration peaking factors occurred in 2014 and, for this reason, the 2014 dataset were used to develop and calibrate a biological process model for the NCWRP during pre-design. Since that time, the 2015 and 2016 concentration data have become available; this new data are being used to develop the detailed design.

5.2.2 Projected Wastewater Characteristics

Wastewater characterizations were performed by sampling current wastewater influent to the NCWRP, consisting of two sewer lines, as well as the primary effluent and secondary effluent. Additionally, the four separate sewers, which will be conveyed to the NCWRP via the Morena Pump Station and Pipeline in the future as part of the Project, were also characterized. The data collected from these four sewers were used with flow projections to calculate a combined composite value for various pollutants. This combined composite was used to plan the upgrade for the primary and secondary systems at the NCWRP. Table 5-9 presents a summary of wastewater characterization data. These data were used to model current and future treatment processes.

Table 5-9: Projected Wastewater Characteristics for the North City Project

Parameter	Units	Value[a]
Flow Rate	mgd	51.6
Raw Influent BOD	mg/L	308
Raw Influent TSS	mg/L	348
Ammonia	mg-N/L	37.3
Raw Influent Phosphate	mg-P/L	2.8
Alkalinity	mg $CaCO_3$/L	310

[a] Estimated raw wastewater concentrations are based on water conservation and adding the Morena Pump Station to the NCWRP.

5.3 Wastewater Source Control

PUD staff assigned to the City's IWCP administers and enforces the Source Control Program for the entire Metropolitan Sewerage System. An overview of the Source Control Program for the existing NCWRP and expanded sewershed serving the Project is provided in this section. Also included is a summary of how the IWCP is already enhanced to comply with requirements for the modified discharge permit for the PLWTP and how it will be additionally upgraded to meet future requirements for the North City Project.

San Diego has a history of operating an enhanced Source Control Program with a high degree of success. Effective implementation of this enhanced control program is required in order to qualify for and maintain the modified NPDES permit for the PLWTP that obviates the need for secondary treatment at that location. It is noteworthy that the effectiveness and diligent implementation of this enhanced program has allowed the PLWTP to operate with a modified permit for over 20 years. More details about the City's Source Control Program are available in the City's Annual Pretreatment Report (City, 2016c).

5.3.1 Description of the Source Control Program for NCWRP

The existing NCWRP sewershed and new Morena Pump Station sewershed are described in Section 5.1. The NCWRP is a Metropolitan Sewerage System facility; therefore, it is subject to all requirements of the IWCP.

5.3.1.1 Industrial Wastewater Control Program Objectives

The City's IWCP applies and enforces federal pretreatment regulations set forth by the EPA and pursuant to 40 Code of Federal Regulations Part 403 (40 CFR 403, 1981) and the Clean Water Act, which serve to:

- Protect and improve receiving water quality;
- Prevent the discharge of toxic and potentially harmful pollutants in concentrations that would interfere with treatment plant operations or pass through the plant to the receiving waters;
- Protect system personnel and plant facilities by limiting discharges of potentially hazardous, harmful, or incompatible pollutants;

- Prevent contamination of treatment plant sludge to maximize beneficial reuse options for biosolids; and
- Protect the quality of recycled water.

5.3.1.2 Industrial Wastewater Control Program Organization

The IWCP is managed by the Environmental Monitoring and Technical Services Division of the City of San Diego's PUD. The IWCP organization consists of two operational sections (1) Industrial Permits and Compliance and (2) Industrial Waste Laboratory, which as of 2015, included a total of 42 employees (18 in the Industrial Permits and Compliance Section and 24 in the Industrial Waste Laboratory). The total annual budget for the IWCP (system-wide) was $4.9 million in 2015.

5.3.1.3 Industrial Wastewater Control Program Authority

The City's Municipal Code contains an Ordinance pertaining to industrial users in order to comply with the requirements of the NPDES permits for the PLWTP and South Bay WRP. The Source Control Program implements federal pretreatment standards, local limits, and Best Management Practices (BMP) throughout the Metropolitan Sewerage System, including the NCWRP sewershed. Through Interjurisdictional Pretreatment Agreements, the City (through the IWCP) also administers the Source Control Program of the 12 Participating Agencies contributing wastewater to the Metropolitan Sewerage System.

5.3.1.3.a Municipal Code

On June 6, 1983, the San Diego City Council adopted Ordinance Sections 64.01 through 64.05 of Chapter VI, Article 4 of the San Diego Municipal Code pertaining to industrial waste discharges, permits, and regulations. On July 11, 1988, Section 64.07 was added to establish specific pretreatment regulations for wastes discharged from commercial food establishments. Revisions adopted in 1988, 1989, 1993, and 2000, strengthened pretreatment provisions and authorized increased penalties.

5.3.1.3.b Interjurisdictional Pretreatment Agreements

The pretreatment program for all agencies served by the Metropolitan Sewerage System is implemented as part of the City's IWCP in accordance with contractual service agreements and Interjurisdictional Pretreatment Agreements signed by the City of San Diego and each of the 12 Participating Agencies (see Section 5.1 for a list and map). These agreements establish the IWCP's authority to implement and enforce pretreatment regulations in contributing agencies and require that they adopt equivalent ordinances, penalties, and procedures for regulation of industrial users in their service areas.

5.3.1.3.c Regulatory Cycle

Figure 5-6 illustrates the IWCP regulatory cycle functions that are used to manage each industrial user from permit application to monitoring and to enforcement.

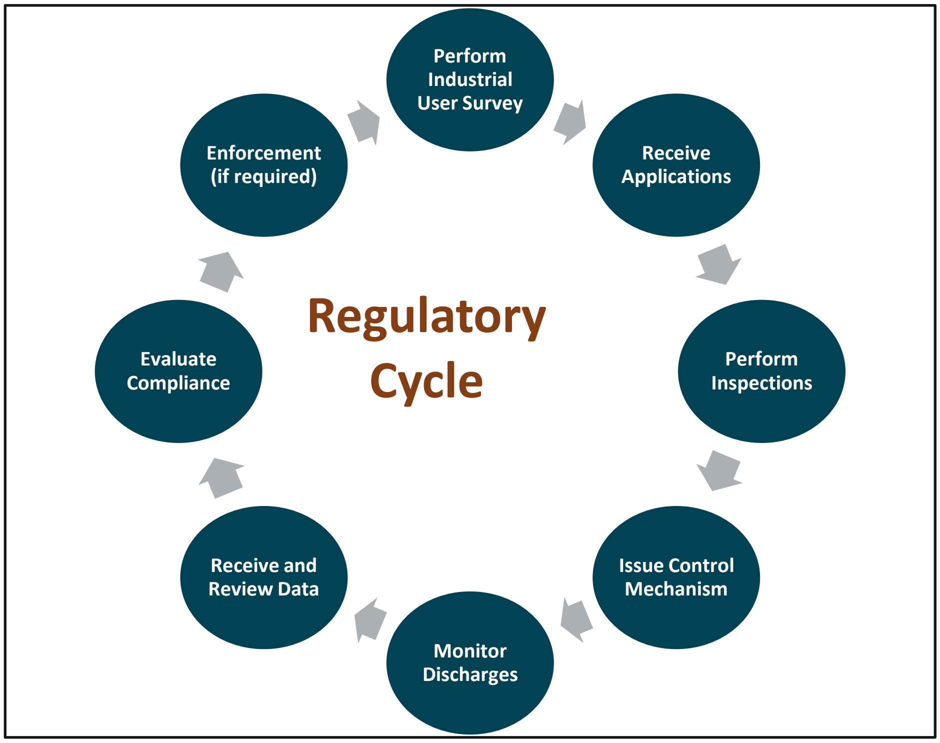


Figure 5-6: San Diego's IWCP Regulatory Cycle

5.3.1.4 Enhanced Requirements for the PLWTP Modified Permit

The City has a modified NPDES permit for the PLWTP that does not require secondary treatment technology. In lieu of secondary treatment, the permit requires that the City comply with the comprehensive Urban Area Pretreatment Program and Toxics Control provisions that were promulgated in Section 303(c) of the Water Quality Act of 1987. That regulatory change amended Section 301(h) of the Clean Water Act by adding additional source control requirements for dischargers holding modified discharge permits in lieu of secondary treatment.

The Urban Area Pretreatment Program requires that, for any toxic pollutant introduced into the PLWTP by an industrial source, the City must demonstrate that industrial sources are in compliance with all applicable pretreatment requirements, and the City will enforce those requirements. In addition, for each toxic pollutant for which there is no applicable pretreatment requirement in effect, the applicant must have in effect a pretreatment program that, in combination with the treatment of discharges from the treatment plant, removes the same amount of such pollutant as would be removed if the treatment plant were to apply secondary treatment and had no pretreatment program for such pollutant.

The regulations provide two methods for satisfying the urban area pretreatment requirements, and the City chose to demonstrate that, for each toxic pollutant introduced by an industrial discharger, it has an "applicable pretreatment requirement in effect." As a result, the City's Source Control Program is more comprehensive than those implemented by other agencies operating secondary treatment facilities. The City's comprehensive Source Control Program required by the PLWTP modified NPDES permit is applied throughout the entire Metropolitan Sewerage System, including the existing NCWRP sewershed, Morena Pump Station sewershed, and expanded NCWRP sewershed. In other words, the same enhanced pretreatment requirements for the PLWTP modified permit, including any adopted local limits, will be continued for the Project.

Measures implemented to demonstrate that an applicable pretreatment requirement is in effect for each toxic pollutant introduced by an industrial discharger include:

- Identify any and all toxic pollutants being introduced by industrial sources into the publicly owned treatment works;
    - The City continually updates its comprehensive Industrial Waste Survey of industrial users with information on processes performed, chemical use, waste streams generated, and discharge operations, and conducts sampling and analyses of industrial discharges.
    - The City also performs a Reportable Quantity review of the chemical lists submitted by industrial dischargers and confirms that a control mechanism is in place to control each chemical.
    - The City conducts ongoing comprehensive, representative sampling of the PLWTP influent, effluent, and sludge in order to identify any toxic pollutants that are present.
- Demonstrate that the City has in effect applicable pretreatment requirements for each toxic pollutant discharged by industrial users;
    - The City meets this requirement by applying and enforcing Federal Categorical Pretreatment Standards, and by conducting a local limits analysis and apportioning the allocation to industrial sources of the toxic in a manner that attains the required equivalent level of toxic pollutant reduction.
    - In addition to numeric local limits, the City has developed and implemented BMP requirements as an effective regulatory control strategy for some commercial sectors having a large number of low flow, potentially toxic, discharges.
- Perform an annual local limits re-evaluation for the PLWTP; and
    - The City meets this requirement by updating all applicable regulatory compliance criteria each year and comparing the maximum influent and effluent plant concentrations in the prior 12 months to the updated compliance criteria to identify pollutants of concern.
    - For each pollutant of concern, influent loadings and plant removal efficiencies are re-calculated, sources are identified using system and industry sampling, and numeric discharge limit or BMP requirements are developed as needed to control pollutant loadings and comply with all regulatory criteria.
- Meet an annual rate of 15 percent or less of Significant Industrial Users (SIU) in Significant Non-Compliance;
    - A program of consistent, timely, and effective enforcement ensures industries consistently achieve a Significant Non-Compliance rate below 15 percent, adjusted for second level enforcement.

5.3.1.5 Permitting and Inventory of Regulated Industries

An industrial wastewater discharge permit system is being implemented through the IWCP to regulate pollutant discharges into the Metropolitan Sewerage System from industrial facilities. This involves issuing permits that establish enforceable pollutant limits and authorize civil and criminal penalties for discharge violations. The IWCP also establishes sampling, reporting, record keeping, and notification requirements. Permits are issued for a maximum of five years and are non-transferrable.

5.3.1.5.a Permit Classifications

Industrial facilities and certain commercial facilities that intend to discharge industrial wastewater to the Metropolitan Sewerage System are required to first obtain industrial wastewater permits. Permits contain prohibitions, numeric discharge limits, BMP requirements, monitoring and reporting requirements, and facility-specific conditions, as applicable.

The IWCP administers the different industrial user permit classifications, as presented in Table 5-10.

Table 5-10: Industrial User Classifications

Class	Description
1	Users with processes subject to Federal Categorical Pretreatment Standards. Class 1 users require source control, pretreatment, or both.
2	Targeted industrial sectors that have some toxic constituents in their discharge, but are not subject to Federal Categorical Pretreatment Standards. Class 2 permits may include numeric limits, (e.g., at industrial laundries and membrane manufacturers), or BMP requirements, (e.g., at laboratories, radiator shops, and hospitals). Groundwater remediation projects receive Class 2 permits.
3	Targeted industrial sectors to regulate conventional pollutants. Class 3 facilities may include numeric limits, (e.g., commercial laundries discharging > 25,000 gpd), or BMPs, (e.g., auto repair facilities, boatyards, and shipyards). Construction dewatering projects receive Class 3 permits.
4 No Permit Required	Industries with sanitary flow only and Class 2 and 3 facilities with flows below permitting thresholds (25 gpd and 2500 gpd, respectively) and not otherwise designated as a SIU. Class 4 facilities are re-evaluated every five years.
4C No Permit Required	Facilities with processes subject to Federal Categorical Pretreatment Standards that generate process wastewater and have elected to go zero discharge to sewer are issued Class 4C "No Permit Required" letters. These facilities are inspected annually, at which time they must also sign a Certification of Zero Discharge of Federally Regulated Waste Streams as a condition of retaining their Class 4C status.
4Z No Permit Required	Facilities with processes subject to Federal Categorical Pretreatment Standards that generate no process wastewater are issued Class 4Z letters. These facilities are inspected once every two years to confirm continued zero discharge, at which time they must sign a Certification of Zero Regulated Waste Water Generated as a condition of retaining their Class 4Z status.
5 No Permit Required	Industries with sanitary flow only and minimal potential to ever generate industrial wastewater.

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Class	Description
Trucked Waste Hauler Permits	Issued to trucked waste haulers authorizing the disposal of wastes into the Metropolitan Sewerage System at a designated dumpsite. Hauler permits are issued for one year. Three types of waste hauler permits are issued (1) Domestic: For hauling of domestic septic tank/cesspool, holding tank and portable toilet wastes, (2) Industrial: For hauling of industrial wastes under generator specific permits, and (3) Listed Industrial: For hauling of listed dilute waste streams such as water softener regenerant and swimming pool water; these wastes can be combined and no generator permit is required.
Trucked Industrial Waste Generator Permits	Non-domestic wastewater generators that propose to have wastes hauled to the City sewer dumpsite must obtain a Trucked Industrial Waste Generator Permit. These permits specify a source, such as bilge water from a Navy ship, and are issued for the duration of the specified job. The generator must collect a representative sample of the proposed discharge, analyze for pollutants known or expected to be present, and submit the results with the permit application. Sampling and reporting are required monthly thereafter for the duration of the job.
Temporary Groundwater Discharge Permits	Issued for flows resulting from construction dewatering and groundwater remediation projects, where no alternative disposal method is reasonably available. These permits are issued for a maximum of two years, after which time the generator must discharge under an NPDES permit or cease discharge. In 2006, the program began regulating groundwater remediation discharges >14,000 gpd or having free product, and construction dewatering discharges > 25,000 gpd as SIU. Groundwater discharges below the flow thresholds receive Non-SIU permits.
Class 2F and 4D BMPs Discharge Authorizations	Authorizations consist of a statement of BMP requirements followed by a certification of compliance for management and discharge of silver-rich solutions (2F) or dry cleaning solvents (4D). When signed by the commercial discharger, the certification authorizes discharges in compliance with BMP requirements for a period of up to five years. Random inspections are performed after receipt of the certification to ensure compliance. Additionally, re-certification is required every six months. Implementation of the BMPs Certification and Discharge Authorization programs in 1998, in lieu of the previously applied numeric limits, enabled the program to extend coverage of BMP requirements with no increase in inspection staff and reduced laboratory sampling and analysis costs formerly associated with the targeted sectors.
Batch Discharge Authorizations	One-time, or short-term non-routine discharges not otherwise covered by a current permit, are subject to review of analytical data from a sample of the proposed discharge and compliance with all applicable requirements and standards.

5.3.1.5.b Significant Industrial User Permit Requirements

In accordance with federal regulations, the IWCP defines a SIU as an industrial user that:

- Is subject to Federal Categorical Pretreatment Standards under 40 California Federal Regulations (CFR) 403.6 and 40 CFR Chapter I, Subchapter N; and
- Any industrial user that meets one or more of the following:

- Discharges an average of 25,000 gpd or more of process wastewater to the Publicly Owned Treatment Works (excluding sanitary, non-contact cooling and boiler blow down wastewater);
- Contributes a process waste stream which makes up 5 percent or more of the average dry weather hydraulic or organic capacity of the Publicly Owned Treatment Works; or
- Is designated as such by the Control Authority on the basis that the industrial user has a reasonable potential for adversely affecting the Publicly Owned Treatment Works' operation or for violating any pretreatment standard or requirement. For metals, program policy defines "reasonable potential" as a facility having the potential to discharge 5 percent or more of the allowable industrial headworks loading in a single non-routine discharge. For groundwater remediation sites, the presence of free product or discharges >14,000 gpd have "reasonable potential" and are regulated as SIUs. For construction dewatering sites, discharges >25,000 gpd are regulated as SIUs. Facilities with high strength discharges or the potential for a slug discharge that would impact the plant or operations also have "reasonable potential" and are regulated as SIUs.

All Class 1 permittees are SIUs; however, given they are, by definition, subject to Federal Categorical Pretreatment Standards, they are also CIUs. Class 2 and Class 3 permittees meeting one or more of the additional criteria listed above are also SIUs ("flow", "slug", or "high strength" SIUs).

Pretreatment regulations provide for a determination that an industrial user subject to Federal Categorical Pretreatment Standards under 40 CFR 403.6 and 40 CFR Chapter I, Subchapter N as a Non-Significant CIU rather than an SIU in accordance with requirements and conditions established in 40 CFR 403.3(v)(2). To date, the IWCP has not implemented this provision of the streamlining regulations.

The IWCP's SIU permits identify constituents of concern; list prohibited discharges; specify applicable federal or local limits, standards, and requirements; require access for sampling and inspections; describe sources and volume of the authorized industrial discharge; and specify self-monitoring and reporting requirements. SIU permits incorporate detailed fact sheets and, when determined necessary, require implementation of formal Slug Discharge Control Plans. Permits may also establish additional requirements and compliance schedules.

The San Diego Municipal Code authorizes the IWCP Manager to establish local limits and apply those limits in user permits. Local limits have been developed to apply only to SIU facilities. They are applied such that each SIU gets the full federal allowance for applicable federally regulated pollutants and the local limit for each locally regulated pollutant that is not federally regulated and that is discharged by the facility at a concentration higher than background levels. The IWCP's SIU sampling and facility inspection frequencies meet or exceed the required minimum standards set by regulations and EPA Guidance.

5.3.1.5.c Control of Pharmaceuticals

The IWCP prohibits the discharge of pharmaceutically active ingredients from hospitals, commercial and research and development laboratories, and pharmaceutical manufacturers. Potentially harmful biological constituents used in research, analysis, or pharmaceutical manufacturing must be inactivated prior to discharge. The City's enhanced Source Control Program effectively controls discharges of pharmaceuticals to the Metropolitan Sewerage System as part of the modified discharge permit for the PLWTP.

5.3.1.5.d Current Inventory of Industrial Permits in Expanded NCWRP Sewershed

Table 5-2 and Table 5-4 present the industrial discharge permits in the existing NCWRP and new Morena Pump Station sewersheds. As of August 15, 2016, the expanded NCWRP sewershed, which includes wastewater to be diverted by the Morena Pump Station, would total 48 SIUs, of which 30 are Class 1 permittees subject to Federal Categorical Pretreatment Standards (CIUs), ten are Class 2 SIUs (with toxics, but not CIUs), and eight are Class 3 SIUs (with conventional pollutants, including breweries and groundwater construction dewatering projects). Wastewater in the expanded NCWRP sewershed is primarily from residential and commercial customers. Table 5-5 presents industrial flows in the Project's collection area.

5.3.1.5.e Inventory Maintenance

The IWCP maintains a current Industrial User Inventory and identifies new sources or SIUs by using:

- Industrial User application requests;
- Referrals from the following sources;
  - County Department of Health Services Hazardous Materials Management Unit
  - City of San Diego, Development Services Department, Building Departments
  - Public Works Departments of Participating Agencies' Permit Assistance Centers
- Drive-by surveys;
- Periodic screening of the business license list;
- Annual review of internet Yellow Pages for the area. New listings are compared with the previous directory and current industrial user inventory to check for new, relocated, and closed businesses; and
- Questioning of industry contacts about their competitors in the area.

5.3.1.6 Inspection and Monitoring

Site inspections of applicants' facilities and operations are conducted to:

- Identify and characterize wastewater flows and pollutants;
- Obtain process information;
- Determine applicable Federal Categorical Pretreatment Standards, if any;
- Evaluate pretreatment technology design, maintenance, and operation and, for CIUs, compare with EPA's 'Model Technology';
- Locate discharge points where limits apply and compliance will be determined; and
- Communicate permit requirements, such as Standard Conditions, General and Specific Prohibitions, and site-specific sampling, analysis, and reporting requirements.

5.3.1.6.a Types of Limits

One of IWCP's goals is to determine what constituents are the most critical to control. Three types of discharge limitations are implemented through the IWCP:

- General and Specific Prohibitions that apply to all dischargers;
- Federal Categorical Pretreatment Standards that apply nationally to EPA-specified categories of manufacturers and processes termed CIUs; and

  - These standards are technology-based (i.e., they are based on the performance of industrial treatment and control technologies and not on the risk or impacts upon receiving waters).
  - Concentration-based limits are established for the Clean Water Act Priority Pollutants. EPA has established standards for 56 different industrial categories.
  - IWCP is obligated to implement and enforce these standards for applicable industries in its service area.
- Local Limits that are established specifically by the IWCP and are Publicly Owned Treatment Works-specific, which allows the IWCP to identify and prioritize any constituent for control at any time as needed, based on a technical review of the collection system and treatment plant operations and applicable compliance criteria.
  - Different types of local limits include concentration-based limits that apply to all SIUs within the Metropolitan Sewerage System, facility-specific concentration-based limits, or industry BMPs.

5.3.1.6.b Inspections and Monitoring

The IWCP staff conduct scheduled inspections of SIU and non-SIU operations and pretreatment facilities, rainwater diversions, and storm water discharges. They also perform water use audits and calculate surcharges. The Industrial Waste Laboratory personnel also conduct unannounced sampling visits, collect industry samples, and perform lab analyses. Industrial users submit results at least quarterly from self-monitoring samples and self-certifications of compliance with BMP requirements.

5.3.1.6.c Pretreatment Compliance Inspection

The EPA requires that pretreatment programs be evaluated annually for compliance with federal pretreatment program implementation requirements. A pretreatment program inspection of the City's IWCP was conducted in 2015 by the RWQCB staff and EPA's contract inspection firm, PG Environmental, LLC (City, 2015b). EPA's annual review of the IWCP in 2015 confirmed that the City is meeting its NPDES permit obligations to achieve compliance rates and perform the pretreatment functions required by 40 CFR 403.

5.3.1.7 Enforcement

The IWCP's primary objective is to bring permittees into compliance with applicable federal pretreatment standards, local discharge standards, and BMP Requirements to control discharges and reduce mass emissions of industrial pollutants to the sewer. As provided in its EPA-approved Enforcement Response Plan and the City of San Diego Municipal Code referenced earlier, the City's IWCP staff has a broad range of enforcement mechanisms available, including:

- Recovery of administrative and supplemental monitoring costs related to violation identification and processing;
- Issuance of Notices of Violation and Compliance or Penalty Orders requiring non-compliant permittees to take corrective actions to achieve and maintain permit compliance within a specified time period;
- Publication of the annual List of Facilities in Significant Non-Compliance;
- Permit revocation or suspension; referral for civil/criminal enforcement; and
- Disconnection of the process discharge to the sewer.

5.3.1.8 Other Activities

The City's IWCP staff conducts other source control programs:

- Dry Cleaner Zero Discharge BMPs that require perchloroethylene wastes to either be evaporated or hauled offsite for disposal;
- Silver-Rich Solution BMPs that require these solutions to either be pretreated to recover silver before being discharged to the sewer or lawfully hauled offsite for treatment and disposal;
- Food Establishment Wastewater Discharge Program controls the discharge of grease into the wastewater collection system to prevent sewer blockages; and
    - Food establishments must obtain permits requiring installation of grease-removal equipment designed to trap cooking grease before disposal to the wastewater system, and pump-out maintenance at specified intervals.
- Household Hazardous Waste Collection, which is jointly financed by the City's Environmental Services Department, PUD, and Storm Water Department, and is designed to reduce the introduction of pollutants from non-point sources into sewers, storm drains, and municipal landfills;
    - The City operates a permanent household hazardous waste collection facility, sponsors auto product recycling events, and conducts public outreach activities.

5.3.2 Enhanced Source Control Program for the Project

The SWA regulations will not be finalized by the time this Engineering Report is submitted to DDW. Please be advised that the content below is draft and is based on the assumption that the source control requirements in the SWA regulations will be the same as those in the June 2014 groundwater replenishment regulations.

The SWA regulations stipulate various requirements for source water protection as discussed in Section 5.3. The City already complies with many of the requirements because it administers an enhanced industrial pretreatment program to support the PLWTP permit, and this same program applies to the NCWRP. Other potential enhancements are planned for the City's Industrial Pretreatment and Source Control Program for the Project in order to comply with the regulations, as described below.

5.3.2.1 Industrial Pretreatment and Source Control Program

Section 60320.306(a) of the SWA regulations requires that:

> *"...the recycled municipal wastewater used for a [SWA project] shall be from a wastewater management agency that administers an industrial pretreatment and pollutant source control program."*

As described in Section 5.3.1, the City's IWCP complies with all EPA requirements for industrial pretreatment standards, local limits, and BMPs in the entire Metropolitan Sewerage System area, which includes the NCWRP and Morena Pump Station sewersheds. The City will review the Interagency Pretreatment agreements between the City and Participating Agencies that are served by the Metropolitan Sewerage System to determine if any revisions are required for the Project.

5.3.2.2 Enhanced Source Control Program

Section 60320.306(b) of the SWA regulations requires that:

> *"...the recycled municipal wastewater used for a [SWA project] shall be from a wastewater management agency that implements and maintains a source control program that includes, at a minimum:"*

5.3.2.2.a Assessment of the Fate of Specified Chemicals and Contaminants

> *"An assessment of the fate of SWRCB-specified and RWQCB-specified chemicals and contaminants through the wastewater and recycled municipal wastewater treatment systems."* (Section 60320.306(b)(1))

5.3.2.2.b IWCP Monitoring

The IWCP staff monitors for numerous chemicals and contaminants in the influent to the NCWRP, as well as in the wastewater collected in the Morena Pump Station sewershed, which will supplement flows to the expanded NCWRP. The City Operations staff at the NCWRP monitors the water quality of the recycled water, while the City Operations staff at the NCPWF will monitor the water quality of the purified water.

The NCWRP and NCDPWF, which began operation in 2011, have provided actual operating experience to assess the fate of chemicals and contaminants through the various treatment processes, beginning with raw wastewater and ending with purified water. The NCDPWF and associated special studies have yielded valuable information to track and measure the presence of CECs. The MRP presented in Section 15 for the expanded NCWRP and full-scale NCPWF includes provisions for monitoring CECs and other contaminants. Critical control points and limits will be monitored for optimization of treatment process performance.

5.3.2.2.c Chemical and Contaminant Source Investigations

> *"Chemical and contaminant source investigations and monitoring that focuses on SWRCB-specified and RWQCB-specified chemicals and contaminants."* Section 60320.306(b)(2))

The City's IWCP staff investigates discharges into the wastewater collection system and monitors the quality of the discharges as part of its Regulatory Cycle for the Industrial Pretreatment and Source Control Program as illustrated on Figure 5-6. As described earlier in Section 5.3.1, unannounced sampling events and inspections of industrial dischargers are conducted, as well as planned inspections. SIU permittees are inspected at least annually to identify any changes that may affect permit limits or requirements and permits are amended as needed. Enforcement actions, also discussed in Section 5.3.1, are taken as necessary.

The City monitors the quality of influent to the existing NCWRP, as well as the quality of the Morena Pump Station sewershed. These flow streams were sampled monthly from March, 2016 to March, 2017 for a number of constituents based on experience from Orange County Sanitation District's Groundwater Replenishment System. Those targeted constituents include:

- 1,4-Dioxane;
- N-Nitrosodimethylamine (NDMA);
- Tritium;
- Formaldehyde;
- Acetone; and
- Perchlorate (sampling began in September 2016).

Wastewater quality monitoring of the NCWRP and Morena Pump Station sewersheds was conducted from March, 2016 to March, 2017 that targeted constituents based on source control experience at Orange County Sanitation District's Groundwater Replenishment System. A comparison of the sampling results of these two wastewater streams is presented in Table 5-11 and will be used to characterize the Morena Pump Station wastewater source flows that will be diverted to the NCWRP. If the Morena Pump Station wastewater concentration of a chemical or contaminant is equal to or less than the existing influents to the NCWRP, no further action will be taken at this time, since the year-long NCDPWF experienced no drinking water violations. If the Morena Pump Station wastewater concentration of a chemical or contaminant is greater than that of the existing NCWRP influent, then the pollutant will be termed a constituent of concern for the purposes of the comparison, and a modified NCWRP influent concentration will be calculated. For each constituent of concern, an estimate of the removal efficiency across the NCWRP and NCPWF will be determined and used to calculate the allowable headworks loading of that chemical or contaminant into the NCWRP. If the maximum allowable headworks loading is exceeded, then the likely sources of those chemical(s) or contaminant(s) will be identified and controls will be developed as BMPs or numeric limits in accordance with the City's EPA- approved local limit study headworks loading allocation methodology.

The City performed an annual local limits evaluation for the PLWTP in 2015 that confirmed that the local limits developed in 1996 remain technically justified and sufficient to protect the PLWTP and the environment (City, 2016c). The 2016 annual local limits study was completed on July 1, 2017; no new limits were proposed at that time. Prior to the start of flow diversion via the Morena Pump Station, a local limits study will be completed for the existing NCWRP sewershed to include pollutants with drinking water criteria, both MCLs and Notification Levels, and Drinking Water Contaminant Candidate List of unregulated CECs prioritized for monitoring and possible regulation.

When the NPDES permit for the Project is issued, a local limit study for the expanded tributary area will be conducted that includes all criteria for both the NCWRP and NCPWF.

Table 5-11: Comparison of Selected Constituents in NCWRP and Morena Pump Station Influents

Constituent	Units	Existing NCWRP Sewershed[a]	Morena Pump Station Sewershed[a]
1,4-Dioxane	µg/L	0.7	0.5
N-Nitrosodimethyamine	µg/L	0.8	1.1
Tritium	pCi/L	120	94
Formaldehyde	µg/L	62	44
Acetone	µg/L	243	198
Perchlorate	µg/L	36.2	4.4

[a] Average concentrations in raw wastewater from March, 2016 to March, 2017 based on available results and monthly sampling.

5.3.2.2.d Outreach Program

> *"An outreach program to industrial, commercial, and residential communities within the portions of the sewage collection agency's service area that flows into the water reclamation plant subsequently supplying the [SWA project], for the purpose of managing and minimizing the discharge of chemicals and contaminants at the source."* (Section 60320.306(b)(3))

As described in Section 5.3.1.8, the City's Household Hazardous Waste Program sponsors seven to eight auto product recycling events per year and coordinates and advertises commercial locations that accept auto products for recycling. The City also conducts public outreach activities at schools, businesses, and community group meetings to educate the public about proper disposal of household hazardous wastes, such as paints, batteries, auto products, and medications/pharmaceuticals. These efforts have been successful in increasing public awareness of the importance of proper waste disposal to prevent pollution and protect water quality. All Participating Agencies tributary to the NCWRP have similar Household Hazardous Waste Collection programs at no charge to the residents served by those agencies.

As described in Section 3, the City has implemented an exemplary public outreach program for the Pure Water Program. Tours of the NCDPWF and presentations to various groups by City staff help support the entire Project, including the City's Source Control Program. The tours describe the source wastewater and how the City's industrial pretreatment program supports water recycling and protects water quality.

With regard to industrial users, the City's IWCP staff meets with permittees during onsite inspections to provide guidance and education on the importance of source control. Even when enforcement actions are required, City staff assigned to the IWCP works with industry contacts as the first step to help them correct the problems and successfully comply with their permit. This outreach to industrial dischargers promotes cooperation and openness.

To further support the Source Control Program, the City plans to develop enhanced outreach materials for the Project's service area to encourage continued improvements in pollutant management and minimization at the source. In addition to mail-outs and hand delivery to industrial users, the City's IWCP staff will work with tributary agencies and water providers to distribute these materials to all dischargers, including residential discharges, throughout the Project's expanded sewershed.

5.3.2.2.e Inventory of Chemicals and Contaminants that May Be Discharged into the Wastewater Collection System

> *"A current inventory of chemicals and contaminants identified and evaluated pursuant to this section, including new chemicals and contaminants resulting from new sources or changes to existing sources, that may be discharged into the wastewater collection system."* (Section 60320.306(b)(4))

The IWCP database currently contains, for each permitted discharger, the connecting sewer line section, major downstream pump station, and downstream treatment plant. The City owns and operates the collection system that represents the majority of the Metro flows. The City's PUD geographic information system makes extensive use of the database of sewer infrastructure to locate and track flows when necessary. The City plans to work with the Participating Agencies to obtain digital sewer maps in those service areas where available, and expand its sewer line traceability capability. The City's IWCP staff is investigating whether it can connect permitted industries in its database to other regulatory chemical use databases. The City's geographic information system and digital sewer maps are currently being upgraded, and the City's IWPC staff plans to add industrial user locations and flows to the updated geographic information system database.

6. Project Facilities Description

This section describes the physical infrastructure associated with the North City Pure Water Project. Included in the infrastructure descriptions are details of the conveyance and treatment facilities, their layouts and capacities, and the design criteria associated with all proposed improvements. The detailed facility descriptions substantiate the rationale made in other sections of this Engineering Report that the Project provides full regulatory compliance. Later sections of the report, including Sections 10 through 17, provide details on special features or aspects of those facilities that are more related to their operation. Specific topics addressed in the various subsections include:

- Project description, which presents an overview of the North City Project facilities;
- Wastewater collection system, which describes the sewer system and Morena Pump Station and Pipeline;
- The NCWRP, which will be expanded and upgraded to produce NPR water (disinfected tertiary effluent) for NPR applications and tertiary treated water for the ultimate production of potable reuse;
- Tertiary Treated Water Conveyance System, which will pump tertiary treated water via a pipeline from the NCWRP to the NCPWF;
- The NCPWF, which features advanced treatment processes to produce purified water for SWA and to supplement and effectively reduce the salinity of the NPR water supply;
- The NCPW Conveyance System, which will consist of the NCPW Pump Station and Pipeline (including the NCPW Dechlorination Facility) that will convey purified water from the NCPWF to Miramar Reservoir;
- Miramar Reservoir, which will store purified water produced by the NCPWF; and
- The Miramar DWTP, which will receive and treat water stored in Miramar Reservoir and/or imported water, producing drinking water for distribution to the plant's service area.

The Project facility descriptions provided in this section are based on at least the 60% designs developed for each facility. Therefore, the design approaches presented here have been "locked down" and represent the final design. Subsequent design packages will be submitted to DDW for their review.

6.1 Project Overview

The Project is a planned SWA project that will treat municipal wastewater to generate tertiary treated water to be processed further at an AWT facility, which in turn will produce purified water to supplement a reservoir that supplies a DWTP. A portion of the purified water will be used to reduce the salinity of the NPR water produced by the NCWRP. The use of purified water for salinity management is more reliable and cost effective than the methods currently used by the City. The Project involves multiple treatment processes and barriers to protect public health and the environment, and a reservoir that provides a significant environmental buffer. An overview of the Project is illustrated on Figure 6-1.

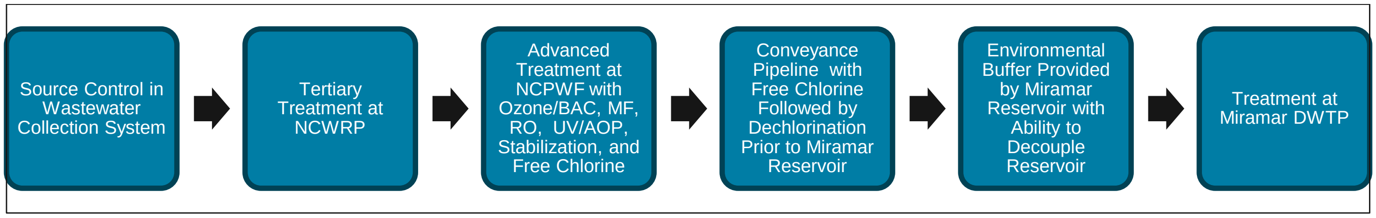

Figure 6-1: North City Pure Water Project Overview

The Project is designed to produce and convey an annual average of up to 30 mgd (33,600 AFY) of purified water to augment Miramar Reservoir as a source water for the Miramar DWTP. In addition, the Project is designed to produce an annual average of approximately 4 mgd (4,480 AFY) of purified water to supplement and reduce the TDS concentration of the NCWRP NPR water that is used for irrigation and other approved Title 22 applications. The Project is designed to produce up to 34 mgd of purified water. Figure 6-2 illustrates a general layout of the Project in north San Diego.

Figure 6-2: General Project Location

Figure 6-3 illustrates the schematic of the entire Project, including the wastewater collection system, the NCWRP, NCPWF, NCPW Dechlorination Facility, Miramar Reservoir, Miramar DWTP, as well as interconnecting pump stations and pipelines.

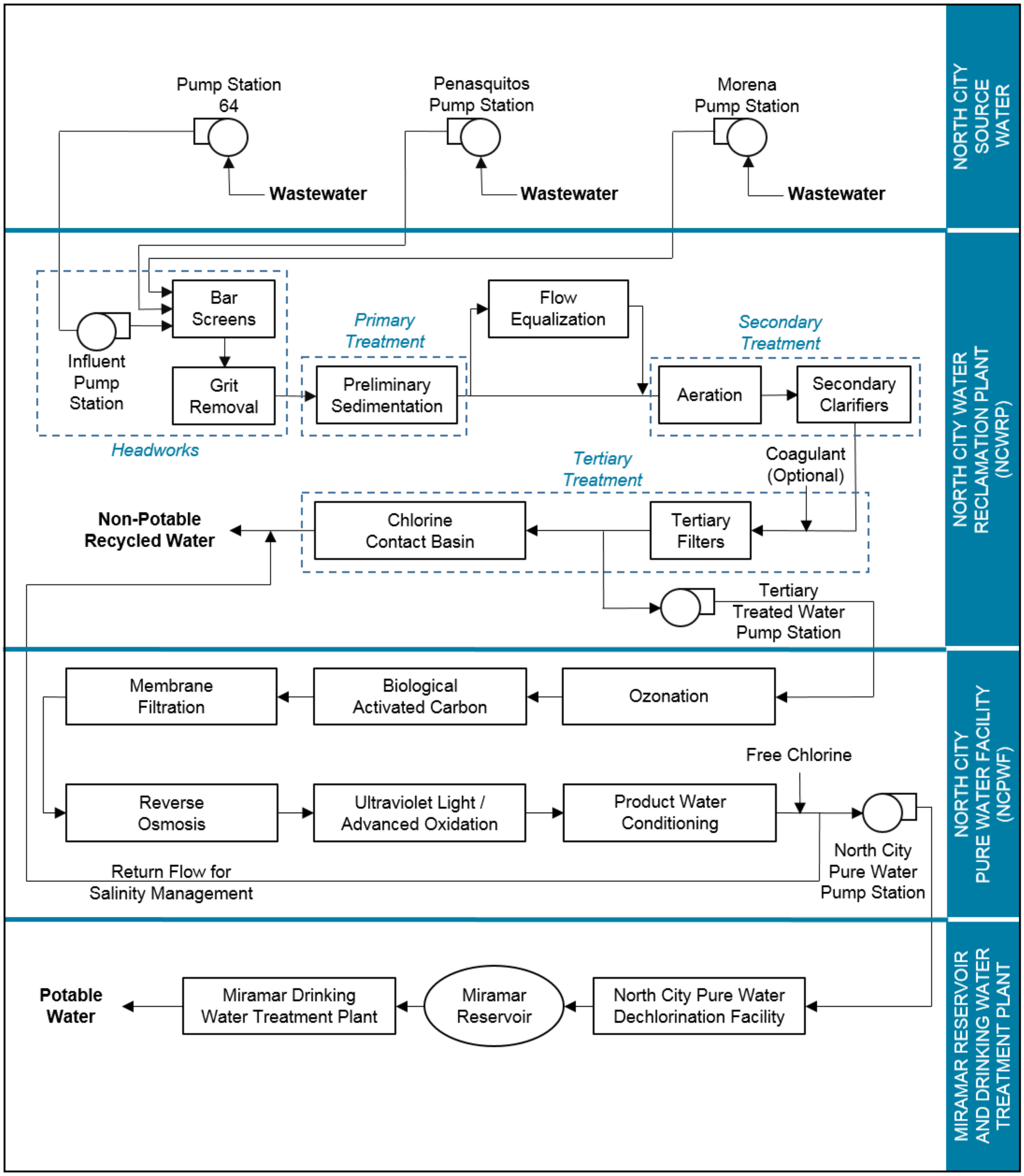

Figure 6-3: North City Project Process Schematic

The Project sewershed is described in Section 5.1, and the wastewater collection system is described in Section 6.2. On average, a total of approximately 52 mgd of raw wastewater from the NCWRP's existing sewershed and the new Morena Pump Station sewershed will be conveyed to the NCWRP for treatment. Morena Pump Station will be located northeast of the intersection of Interstate 5 and Interstate 8. The Morena Pipeline, a new 48-inch-diameter forcemain extending approximately 10.4 miles, will convey wastewater to the NCWRP.

The existing NCWRP, located at Eastgate Mall and Interstate 805, currently produces an average of about 7 mgd of disinfected tertiary-treated recycled water for direct, non-potable use. Following secondary and tertiary treatment, a portion of the flow is demineralized using two parallel treatment trains, one uses electrodialysis reversal and the other includes RO. This RO train makes use of the NCDPWF. Either one or both of these trains may be in use at any given time. Demineralizing a portion of the flow allows the overall NPR water to have lower salinity. The existing NCWRP has an average daily treatment capacity of 30 mgd and acts as a scalping plant, receiving flows that would otherwise be treated at the PLWTP.

Figure 6-4 illustrates the process flow diagram of the wastewater collection system, NCWRP, and NCPWF.

The NCWRP will be expanded and upgraded to produce sufficient NPR water to meet NPR water demands and generate undisinfected tertiary treated water for the NCPWF. Treatment at the expanded NCWRP will feature screening, grit removal, chemically-enhanced primary sedimentation, primary effluent flow equalization, biological treatment using the 4-stage Bardenpho (nitrification- denitrification) process for nitrogen removal, secondary clarification, coagulation followed by deep bed anthracite filtration, and chlorine disinfection, only for filtered secondary effluent that will be used for NPR; non-disinfected filtered secondary effluent will be conveyed to the NCPWF. The flow equalization facilities help mitigate impacts from diurnal flow variations, supporting a stable biological process and filtration, as well as consistent flows to the NCPWF. Secondary and tertiary treatment are the initial treatment barriers for pathogen reduction for potable reuse, as detailed in Section 10. Solids from the NCWRP will be conveyed to the MBC for treatment and disposal. Section 6.2.2 provides more details about the NCWRP expansion.

The Tertiary Treated Water Conveyance System, described in Section 6.2.4, will convey approximately 42 mgd of undisinfected tertiary treated water from the NCWRP to the NCPWF.

The NCPWF is located immediately to the north, across Eastgate Mall and adjacent to the NCWRP, and is designed to produce up to 34 mgd (38,080 AFY) of purified water. Approximately 30 mgd (33,600 AFY) of purified water (on average) will be pumped to Miramar Reservoir and the remainder of the purified water will be used for in-plant water and salinity management in the NPR water system. Discussed in more detail in Section 6.3.1, the NCPWF will feature AWT processes that provide multiple treatment barriers for reduction of pathogens and chemical contaminants. Treatment processes will include ozonation, BAC filtration, MF, RO, UV/AOP, stabilization via carbon dioxide and lime addition, and chlorination.

A free chlorine residual will be maintained in the NCPW Pipeline from the NCPW Pump Station to just upstream of the inlet at Miramar Reservoir, where the purified water will be dechlorinated. The conveyance pipeline will be a 48-inch-diameter pipeline that is approximately 8 miles long, ending with a subaqueous pipeline with numerous orifices to disperse the purified water in the reservoir. Section 6.3.2 presents information on the NCPW Pump Station and NCPW Pipeline, NCPW Dechlorination Facility, and reservoir inlet.

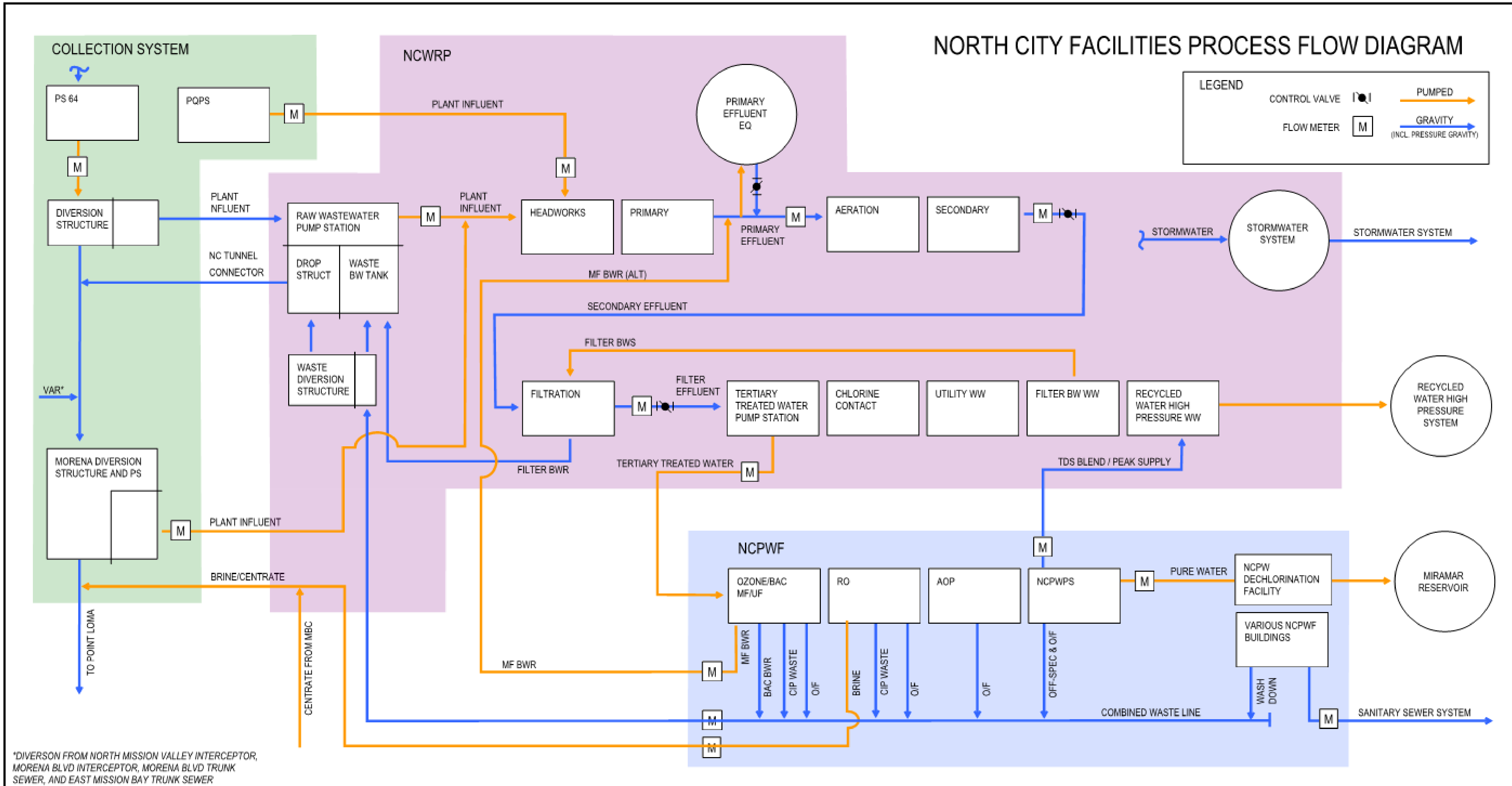

Figure 6-4: North City Project Process Flow Diagram

Note: MF Backwash line has been incorporated into the Combined Waste Line.

Miramar Reservoir, illustrated on Figure 6-5, currently stores water imported from the Colorado River and Northern California. Its earth-fill dam was built in 1960 and impounds a small, naturally dry canyon. The local watershed contributes essentially no runoff to the reservoir. The only outflow from the reservoir is to the adjacent Miramar DWTP, also illustrated on Figure 6-5. Miramar Reservoir's primary use is municipal water supply; other beneficial uses include limited recreational activities.

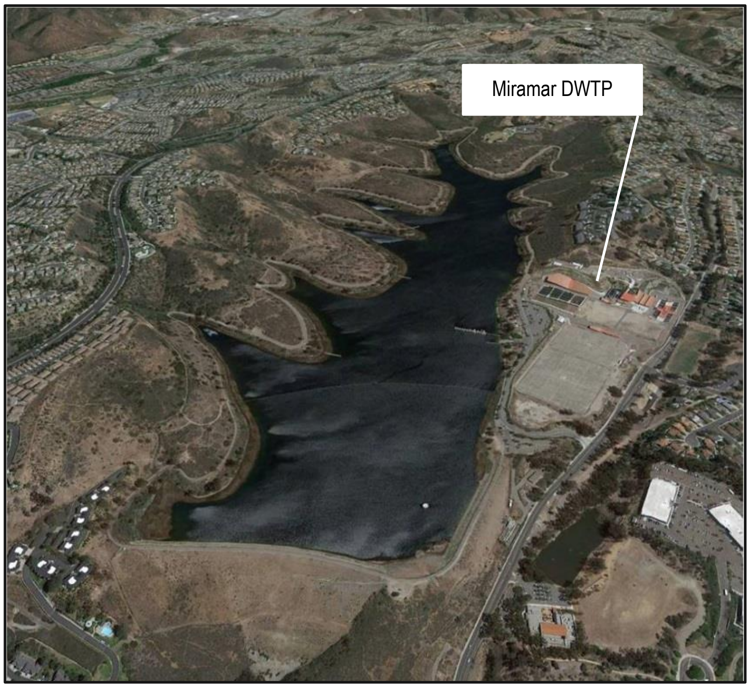

Figure 6-5: Miramar Reservoir and the Miramar DWTP

Miramar Reservoir has a maximum volume of approximately 6,700 AF, a surface area of about 162 acres when full, and a maximum depth of approximately 114 ft. The operational storage ranges from 5,800 AF to 6,100 AF.

While the Project will augment Miramar Reservoir with an annual average of 30 mgd (33,600 AFY) of purified water, it is anticipated that seasonal variations in the inflow of purified water to the reservoir will occur due to variable NPR water demands at the NCWRP. Average winter daily inflows to the reservoir may range up to 32.8 mgd and average summer daily inflows may range down to 23.4 mgd. At an average reservoir withdrawal rate of 30 mgd (33,600 AFY) (to match average purified water inflows), and at a typical reservoir volume of 5,800 AF, the theoretical average purified water retention time in the reservoir will be at least two months. Thus, Miramar Reservoir provides an important environmental buffer. Section 6.3.3 provides a more detailed description of Miramar Reservoir and its associated infrastructure while Section 11 presents the hydrodynamic modeling performed to simulate reservoir operating conditions, predict water quality, and demonstrate that Miramar Reservoir can be used as an environmental barrier according to the requirements of the SWA regulations.

The Miramar DWTP has a current rated capacity of 144 mgd and serves the northern portion of the City's drinking water distribution system. After construction of the new clearwells and chlorine contact chamber is completed, the Miramar DWTP will have the ability to produce 215 mgd, which will require a permit amendment to allow high-rate filtration to attain the higher rated capacity. The Miramar DWTP is a conventional water treatment facility that uses ozone as a primary disinfectant. Sections 6.3.4 and 12 describe the Miramar DWTP and the drinking water distribution system in more detail.

The Miramar DWTP is normally supplied by imported water via direct connections to the SDCWA's Aqueduct. Imported water is also stored in Miramar Reservoir for operational use, and can be pumped to the adjacent plant for treatment. Each of these sources is under the immediate control of the City's plant operator and can be shut off without disrupting the Miramar DWTP's ability to supply the distribution system. Thus, should Miramar Reservoir need to be taken off-line for any reason, the Miramar DWTP can continue to meet system demands using the direct connections to the SDCWA's system. This ability to decouple the purified water stored at Miramar Reservoir from the Miramar DWTP is another key mechanism that allows the City to provide full protection of public health.

More detail about each component of the Project is provided in the following sections. Project components are grouped into two general sections: (1) NPR Facilities, and (2) Potable Reuse Facilities, to facilitate the review of this Engineering Report given the need for separate NPDES permits for the NCWRP and NCPWF.

6.2 Non-Potable Reuse Facilities

6.2.1 Wastewater Collection System

The NCWRP operates as a scalping plant, receiving wastewater flows that would otherwise be treated at the PLWTP. It is currently fed from two different sources in the collection system, as illustrated on Figure 6.4 in the green highlighted area. The flow from Pump Station 64 is pumped to a diversion structure, which then flows by gravity to the NCWRP Raw Wastewater Pump Station. The NCWRP Raw Wastewater Pump Station then pumps wastewater to the headworks facility for preliminary screening. The Peñasquitos Pump Station pumps wastewater directly to the NCWRP headworks facility.

Currently, the existing pump stations that deliver wastewater to the NCWRP are not able to deliver the 52 mgd required, during average dry weather conditions, to produce 34 mgd of purified water and 11.8 mgd of NPR water. To provide an adequate supply of wastewater for the NCWRP, new diversion structures, a pump station, and a force main will be built. The Morena Pump Station will take wastewater from the area near the intersection of Friars Road and Morena Boulevard, and pump it north to the NCWRP. This will allow the NCWRP to operate consistently at 52 mgd on an average annual flow basis.

The Morena Pump Station and Pipeline will divert wastewater from four different existing sanitary sewers. The Morena junction and diversion structures connects the North Mission Valley Interceptor, Morena Boulevard Interceptor, Morena Boulevard Trunk Sewer, and East Mission Bay Trunk Sewer (illustrated on Figure 6-4) to the new Morena Pump Station. Influent flows are conveyed through a new 60-inch-diameter plastic-lined reinforced concrete pipe diversion to the flow separator structure before entering the intake screening building. Wastewater is conveyed to the pump station building through another 60-inch-diameter plastic-lined reinforced concrete pipe downstream of the intake screening building.

Table 6-1 presents design criteria for the Morena Pump Station based on the Morena Pump Station and Pipeline 10% Engineering Design Report (MWH/BC, 2016a). It will consist of a below-grade, cast-in-place reinforced concrete structure with five sets of two-stage vertical-turbine, non-clog pumps operating in a four active plus one set standby (4+1) configuration. The total dynamic head of 600 ft is required to overcome dynamic losses during the 10.4-mile force main conveyance, difference in elevation, and operating pressure at the NCWRP Raw Wastewater Pump Station force main, where the Morena Pump Station force main will connect. The need for variable-frequency drives and multiple pumps allows the Morena Pump Station to deliver the required range of flow and head conditions. The Morena Pump Station will be controlled via a pumping set point received from the distributed control system. The pumping set point will be based on water level in the equalization basins at the NCWRP. The number and speed of active pumps will be selected based on the target pumping rate to maximize efficiency.

Table 6-1: Morena Pump Station and Pipeline Design Criteria

Parameter	Units	Value
Morena Pump Station		
Design flow	mgd (average annual daily flow)	32.0
Number of pumps		
Total	units	5
Duty	units	4
Standby	units	1
Type	--	Two-stage vertical, non-clog
Rated capacity, each	mgd	9.4
Rated total discharge head	ft	600
Horsepower, each	hp	1,000
Drive type	--	Variable Frequency Drive
Flow metering	--	Magnetic
Morena Pipeline		
Diameter	inches	48
Length	miles	10.4

The Morena Pump Station site will include new facilities to supply high purity oxygen for odor control in the force main and to manage septicity in the long pipeline, and an odor control system to remove and treat foul air (using granular activated carbon [GAC]) from the screening facility and Morena Pump Station wetwell.

Wastewater will be conveyed from the Morena Pump Station via the Morena Pipeline, a new 48-inch-diameter force main, approximately 10.4 miles north to the NCWRP. Most of the Morena Pipeline is anticipated to be constructed using open-trench methods, and a portion will be constructed using tunneling methods. Figure 6-6 illustrates the Morena Pipeline's planned alignment.

The Morena Pipeline will connect to the existing NCWRP Raw Wastewater Pump Station discharge line, which is an existing 60-inch-diameter pipeline that ends at the headworks building. Figure 6-7 illustrates the ground surface profile and hydraulic grade of this pipeline. There will be a significant grade change along the pipeline alignment, as indicated by the large static head losses. To meet anticipated discharge pressures from the Morena Pump Station, the pipeline will be constructed of cement mortar lined and coated steel pipe.

Maintenance access manways will be placed along the pipeline alignment, and isolation valves will be installed. Blowoff valves will be located at local low points and air vacuum/air release assemblies located at local high points.

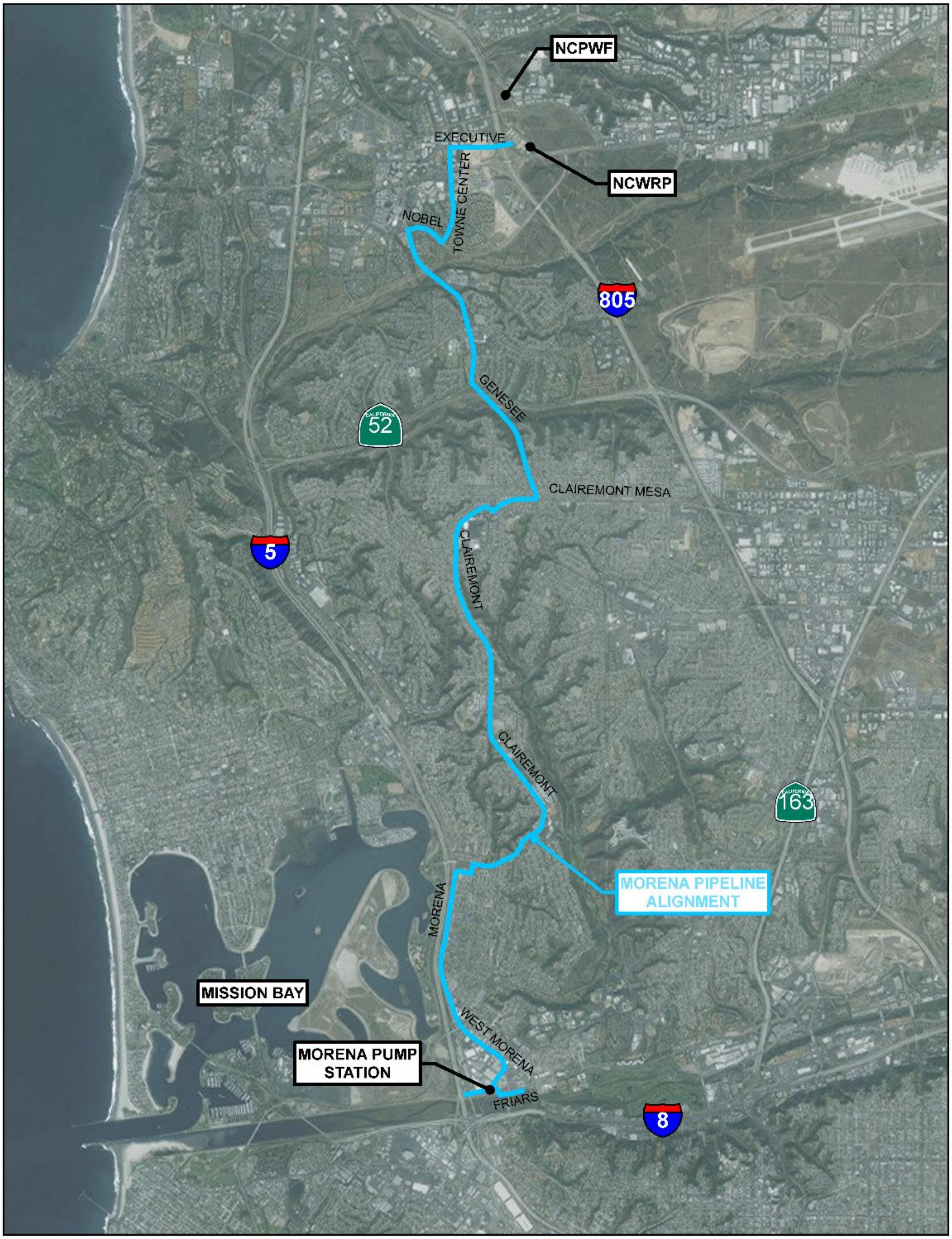

Figure 6-6: Morena Pump Station and Pipeline Alignment

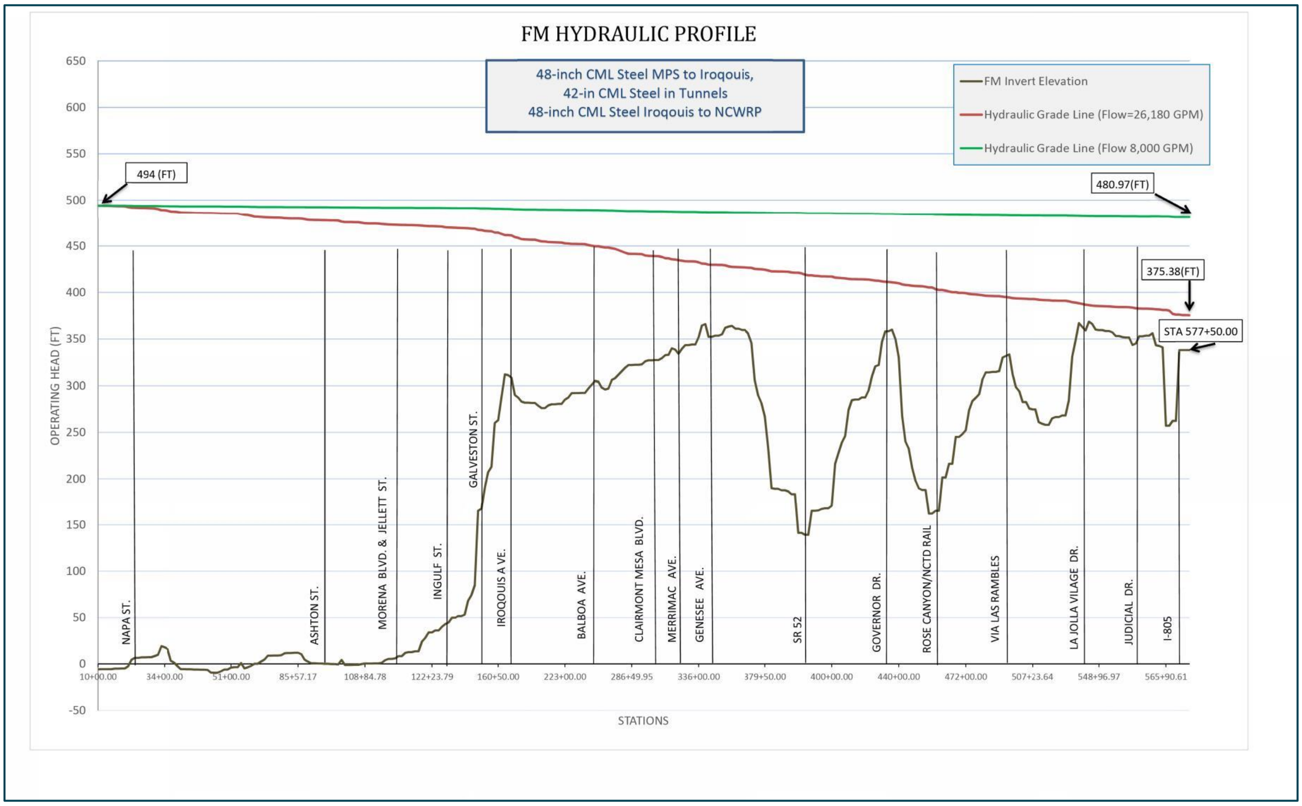

Figure 6-7: Morena Pump Station and Pipeline Hydraulic Grade Line

6.2.2 North City Water Reclamation Plant Expansion

The following section describes the NCWRP expansion, which is further documented in the NCWRP Expansion 10% Engineering Design Report (MWH/BC, 2016b). It should be noted that the detailed design is being updated to include the re-purposing of the NCWRP's existing clarifiers to serve as the second stage of the recommended 4-stage Bardenpho process. This design revision is included in this Engineering Report.

6.2.2.1 North City Water Reclamation Plant Expansion Overview

The Project's initial phase will produce up to 34 mgd of purified water for reservoir augmentation. The NCPWF will receive tertiary treated water from the NCWRP. The NCWRP was initially rated for an annual average design capacity of 30 mgd. It began operation in 1997 and, in 2014, it delivered approximately 6.7 mgd (7,500 AFY) of NPR water to irrigation and industrial customers throughout the northern San Diego region. The location of the NCWRP in relation to other North City Project facilities is illustrated on Figure 6-2 presented earlier.

The design upgrades to the NCWRP will increase the annual average flow capacity from 30 to 52 mgd with a peak day flow of 55 mgd. The NCWRP will have flow equalization facilities that will allow different flows through various process units while maintaining a relatively constant flow through the secondary treatment and tertiary filtration systems. The upgrades will allow the NCWRP to produce a relatively constant flow to continue production of NPR water and provide a new tertiary treated water stream for advanced treatment at the NCPWF to produce purified water. Based on customer requests currently under consideration, the annual average and maximum daily NPR flows have been established at 11.8 and 21.6 mgd, respectively.

The existing NCWRP consists of screening and grit removal, primary sedimentation, primary effluent flow equalization, secondary aeration with full nitrification and partial denitrification, secondary clarification, deep-bed anthracite filtration, chlorine disinfection, and a NPR water pump station to satisfy NPR water demands. Demineralization is also performed to meet TDS requirements for NPR. Chlorination disinfection meets the Title 22 Water Recycling Criteria (CCR, 2014) requirements for current uses of the NPR water. The NCWRP's existing treatment processes are illustrated on Figure 6-8, and an aerial view of the facility is illustrated on Figure 6-9. A more detailed site plan of the existing NCWRP is provided in the NCWRP Expansion 10% Engineering Design Report (MWH/BC, 2016b).

The expanded NCWRP facilities will include an additional bar screen, grit pumps, primary sedimentation tanks, a new primary effluent flow equalization basin, aeration basins, secondary clarifiers, tertiary filters, and ancillary and support systems. The NCWRP expansion will also add CEPT. Adding a third flow equalization basin will enhance the NCWRP's operational flexibility and reliability by providing a constant flow to the secondary treatment and filtration processes. Sizing is based on an N+1 concept, such that at least one additional standby unit or basin will be provided for redundancy.

The expanded biological treatment process at the expanded NCWRP will employ the 4-stage Bardenpho process, which is a process for biological nutrient removal that uses a series of anoxic and aerobic processes for the conversion of ammonia to nitrate then to nitrogen gas. The target total nitrogen concentration for the NCWRP tertiary treated water is 10 milligrams per liter (mg/L) as nitrogen or below. This threshold assumes a 90 percent reduction of total nitrogen through the NCPWF to produce a concentration of 1 mg/L as nitrogen in the purified water. The City has stress-tested existing facilities as part of the Project's predesign to ensure robust and reliable treatment operation at the expected flow rates. A rendering of the expanded NCWRP is illustrated on Figure 6-10.

Design of the NCWRP expansion assumes a total SRT of ten days. Coupled with ozone treatment that follows the tertiary process, effective CEC removal is expected to be consistently high and reliable.

The secondary treatment facility will consist of first stage aeration basins with mixed liquor recycle, second stage aeration basins, and new circular secondary clarifiers. Within the aeration basins, the mixed liquor, a combination of equalized primary effluent and return activated sludge, will pass through five zones of unaerated (anoxic) volume. Following the anoxic zones, the flow will enter four sequential aerobic zones. At the end of the final aerobic zone, a portion of the nitrified mixed liquor will be recycled back to the first anoxic zone.

The remaining volume in the first stage aeration basins (that is not recycled back) will be conveyed to the second stage aeration. The existing secondary clarifiers will be repurposed to serve as the second stage aeration basins. Upon entering the second stage aeration basins, the flow will enter two sequential post-anoxic zones for denitrification. If necessary, supplemental carbon will be fed into the first zone to accelerate the denitrification process. Following the second stage of denitrification, the mixed liquor will enter two stages of aerobic zones for final treatment.

The improvements proposed as part of the NCWRP expansion will provide sufficient capacity to meet the NCPWF flow and water quality requirements, improve energy efficiency, and minimize additional operational and maintenance requirements.

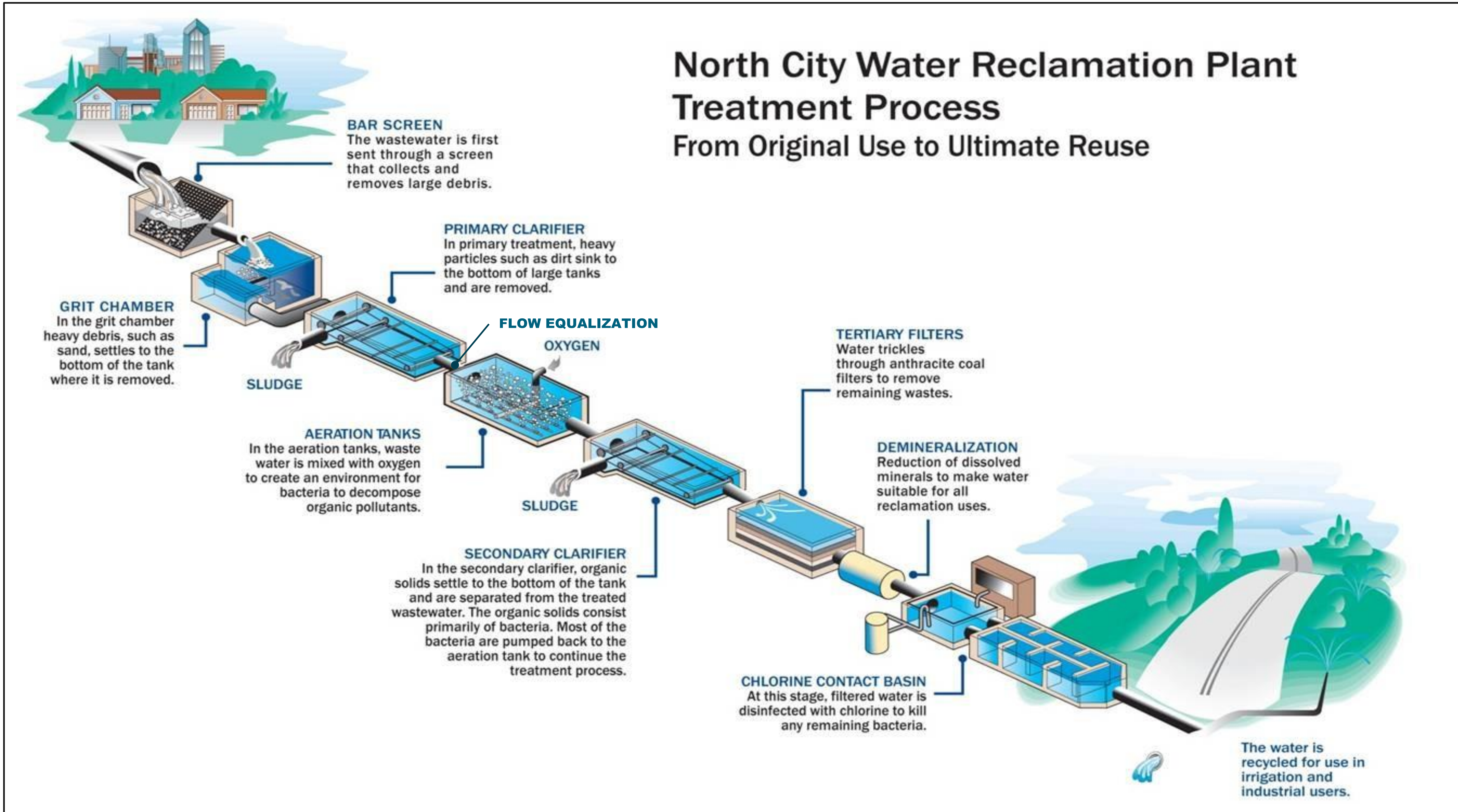

Figure 6-8: NCWRP Existing Treatment Processes

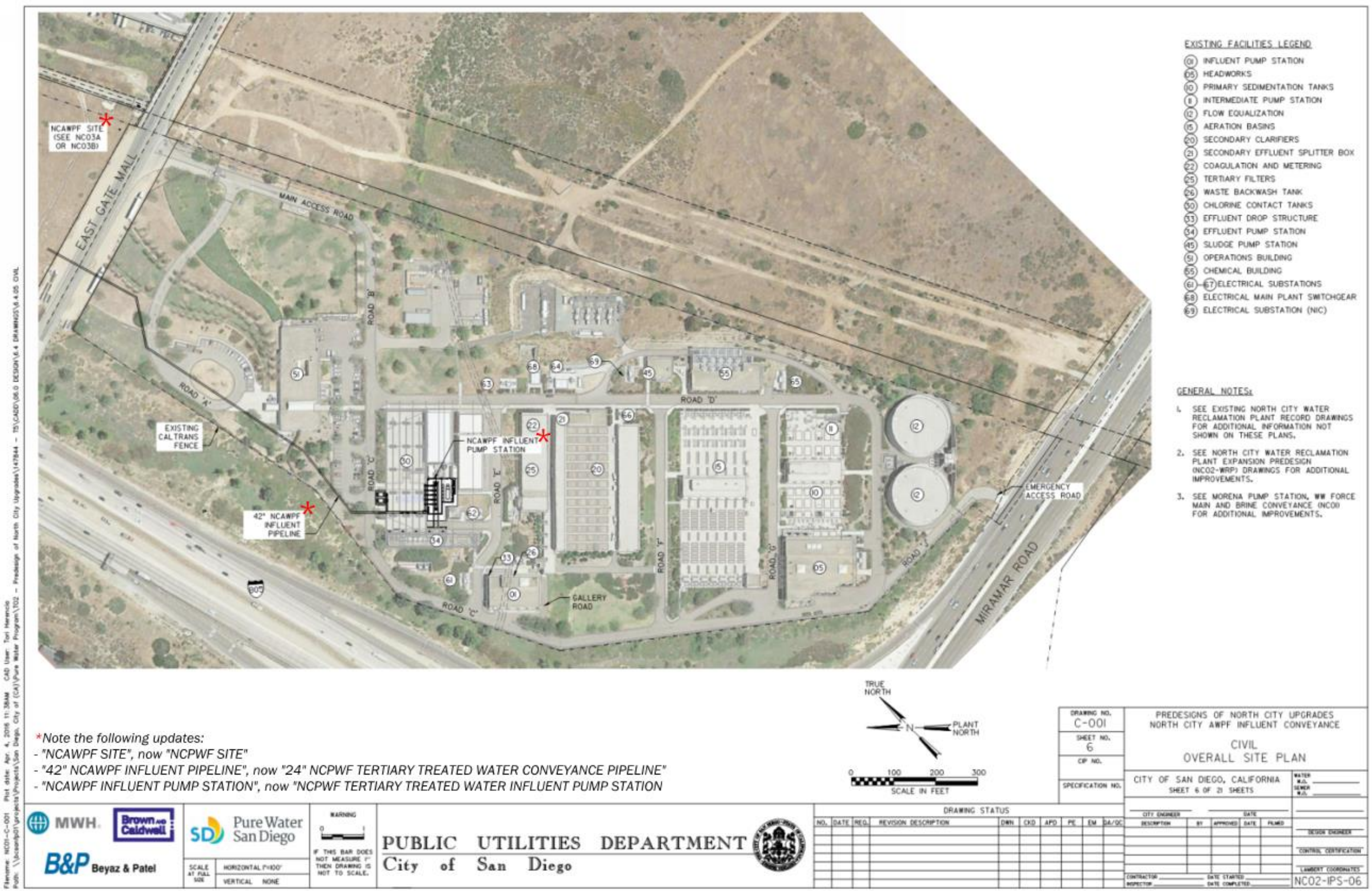

Figure 6-9: Existing NCWRP Aerial View

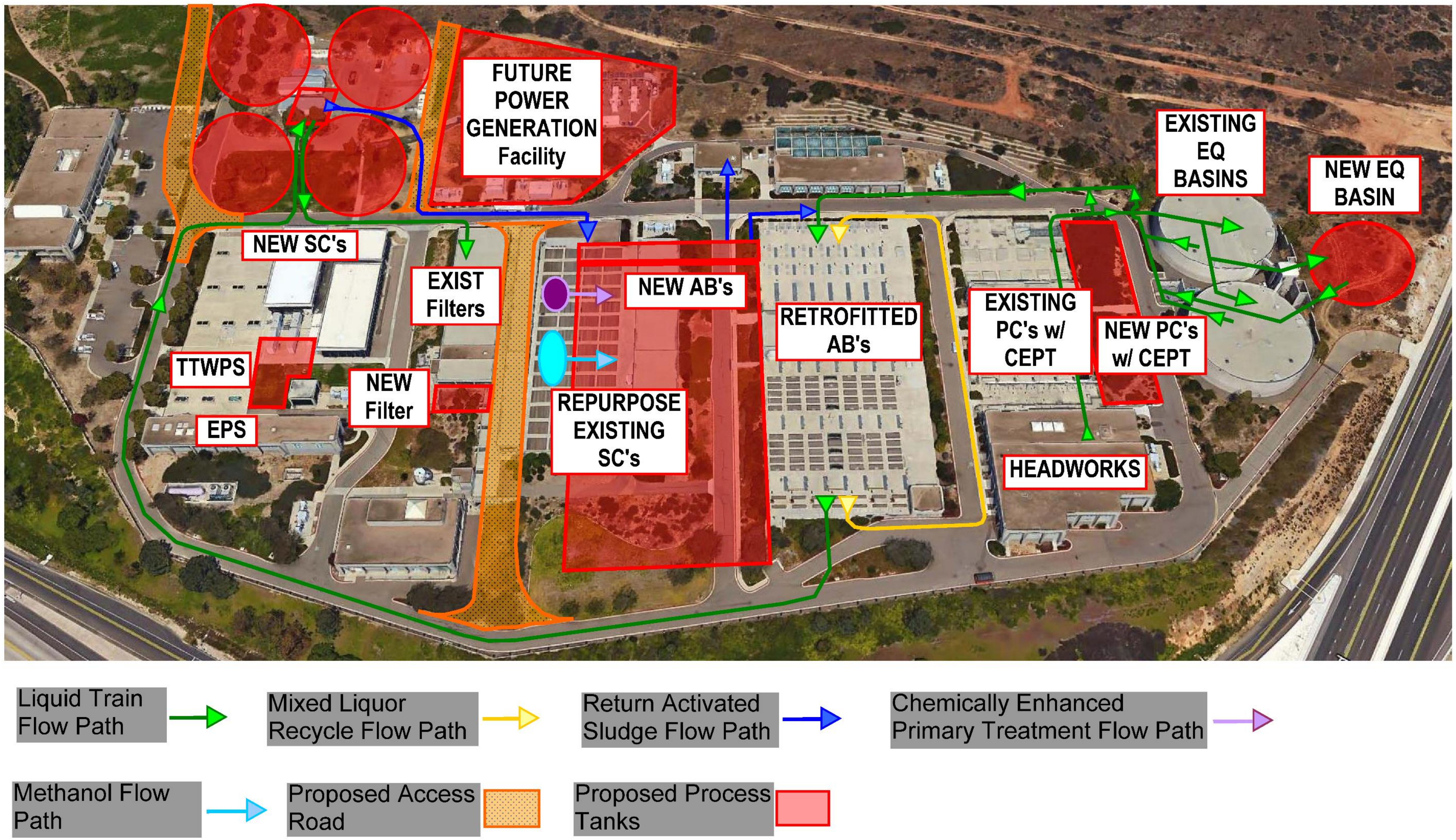

Figure 6-10: Schematic of Expanded NCWRP

AB's = aeration basins
EPS = NPR water pump station
EQ = flow equalization
PC's = primary clarifiers
SC's = secondary clarifiers
TTWPS = Tertiary Treated Water Pump Station to NCPWF

6.2.2.2 Process Unit Sizing and Recommended Equipment Improvements

The following section describes the required improvements at each process area of the NCWRP. More detailed unit process design criteria can be found in the NCWRP Expansion 10% Engineering Design Report (MWH/BC, 2016b). The NCWRP existing process and planned expansion summary are presented in Table 6-2.

Table 6-2: NCWRP Existing Process and Planned Expansion Summary

Process	Number of Basins		
	Existing	New	Total
Bar screens	2	1	3
Primary clarifiers with CEPT	6	3	9
Flow equalization	2	1	3
Aeration basins (4-stage Bardenpho)	7	9	16
Secondary clarifiers	14 rectangular	4 circular	4 circular
Tertiary filters Based on 5 gpm/sf Based on 7.5 gpm/sf	6	 3 1	 9 7

6.2.2.2.a North City Water Reclamation Plant Raw Wastewater Pump Station

The existing NCWRP Raw Wastewater Pump Station, with four pumps installed, has sufficient capacity to convey the required annual average flow of 52 mgd. The expected minimum flows can be conveyed with one pump operating, and average and peak flows can be conveyed with two pumps operating at reduced speed (470 revolutions per minute). The existing third and fourth pumps will be in standby mode; therefore, the existing Raw Wastewater Pump Station is hydraulically sufficient for the expanded NCWRP and North City Project. Design criteria are presented in Table 6-3.

Table 6-3: NCWRP Raw Wastewater Pump Station Design Criteria

Parameter	Units	Existing NCWRP	Modified NCWRP
Design flow	mgd (avg/peak)	34 / 60	34 / 60
Number of pumps			
Total	units	4	4
Duty (avg/peak)	units	2 / 3	2 / 3
Standby (avg/peak)	units	2 / 1	2 / 1
Type	--	Mixed Flow, Non-Clog, Dynamically Balanced	Mixed Flow, Non-Clog, Dynamically Balanced
Rated capacity, each	gpm	17,300	17,300
Rated total discharge head	ft	95	95
Horsepower, each	hp	600	600
Drive type	--	Adjustable Frequency Drive	Adjustable Frequency Drive
Flow metering	--	Magnetic	Magnetic

Reliability and redundancy criteria for the raw wastewater pump station require that it is able to pump the peak flow with the largest unit out of service. As described above and presented in Table 6-3, this criterion is met.

The following conditions at the NCWRP Raw Wastewater Pump Station are alarmed to the distributed control system: influent wet well explosion hazard, influent pump room explosion hazard, gas analyzer trouble, influent wet well low, influent wet well high, influent wet well gate trouble, influent pump roof flooded, draft tube drain sump flooded, influent pump discharge valve fail, influent pump seal water low pressure, influent pump fail, influent bubbler fail, ventilation trouble, headworks sample jar full, plan drain sample jar full, and waste backwash water sample jar full.

6.2.2.2.b Screening

The existing screening facility structure was designed for plant influent peak hour flow of 90 mgd, (with all units in service), although not all screening equipment required to pass that rate was installed, thus reducing the capacity of the facility to 30 mgd (with one unit in standby). For the expanded NCWRP, the screening facility will receive flows from the existing Pump Station 64 via the NCWRP Raw Wastewater Pump Station, the existing Penasquitos Pump Station, and the new Morena Pump Station. Flows from the Penasquitos Pump Station will come directly to the screening facility, and flows from the Morena Pump Station will mix with flows from the NCWRP Raw Wastewater Pump Station prior to reaching the screening facility.

The expansion of the NCWRP will include increasing the capacity of the headworks and refurbishing or replacing major equipment. The existing screening conveyor will be rehabilitated, and the two existing screens will be removed, three new fine screens will be installed, and washer compactors will be installed with each new screen. Miscellaneous work, such as wash water piping, instruments, and equipment pads, will be constructed. Rehabilitation or replacement of existing isolation gates for each screen will be performed prior to commissioning of the new screens. The gate replacement work will also be performed. Design criteria are presented in Table 6-4.

Table 6-4: NCWRP Screening Facility Design Criteria

Parameter	Units	Existing NCWRP	Modified NCWRP
Design Flows, each	mgd	30	42.5
Type	--	mechanically cleaned – climber type	mechanically cleaned – multi-rake type
Number			
Total	units	2	3
Duty	units	1	2
Standby	units	1	1
Number of manual bar screens	units	None	None
Maximum channel side water depth	ft	10	10

Reliability and redundancy criteria for the screening facility require that the facility be able to screen the peak flow with the largest unit out of service. As described above and demonstrated in Table 6-4, this criterion is met.

The following conditions at the screening facility are alarmed at the distributed control system: bar screen plugged, bar screen trouble, screenings washer/press trouble, screenings conveyor trouble, and screenings hopper full.

6.2.2.2.c Grit Removal

The existing grit removal facility is designed for a plant influent peak hour flow of 90 mgd and is adequate for the expanded NCWRP. Currently, only one grit tank is required to be in operation while keeping the second tank on standby mode; however, the expanded NCWRP requires that two grit tanks be in operation and the agitation air system operate continuously. Currently, six grit pumps are each dedicated to three individual grit tank hoppers in each tank. There is cross-connection of suction and discharge lines of Grit Pumps 1 and 2, 2 and 3, 4 and 5, and 5 and 6. This arrangement substantially limits reliability and redundancy of the entire existing grit removal system; specifically, the grit pumping system has potential to be a major source of operation and maintenance problems. To alleviate this issue, four additional standby grit pumps (7 through 10) will be installed to improve system reliability and redundancy. These pumps will match the existing horizontal recessed-impeller grit pumps.

The existing grit cyclones and classifiers will be replaced with new cyclones and classifiers sized for equal capacity as the current equipment. New instruments will be provided for pressure readout on the new connections. The new classifier will be of similar style as the previous one, but will be constructed of 316 stainless steel to prevent corrosion.

Table 6-5: NCWRP Grit Removal Facility Design Criteria

Parameter	Units	Existing NCWRP	Modified NCWRP
Grit Removal			
Design Flows	mgd (avg/peak)	30 / 90	55 / 80
Number Installed	--	2	2
Type	--	Aerated grit	Aerated grit
Volume, each	cubic ft	16,800	16,800
Total volume	cubic ft	33,600	33,600
Detention time, all units in service	minutes (avg/peak)	10.7 / 4.02	6.09 / 5.73
Detention time, one unit out of service	minutes (avg/peak)	5.35 / 2.01	3.04 / 2.87
Grit Pumps			
Number			
Total	units	6	10
Duty	units (avg/peak)	3 / 6	6 / 6
Standby	units (avg/peak)	3 / 0	4 / 4
Type		Recessed impeller	Recessed impeller
Capacity, each	gpm	250	250
Continues on next page...			

Parameter	Units	Existing NCWRP	Modified NCWRP
Pump discharge pressure	ft	75	75
Motor Size	hp	40	40
Grit Aeration Blowers			
Number			
Total	units	3	3
Duty	units	2	2
Standby	units	1	1
Type	--	Rotary Lobe Positive Displacement	Rotary Lobe Positive Displacement
Capacity per blower	standard cubic ft per minute	300	300
Blower discharge pressure	psig	10	10
Motor size	hp	25	25
Grit Cyclones			
Number			
Total	units	6	6
Duty	units	4	4
Standby	units	2	2
Capacity per Cyclone	gpm	250	250
Grit Classifiers			
Number			
Total	units	2	2
Duty	units	2	2
Standby	units	0	0
Capacity per Classifier	gpm	750	750

Reliability and redundancy criteria for the grit removal facility require that the grit tanks and pumps be able to handle the peak flow with the largest unit out of service. As described above and demonstrated in Table 6-5, this criterion is met.

The following conditions at the grit removal facility are alarmed at the distributed control system: grit pump overpressure, and grit pump under-pressure.

6.2.2.2.d Primary Sedimentation

To expand the NCWRP, the Project will include three additional primary sedimentation tanks of equal size and same configuration as the existing six tanks (20 ft wide and 208 ft long) for a total of nine primary sedimentation tanks. The addition of primary sedimentation tanks will require additional primary sludge pumps. The existing configuration, in which every tank has a dedicated pump and every two tanks share a swing standby pump, will be retained. Since there will be an odd number of clarifiers, one tank will have a dedicated standby primary sludge pump. Two swing standby pumps and three new dedicated pumps will be added for primary Sedimentation Tanks 7, 8, and 9, for a total of five new primary sludge pumps. The existing nine primary sludge pumps will be replaced with pumps of a similar design operating condition, and five additional pumps will be installed for the three new primary sedimentation basins to meet the hydraulic requirements of the expanded facility. Design criteria are presented in Table 6-6.

Table 6-6: NCWRP Primary Sedimentation Design Criteria

Parameter	Units	Existing NCWRP	Modified NCWRP
Primary Clarifiers			
Design Flows	mgd (avg/peak)	33.8 / 60	56.7 / 85
Number			
Total	units	6	9
Duty	units	5	8
Standby	units	1	1
Type	--	Rectangular - Conventional	Rectangular – CEPT
Surface area per clarifier	sf	4,160	4,160
Total surface area	sf	24,960	37,440
Volume, each	cubic ft	45,760	45,760
Total volume	cubic ft	274,560	411,840
Avg / Peak overflow rate, all units in service	gpd/sf	1,355 / 2,404	1,513 / 2,270
Avg / Peak overflow rate, one unit out of service	gpd/sf	1,626 / 2,885	1,628 / 2,554
Design BOD removal	percent	26	51
Design TSS removal	percent	60	78
Primary Sludge Pumps			
Number	--	9	14
Type	--	Horizontal recessed impeller	Horizontal recessed impeller
Capacity, each	gpm	300 / 300	250/250
Head at Capacity	ft	41 / 41	41/41
Motor Horsepower	hp	25 / 25	25/25

Reliability and redundancy criteria for the primary sedimentation facility require that the primary clarifiers and primary sludge pumps be able to handle the peak flow with the largest unit out of service. As demonstrated in Table 6-6, this criterion is met.

The following conditions at the primary sedimentation facility are alarmed at the distributed control system: primary sludge collector flight fail, primary sludge collector torque high, primary sludge collector shear pin fail, primary sludge pump trouble (no flow, overpressure), primary scum pump trouble, and primary effluent sample jar full.

6.2.2.2.e Primary Effluent/Return Activated Sludge Mixing and Flow Equalization Basins/Intermediate Pumping

The existing primary effluent/return activated sludge mixing channel will be retained without the need for expansion. One new flow equalization tank will be added for the expanded NCWRP.

Currently, six submersible mixers operate to keep the primary effluent and return activated sludge in suspension to avoid settling. Although the mixers have sufficient capacity for the expanded NCWRP, plant operations staff have cited several issues related to reliability and maintenance with the existing submersible-type mixers; therefore, the existing submersible mixers will be replaced with six new vertical-shaft-mounted mixers. Hydraulic modeling of the existing intermediate pump station indicates insufficient flow capacity with four pumps; therefore, a fifth pump will be added to increase the capacity.

Based on the flow equalization analysis conducted as part of the NCWRP Expansion 10% Engineering Design Report (MWH/BC, 2016b), a third 2.35-million gallon (MG) (314,150 cubic ft) equalization basin will be constructed. This will allow a volume of flow equalization storage equal to a total of 8.75 MG (1,169,700 cubic ft).

The single magnetic flow meter located between the primary effluent channel and the aeration basins controls both the operations of the intermediate pumps and the butterfly valve controlling the release of wastewater from the equalization basins back to the treatment process. The systems can be controlled manually in the event of equipment or instrument failure, or to temporarily modify system operation. Design criteria are presented in Table 6-7.

Table 6-7: NCWRP Primary Effluent/Return Activated Sludge Mixing and Flow Equalization Basins/Intermediate Pumping Facilities Design Criteria

Parameter	Units	Existing NCWRP	Modified NCWRP
Primary Effluent/Return Activated Sludge Channel Mixers			
Number of mixers	units	6	N/A
Type	--	Submersible	Course Bubble Mix Diffusers
Maximum Clean Water Capacity	gpm	4,400	N/A
Motor Horsepower	hp	4	0
Mix Air Required (per channel bottom area)	scfm/ft2	N/A	0.05
Continues on next page...			

Parameter	Units	Existing NCWRP	Modified NCWRP
Intermediate Pumps (To Send Flow To Equalization Basins)			
Number			
Total	units	4	5
Duty	units	3	4
Standby	units	1	1
Type	--	Submersible non-clog	Submersible non-clog
Best Efficiency Capacity	gpm	4,400	4,400
Head at Best Efficiency	ft	26	26
Horsepower	hp	60	60
Flow Equalization Basins			
Type	--	Circular	Circular
Number	units	2	2/1
Volume, each	cubic ft	429,000	Two at 429,000 each One at 314,150
Total volume	cubic ft	858,000	1,169,700
Volume as a percent of average one day wastewater flow (all units in service)	percent	19	18

Reliability and redundancy criteria for the intermediate pump station requires that the pumps be able to handle the peak flow with the largest unit out of service. As described above and presented in Table 6-7, this criterion is met.

The following conditions at the intermediate pump station are alarmed at the distributed control system: wet well level low, and intermediate pump/drive fail. The following condition at the flow equalization facility is alarmed to the distributed control system: equalization basins level high.

6.2.2.2.f Aeration Basins

Based on the findings of the process modeling, the aeration basins' existing configuration will be changed from a Modified Ludzack-Ettinger treatment process to a 4-stage Bardenpho process. The existing basins, comprising five anoxic zones followed by four aerobic zones, will be converted to a 4-stage Bardenpho system. About 81.5 mgd annual average flow and 96.5 mgd peak day flow (design flow rates that include secondary process recycled flows) will be treated in the aeration basins.

The existing basins are operated at a target SRT of ten days. Construction of nine new aeration basins, in addition to the seven existing basins, is necessary to meet treatment requirements based on a ten-day SRT. The design SRT of the expanded basins is ten days. The new secondary treatment process will include two sets of aeration basins in series: (1) the first-stage aeration basins, and (2) the second-stage aeration basins. The first stage consists of modifications to the existing seven aeration basins 4 to 10, plus three new aeration basins. The second stage will consist of 19 second-stage aeration basins comprising of the 13 existing rectangular secondary clarifiers repurposed to serve as second stage aeration basins and six new basins.

The new aeration basins and modified existing aeration basins will use a four-stage Bardenpho process. The mixed liquor starts in the pre-anoxic zone, where denitrification begins, and then flows to the aeration zone. Nitrification occurs in the aeration zone, and nitrified mixed liquor is recycled to the pre-anoxic zone for denitrification. The post-anoxic zone will provide a final denitrification step, aided by the addition of a supplemental carbon source as required to meet the target effluent total nitrogen concentration. The re-aeration step is used to remove nitrogen bubbles that may inhibit settling at the secondary clarifiers and nitrify any ammonia produced from endogenous respiration in the post-anoxic zone.

The existing blowers are unable to meet the required air demand associated with the NCWRP expansion and improvements. The existing blowers will be replaced with four new 800-hp blowers (three duty and one standby) to serve the first-stage aeration basin. One 250-hp blower will also be added to serve the second-stage aeration basin. Custom-engineered single-stage turbo blowers, similar to the type currently installed, provide the best fit for the required flow regime. Valved connection will allow first-stage blowers to supply air to the second-stage aeration basin when needed. The redundant blower will be available during plant peak hour conditions.

The existing blowers are unable to meet the required air demand associated with the NCWRP expansion and improvements. The existing blowers will be replaced with five new 950-hp blowers. Custom-engineered single-stage turbo blowers, similar to the type currently installed, provide the best fit for the required flow regime. Peak day aeration demand will be met with four blowers operating concurrently, and one blower serving as a standby unit.

Installation of new, higher-capacity mixed liquor recycle pumps in the downstream end of aerobic zone 2 in each aeration basin is required due to the increased flows. The existing vertical-turbine solids handling pumps will be replaced with submersible axial flow pumps. The submersible axial flow pumps will operate at variable speeds to produce a range of flows from 7.3 to 11.4 mgd to meet the process requirements of the 4-stage Bardenpho process. Design criteria are presented in Table 6-8.

Table 6-8: NCWRP Aeration Basins Design Criteria

Parameter	Units	Existing NCWRP	Modified NCWRP
Reactor Type	--	Nitrification-Denitrification Modified Ludzack-Ettinger	Nitrification-Denitrification 4-stage Bardenpho
Influent (Equalized Primary Effluent)			
Design influent flow (without RAS)	mgd (avg/peak)	33 / 48	54.8 / 57.2
Design influent BOD	pounds per day (avg/peak)	49,946 / 97,263	42,131 / 70,053
Design influent TSS	pounds per day (avg/peak)	29,604 / 55,641	35,109 / 58,377
Number of basins			
Continues on next page...			

Parameter	Units	Existing NCWRP	Modified NCWRP
Total	units	7	10 (1st Stage); 19 (2nd Stage)
Duty	units	6	9 (ts Stage); 18 (2nd Stage)
Standby	units	1	1 (1st Stage); 1 (2nd Stage)
Number of anoxic zones per basin	--	3	5 (1st Stage); 2 (2nd Stage)
Anoxic Cells with standby aeration	--	2	2 (1st Stage); 0 (2nd Stage)
Number of anaerobic zones per basin	--	4	4 (1st Stage); 2 (2nd Stage)
Total anoxic volume	cubic ft	224,000	1,029,300
Total aerobic volume	cubic ft	873,600	1,564,100
Total basin volume	cubic ft	1,097,600	2,593,400
Anoxic detention time with one unit out of service	days (avg/peak)	4.3 / 2.6	10 / 10
Aeration Blowers			
Number			
Total	units	4	45
Duty	units	3	4
Standby	units	1	1
Type	--	Single-stage centrifugal Single speed with inlet guide vanes throttling	Single-stage centrifugal Single speed with inlet guide vanes throttling
Capacity	standard cubic ft/minute / psi	12,000 (avg and peak) / 12	13,800 (avg); 15,100 (peak) / 12
Horsepower	hp	800	950
Anoxic Zone Mixers (Small)			
Number	--	21	50 (1st Stage); 38 (2nd Stage)
Continues on next page...			

Parameter	Units	Existing NCWRP	Modified NCWRP
Type	--	Submersible	Hyperboloid, Vertical, Shaft-Mounted
Minimum clean water pumping capacity	gpm	7,920	N/A
Horsepower	hp	10	1 (1st Stage); 2 (2nd Stage)
Anoxic Zone Mixers (Large)			
Number	--	N/A	see above
Type	--	N/A	see above
Minimum clean water pumping capacity	gpm	N/A	see above
Horsepower	hp	N/A	see above
Low Capacity Waste Activated Sludge Pumps			
Number	--	2	N/A
Type	--	Horizontal non-clog centrifugal	N/A
Capacity, each	gpm	660	N/A
Head at max capacity	ft	41	N/A
Horsepower	hp	15	N/A
High Capacity Waste Activated Sludge/Dewatering Pumps			
Number	--	3	1
Service	--	High capacity wasting – 2 Dewatering - 1	High capacity wasting – 0 Dewatering - 1
Type	--	Horizontal non-clog centrifugal	Horizontal non-clog centrifugal
Capacity, each	gpm	1,850	1,850
Head at max capacity	ft	30	30

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Parameter	Units	Existing NCWRP	Modified NCWRP
Horsepower	hp	25	25
Mixed Liquor Recycle Pumps			
Number			
Total	units	7	10
Duty	units	6	9
Standby	units	1	1
Type	--	16-inch vertical wet pit solids handling	32-inch submersible axial flow circulation pump
Capacity, each	gpm	3,275 – 5,240	16,700 – 17,650
Horsepower	hp	40	40
Biofoam Removal/Surface Wasting (from MLSS)			
Capacity	mgd (avg/peak)	N/A	0.40 / 1.60

Reliability and redundancy criteria for the aeration system requires that the tanks, blowers, and mixed liquor recycle pumps be able to handle the peak flows and loads with the largest unit out of service. As described above and presented in Table 6-8, this criterion is met.

The following conditions at the intermediate pump station are alarmed at the distributed control system: aeration basin dissolved oxygen low and aeration basin dewatering sump low.

6.2.2.2.g Secondary Clarifiers

The significant flow increase coupled with the limited space available at the NCWRP necessitated a more efficient means of secondary clarification. Circular clarifiers offer a more efficient method of settling solids when compared to rectangular clarifiers of the same surface area. This enables treatment of higher flows given the same area and higher surface overflow rates; therefore, the existing rectangular clarifiers will be repurposed to serve as 2nd stage aeration basins, and four new 150-ft diameter circular clarifiers will be constructed. The clarifiers will be fitted with aluminum geodesic dome covers to mitigate bird strikes, which is a requirement because of the proximity to Marine Corps Air Station Miramar. The exterior surfaces of the geodesic domes will be made of non-reflective materials to reduce pilot glare. The secondary clarifier domes will require mechanical ventilation, but will not be connected to an odor control system. The new secondary clarifiers are designed to treat an annual average flow of 81.5 mgd and a peak day flow of 96.5 mgd (flow rates include process recycled flows), with one of the four clarifiers out of service.

The construction of new secondary clarifiers will require new return activated sludge pump stations to be constructed to accommodate the new configuration of clarifiers and increased return activated sludge flows.

The existing return activated sludge pumps and rectangular clarifiers will be demolished. Each new clarifier will have its own dedicated return activated sludge sump installed adjacent to the outside of the clarifier's wall that collects return activated sludge from a gravity suction header that discharges into the sump. Three submersible-screw centrifugal pumps will be installed in each of the return activated sludge sumps. Two of the pumps will operate concurrently to meet peak design flows while the third pump will serve as a standby. In addition to new return activated sludge pumps, each clarifier will be fitted with a scum collection sump that is fed by a scum collection trough that collects and conveys scum to the sump. Within each sump is a vertical non-clog centrifugal pump operated at constant speed to convey the secondary scum to the blended sludge pump station. Design criteria are presented in Table 6-9.

Table 6-9: NCWRP Secondary Clarifiers Design Criteria

Parameter	Units	Existing NCWRP	Modified NCWRP
Secondary Clarifiers			
Design flows			
Influent flow (primary effluent only)	mgd (avg/peak)	30.8 / 44.8	54.0 / 60.0
Return activated sludge (less waste activated sludge)	mgd (avg/peak)	20.5 / 29.8	27.5 / 36.5
Mixed liquor (less waste activated sludge)	mgd (avg/peak)	51.3 / 74.6	81.5 / 96.5
Return activated sludge TSS concentration	mg/L (avg/peak)	6,184 / 7,500	6,850-8,000 / 7,450
Mixed liquor TSS concentration	mg/L (avg/peak)	2,474 / 3,000	2,400-2,800 / 2,600
Number			
Total	units	14	4
Duty	units	13	3
Standby	units	1	1
Type	--	Rectangular - conventional	Circular – conventional
Surface area per clarifier	sf	3,600	17,600
Total surface area	sf	50,400	70,400
Volume, each	cubic ft	54,000	320,830
Total volume	cubic ft	756,000	1,283,320
Surface overflow rate, all units in service	gpd/sf (avg/peak)	611 / 890	767 / 866
Surface overflow rate, one unit out of service	gpd/sf (avg/peak)	658 / 958	1,022 / 1,155
Solids loading rate, all units in service	pounds per day/sf (avg/peak)	21 / 37	20.8 / 28.8
Continues on next page...			

Parameter	Units	Existing NCWRP	Modified NCWRP
Solids loading rate, one unit out of service	pounds per day/sf (avg/peak)	23 / 40	27.7 / 38.4
Return Activated Sludge Pumps			
Number			
Total	units	21	12
Duty	units	14	6
Standby	units	7	6
Type	--	Vertical non-clog centrifugal	Submersible screw centrifugal
Capacity, each	gpm (avg/peak)	1,800 / 1,800	3,175 / 4,240
Head at peak capacity	ft	43	28
Horsepower	hp	30	60

Reliability and redundancy criteria for the secondary clarification system requires that the tanks and return activated sludge pumps be able to handle the peak flows and loads with the largest unit out of service. As described above and presented in Table 6-9, this criterion is met.

The following conditions at the intermediate pump station are alarmed at the distributed control system: secondary sludge collector fail, sludge collector high torque, secondary scum wet well level high, and secondary effluent sample jar full.

6.2.2.2.h Biological Foam and Scum Removal

The 4-stage Bardenpho using return activated sludge wasting can promote biological foam formation if an activated sludge system has a “trapping” environment where foam cannot exit the system. Biological foam and scum from the 1st and 2nd stage aeration basin will be removed by modifying the existing mixed liquor scum pump. The scum sump uses a weir gate to surface waste scum from the mixed liquor effluent channel. New chopper pumps will periodically pump from this sump and discharge scum to the blended sludge pump station for conveyance to the MBC.

6.2.2.2.i Odor Control System

No modifications to the Influent Pump Station and Headworks odor control systems are proposed. However, the primary sedimentation odor control will be modified.

The existing primary odor control system is sized for 22,500 cfm. The flow equalization basins are ventilated at 15,000 cfm, and this foul air is transferred into the headspace of the primary sedimentation basins. An additional 7,500 cfm is extracted from the primary basins for a total of 22,500 cfm. The current turnover rate within the primary basins is nine air changes per hour (excluding the 15,000 cfm from the flow equalization basins). When the new primary clarifiers are added, the revised turnover rate will be six air changes per hour (excluding 15,000 cfm from three flow equalization basins). The revised six air changes per hour within the primary clarifiers when the new basins are added is low. Generally, primary clarifiers are recommended to be ventilated at 8-12 air changes per hour, depending on odor loadings, leakage rates, and corrosion potential. The primary odor control system will be increased to 33,750 cfm to prevent risk of corrosion and fugitive emissions. Existing chemical scrubber packings will be replaced with ones that provide the same mass transfer efficiency without increased pressure loss at the higher ventilation rates. The existing carbon media will be replaced with a pelletized coconut shell carbon which prevents excessive pressure losses at the higher volumetric loads.

6.2.2.2.j Coagulation

The influent flow to the tertiary filters passes through two 48-inch-diameter static mixers. Chemicals used for coagulation are injected into the pipe through connected nozzles. The high turbulence from the mixer aids to achieve complete mixing of the chemicals before the tertiary filter process.

Title 22 requires that one of five specific coagulation reliability features be provided. The feature incorporated into this Project is the "alarm and long-term storage or disposal provisions." The turbidity of the secondary effluent and combined filter effluent are continuously monitored. An alarm is triggered if the secondary effluent deviates from a preset range or the combined filter effluent exceeds a preset value of approximately 1.5 NTU. The chemical dose can be adjusted manually through the distributed control system if there is a significant change in either of these turbidities. In addition, turbidity is monitored at the NPR water wet well. The tertiary treated water and NPR water pumps will automatically be shut down if the turbidity exceeds a preset value for a specified period. In the event that this condition occurs, the high turbidity water will flow over a fixed weir to the sewer system via the effluent drop structure.

The following conditions at the coagulation metering and mixing structure are alarmed to the distributed control system: secondary effluent turbidity low (to verify the sensor is working), and secondary effluent turbidity high.

6.2.2.2.k Tertiary Filtration

The existing filters were designed to achieve 32 mgd, while staying under the maximum Title 22 water reuse filter loading rate of 5 gpm/sf with two units out of service. The NCWRP improvements will result in an increase inflow to the tertiary filters to 55.6 mgd annual average flow and 59.2 mgd peak day flow. The original NCWRP design included six filters, with flexibility to add four additional filters. For the purpose of calculating loading rates and determining the number of required filters, it is assumed that one filter will be out of service for backwashing and one for maintenance or standby mode. The resulting calculated loading rate initially indicated the need for three additional filters to meet peak day flow per Title 22 requirements.

Depending on the results of the City's filter loading rate study (see below and Section 7), and DDW approval of a higher filtration rate, one or three new filters would be required. These filters will be sized and configured identically to the existing filters to take advantage of the existing infrastructure. Filter influent boxes along the filter influent channel, in addition to influent and effluent wall penetrations with blind flanges for future filters, have already been constructed to facilitate the expansion.

The existing filter backwash pumps, located in the filter backwash wetwell at the north end of the NPR Water Pump Station, are of sufficient capacity to provide low- and high-rate backwashing to the filters. The filter backwash is returned to the Waste Backwash Tank located in the NCWRP Raw Wastewater Pump Station. Contents of the Waste Backwash Tank can either be recirculated to the headworks or discharged to the drop structure, which is connected to the sewer. The existing tertiary filter air scour blowers, located in the equipment room east of the new aeration basins, are sufficiently sized to provide air scouring to a filter during backwash. To match the original design intent and equipment sizing for backwash pumps and blowers, only one filter at a time will be backwashed.

As part of an ongoing effort to optimize the existing NCWRP facilities, the City explored ways to increase capacity of the existing tertiary filters while maintaining compliance with Title 22 regulations. Discussed in more detail in Section 7, a filter loading rate evaluation was conducted at two filter loading rates, 5 gpm/sf and

7.5 gpm/sf, which would increase the existing filters from a rated capacity of 30 to 45 mgd. This test successfully demonstrated performance at the higher filtration rate, which will allow the City to eliminate two of the three proposed new filters. Design criteria are presented in Table 6-10.

Table 6-10: NCWRP Tertiary Filtration Design Criteria

Parameter	Units	Existing NCWRP	Modified NCWRP
Design flow	mgd (avg/peak)	30.7 / 32.0	55.6 / 59.2
Number			
Total	units	6	7
Duty	units	4	5
Standby	units	2	2
Type	--	Monomedia	Monomedia
Surface area per filter	sf	1,113	1,113
Total surface area	sf	6,678	7,791
Filtration rate, all units in service	gpm/sf	3.2 / 3.3	5.0 / 5.3
Filtration rate, one unit out of service	gpm/sf	3.8 / 4.0	5.8 / 6.2
Filtration rate, two units out of service	gpm/sf	4.8 / 5.0	6.9 / 7.4
Media Depth	inches	84	84
Media	--	Anthracite	Anthracite
Effective Size	millimeters	1.4 – 1.5	1.4 – 1.5
Uniformity Coefficient	maximum	1.3	1.3

Reliability and redundancy criteria for the tertiary filtration system requires that the filters be able to handle the peak flows and loads with the largest unit out of service. As described above and presented in Table 6-10, this criterion is met.

The following conditions at the tertiary filters are alarmed to the distributed control system: filter influent channel water level high (overflow imminent), filter influent channel water level high-high (overflow occurring), filter water level high, filter differential pressure high, filter effluent turbidity high, combined effluent turbidity high, combined effluent turbidity high-high, backwash inhibited, surface wash pump fail, backwash pump fail, foul air scour blowers temperature high, and air scour blower fail.

6.2.2.2.I Chlorination

NPR water will be chlorinated to comply with Title 22 disinfection requirements. Tertiary treated effluent conveyed to the NCPWF will not be chlorinated.

Peak hourly design flow for the CCT is anticipated to be 18.1 mgd. Adequate disinfection can be met with existing facilities, comprising two CCTs, with one CCT on standby mode. At the chlorine residual currently maintained in the effluent of the NCWRP CCTs, the system will provide 726 milligrams-minute per liter (mg-min/L) CT with a detention time of 145 minutes, exceeding the minimum 450 mg-min/L CT and 90-minute modal contact time required by Title 22 for NPR water. No tracer study has been performed on the existing

CCTs. Tracer studies have typically not been required for Title 22 disinfection due to the conservative design of the theoretical detention times.

Under some conditions when the Filter Backwash Pumps are withdrawing disinfected tertiary effluent from the chlorine contact chambers, the volume of the CCTs can be reduced to an extent that the minimum contact time required to demonstrate adequate disinfection of non-potable reuse water is not achieved. A low-level alarm will be installed in the CCT to alert the operators of this circumstance. When the alarm sounds, the Recycled Water Pumps will suspend operation. During this period, disinfected tertiary wastewater will not be pumped to the recycled water tank. Customers will continue to be served by water stored in the recycled water tank or by potable water, as necessary. The pumps will resume operation when the CCT level returns to a desired value.

As part of the NCWRP expansion, the existing sodium hypochlorite induction units will be removed and replaced. New sodium hypochlorite induction units will be installed at the downward inlet chambers past the point of overflow from the respective upward inlet chamber of each CCT. This configuration will provide an air gap preventing backflow of chlorinated water to the CCT inlet conduit and from reaching the NCPWF. The original sodium hypochlorite induction units were designed for use with chlorine gas, but were converted for use with sodium hypochlorite. The replacement units will be designed for sodium hypochlorite and provide more reliable service. Design criteria are presented in Table 6-11.

Table 6-11: CCTs Design Criteria

Parameter	Units	Existing NCWRP	Modified NCWRP
Design influent flow	mgd (avg/peak)	30.7 / 32.0	18.1 / 18.1
Number of contact tanks			
Total	units	3	3
Duty	units	3	2
Standby	units	0	1
Width, each pass	ft	14.5	14.5
Length, each pass	ft	290	290
Length, each tank	ft	580	580
Volume of each tank	cubic ft	121,945	121,945
Total volume, all tanks	cubic ft	365,835	365,835
Theoretical detention time (all tanks in service)	min	128	145
Design chlorine dose	mg/L	7	7

Reliability and redundancy criteria for the CCTs requires that the tanks be able to handle the peak flows with the largest unit out of service. As described above and presented in Table 6-11, this criterion is met.

The following conditions at the CCTs are alarmed to the distributed control system: chlorine induction units off, CCT chlorine residual high, and CCT chlorine residual low.

6.2.2.2.m NPR Water Pump Station

The NPR Water Pump Station is described in Section 6.2.3 along with the NPR water distribution system.

6.2.2.2.n Blended Sludge Pump Station

The Blended Sludge Pump Station is used to pump primary sludge and waste activated sludge generated at the NCWRP to the MBC. It was originally designed for a minimum average daily flow of 2 mgd and peak day flow of 4.2 mgd. The existing Blended Sludge Pump Station includes two 250-hp, variable frequency drive-controlled, custom-engineered horizontal centrifugal, non-clog blended sludge pumps operating in duty/standby mode, each with an original design point of 2,900 gpm at 216 ft total discharge head. Sludge is transported via a 16-inch-diameter, 5-mile-long pipeline and is discharged into two raw solids receiving tanks located at the MBC for thickening, dewatering, digestion, and ultimate disposal. The existing Blended Sludge Pump Station equipment was selected for a peak flow of 4.2 mgd, which is adequate for the expanded NCWRP operations with the following caveats:

- Sludge pump operating data from 2009 suggests that the pipeline has lost approximately 50 percent of its design capacity; and
    - Possible explanations for this apparent loss of capacity include solids deposition, air binding, and flow meter calibration issues.
    - The City is currently working to resolve the apparent pipeline capacity loss by replacing a number of combination air release valves on the sludge pipeline and investigating the pipeline's performance.
    - It is anticipated that the sludge pipeline's original design system curve will be restored through the City's ongoing pipeline condition assessment and rehabilitation efforts.
    - The City is also investigating alternative technologies to clean the pipeline and restore its hydraulic capacity prior to start-up of the Project.
- The NCWRP's expanded peak day sludge production rate of 4.2 mgd matches the peak capacity of the existing sludge pumps and pipeline.
    - The adequate performance in the future depends on whether the ongoing sludge pipeline inspection and rehabilitation efforts can restore the original conveyance capacity of the sludge pipeline.
    - It is assumed that the City's ongoing efforts will resolve the pipeline capacity issue and that the existing pumps will be adequate for the expanded NCWRP sludge production.

6.2.2.2.o Metro Biosolids Center

The MBC provides two main treatment operations: (1) thickening and digestion of the raw solids (raw sludge) generated at the NCWRP, and (2) dewatering of the wet biosolids from both the PLWTP and NCWRP.

The MBC currently processes approximately 1.0 mgd of biosolids from the NCWRP and 1.2 mgd of digested biosolids from the PLWTP. These flows are anticipated to change significantly following expansion of the NCWRP. As indicated above, the peak day sludge flow from the NCWRP could increase to approximately 2 mgd. The flow of digested biosolids from the PLWTP is not expected to increase and will remain around 1.2 mgd when the North City Project begins operation; however, it will increase slightly by year 2050.

Primary sludge and waste activated sludge from primary and secondary treatment processes at the NCWRP are pumped from the Blended Sludge Pump Station to receiving tanks at the MBC. The flow then passes through degritters where the grit is removed, dried, and disposed of off-site. The raw solids are thickened in five centrifuges before being pumped into one of three anaerobic digesters. From the anaerobic digesters, the biosolids are sent to a digested biosolids storage tank where they are mixed with biosolids from the PLWTP.

The mixed biosolids are piped to eight dewatering centrifuges to remove water from the biosolids. The facility produces dewatered biosolids that are approximately 30 percent solids and 70 percent water. The resulting centrate is currently pumped to the NCWRP Raw Wastewater Pump Station drop structure and, ultimately, conveyed to the PLWTP.

Due to the expansion of the NCWRP, the MBC will experience higher biosolids flows than it is currently receiving. Thus, to accommodate the additional flows, upgrades and improvements of the MBC will be necessary. The required upgrades at the MBC consist of upgrading and installing new equipment in various process areas. The major scope elements entail improvements to the following process areas: grit removal, biosolids thickening, anaerobic digestion, and centrate pump station. Upgrades to the Centrate Pump Station at the MBC will be implemented by installing higher capacity pumps to ensure that sufficient capacity is available to handle the increased flow. The centrate will then be combined with the brine from the NCPWF to be ultimately conveyed to and treated at the PLWTP. The dewatered biosolids will continue to be pumped into storage silos before being trucked offsite.

6.2.2.2.p Chemical Facilities

The Project requires the addition of ferric chloride to the grit tank feed and a polymer for CEPT in the primary sedimentation tanks, a new carbon addition system for denitrification, phosphoric acid to address potential nutrient inhabitation, urea for the gas cleaning system associated with the North City Renewable Energy Project, and ferric chloride for phosphate removal at the tertiary filters.

The NCWRP Expansion requirements for each chemical are described below.

- ***Ferric Chloride Addition***. The CEPT ferric chloride system will include three new 7,500-gallon fiberglass-reinforced polymer storage tanks located on the roof of the new primary sedimentation tanks, a fill station, two duty and one swing peristaltic metering pumps, magnetic flow meters, and control valves.
    - An additional tertiary ferric chloride system will be supplied from the ferric chloride storage facility provided for the CEPT with a day tank located at the filter area for use if needed for supplemental phosphorus removal. The tertiary ferric feed system is separated from the primary CEPT feed system for backflow prevention through separate tertiary transfer pumps, check valves, tertiary day tanks with air gap, tertiary metering pumps, and check valves.
- ***CEPT Polymer Addition.*** A new emulsion polymer system will provide polymer to each of the nine primary sedimentation tanks for CEPT.
    - The system will include a bulk 7,500-gallon storage tank, blending units, aging tanks, metering pumps (duty and standby), and recirculation pumps.
- ***Carbon (Methanol) Addition.*** The carbon addition system will consist of four 10,000-gallon stainless-steel storage tanks, two magnetic drive centrifugal pumps, one duty and one swing, control valves, and magnetic flow meters.
    - Double-walled piping will be used throughout the methanol delivery system.
    - The system will be designed for methanol, but should also be compatible with alternate carbon sources such as glycerin.
    - Dilution water will be available to mitigate fire hazards associated with methanol systems.

- ***Phosphoric Acid Addition.*** A supplemental phosphorus feed system will be provided to address potential nutrient inhibition.
    - The system will include one 7,500-gallon storage tank, two 3.0-gph metering pumps
- ***Urea Addition.*** The NCWRP design will provide the Urea chemical storage facilities required for the North City Renewable Energy Project.

Design criteria are presented in Table 6-12.

Table 6-12: NCWRP Chemical Facilities Design Criteria

Parameter	Units	Existing NCWRP	Modified NCWRP
Ferric Chloride Storage and Feed System for CEPT			
Number of tanks	units	N/A	3
Volume of each tank	gallons	N/A	7,500
Total volume	gallons	N/A	22,500
Ferric chloride average dose	mg/L	N/A	10
Average ferric chloride use	gpd	N/A	877
Storage at average dose	days	N/A	25.7
Number of day tanks	units	N/A	1
Volume of each day tank	gallons	N/A	1,100
Type of feed pump	--	N/A	Peristaltic
Number of pumps	--	N/A	1 duty + 1 swing
Capacity, each	gallons per hour	N/A	45
Horsepower	hp	N/A	1/3
Polymer Storage and Feed System for CEPT			
Number of Storage tanks	units	N/A	1
Volume of each storage tank	gallons	N/A	7,500
Total volume	gallons	N/A	7,500
Number of blending units	units	N/A	3
Active polymer average dose	mg/L	N/A	1.0
NEat polymer flow rate	gph (avg/peak)	N/A	9.3 / 11.0
Dilution water flow rate	gph (avg/peak)	N/A	4,128 / 4,128
Continues on next page...			

Parameter	Units	Existing NCWRP	Modified NCWRP
Methanol Storage and Feed System			
Number of tanks	units	N/A	4
Volume of each tank	gallons	N/A	10,000
Total volume	gallons	N/A	40,000
Storage at peak dose	days	N/A	12
Target nitrogen at end of aeration basin	mg/L-N	N/A	8
Type of feed pump	--	N/A	Peristaltic
Number of pumps	--	N/A	2
Capacity, each	gpm	N/A	130
Horsepower	hp	N/A	0.5
Ferric Chloride Storage and Feed System for Tertiary Filters			
Number of day tanks	units	N/A	1
Volume of each day tank	gallons	N/A	1,100
Total volume	gallons	N/A	1,100
Ferric chloride maximum dose	mg/L	N/A	10
Day tank storage at maximum dose	days	N/A	1
Type of feed pump	--	N/A	Peristaltic
Number of pumps	--	N/A	1 duty + 1 standby
Capacity, each	gallons per hour	N/A	45
Ferrous Chloride Storage and Feed System for Blended Sludge Odor Control			
Number of tanks	units	2	2
Volume of each tank	gallons	7,500	7,500
Total volume	gallons	15,000	15,000
Ferric chloride average dose	mg/L	Varied	Varied
Storage at average dose	days	Varied	Varied
Type of feed pump	--	Hydraulically-actuated Diaphragm	Hydraulically-actuated Diaphragm
Number of pumps	--	5	5
Continues on next page...			

Parameter	Units	Existing NCWRP	Modified NCWRP
Capacity, each	gallons per hour	4 Pumps at 2.7-119 1 Pump at 1.0-45	4 Pumps at 2.7-119 1 Pump at 1.0-45
Horsepower	hp	4 Pumps at 1/2 1 Pump at 1/3	4 Pumps at 1/2; 1 Pump at 1/3
Anionic/Non-ionic Polymer Storage and Feed System for Existing Use			
Number of tanks	units	1	0 – to be removed and replaced with polymer tanks for CEPT
Volume of each tank	gallons	7,500	0
Total volume	gallons	7,500	0
Cationic Polymer Storage and Feed System for Existing Use			
Number of tanks	units	1	1
Volume of each tank	gallons	7,500	7,500
Total volume	gallons	7,500	7,500
Type of feed pump	--	Progressive cavity	Progressive cavity
Number of pumps	--	2	2
Capacity, each	gallons per hour	2.5-15	2.5-15
Horsepower	hp	7.5	7.5
Sodium Hypochlorite Storage and Feed System			
Number of Storage tanks	--	4	4
Volume of each tank	gallons	7,500	7,500
Total volume	gallons	30,000	30,000
Average dose	mg/L	0-10 range; 7 typical	0-10 range; 7 typical
Type of feed pump	---	Hydraulically-actuated diaphragm	Hydraulically-actuated diaphragm
Number of pumps	--	8	8
Capacity, each	gallons per hour	Pump 1: 20 Pumps 2 & 3: 12-180 Pumps 4 & 5: 20-300 Pump 6, 7 & 8: 15-90	Pump 1: 20 Pumps 2 & 3: 12-180 Pumps 4 & 5: 20-300 Pump 6, 7 & 8: 15-90
Horsepower	hp	Pump 1: 1/4 Pumps 2 & 3: 1 Pumps 4 & 5: 1.5 Pump 6, 7 & 8: 3/4	Pump 1: 1/4 Pumps 2 & 3: 1 Pumps 4 & 5: 1.5 Pump 6, 7 & 8: 3/4
Continues on next page...			

Parameter	Units	Existing NCWRP	Modified NCWRP
Sodium Hydroxide Storage and Feed System			
Number of Storage tanks	units	1	1
Volume of each tank	gallons	7,500	7,500
Total volume	gallons	7,500	7,500
Type of feed pump	--	Centrifugal	Centrifugal
Number of pumps	--	2	2
Capacity, each	gpm	45	45
Horsepower	hp	0.5	0.5
Aluminum Sulfate Storage and Feed System			
Number of Storage tanks	units	1	0 – to be removed
Volume of each tank	gallons	7,500	N/A
Total volume	gallons	7,500	N/A
Type of feed pump	--	Hydraulically-actuated diaphragm	0 – to be removed
Number of pumps	--	2	N/A
Capacity, each	gallons per hour	1.0-47	N/A
Horsepower	hp	1/3	N/A

Reliability and redundancy criteria for the chemical systems requires that the facilities be able to handle the peak flows with the largest unit out of service. As described above and presented in Table 6-12, this criterion is met.

The following conditions at the chemical systems are alarmed to the distributed control system: methanol metering pump high discharge pressure, methanol storage tank high level, methanol storage tank low level, ferric chloride metering pump high discharge pressure, ferric chloride storage tank high level, ferric chloride storage tank low level, polymer meter pump high discharge pressure, polymer storage tank high level, polymer storage tank low level, sodium hypochlorite storage tank high level, sodium hypochlorite storage tank low level, and sodium hypochlorite metering pump high discharge pressure.

6.2.2.2.q Electrical

The NCWRP power distribution system consists of 12-kilovolt double-ended switchgear in a main-tie-main configuration with auto throw-over. Power is distributed in a redundant manner to 480-volt double-ended switchboards with main-tie-main configuration via manual kirk key interlock systems. The switchboards feed motor control centers serving the various process areas.

Major electrical modifications are planned for the following process areas at the NCWRP site: headworks, aeration basins, secondary clarifiers, chemical facilities, and odor control system. Other electrical modifications include replacing existing and/or providing new circuit breakers, motor starters, or variable frequency drives based on the process mechanical design.

The NCWRP's existing power distribution system will power the new Tertiary Treated Water Pump Station. A preliminary evaluation identified spare capacity available at the 4,160-volt 64 North Unit Substation capable of providing power to the new Tertiary Treated Water Pump Station, based on its fan-cooled rating.

San Diego Gas & Electric has indicated that their substations have a capacity of 60 megavolt-amperes and are dedicated to serve the City PUD's various existing and planned facilities, which will leave their substations with about 29 percent spare capacity for future needs. In addition, the NCWRP has onsite power generation facility designed to provide primary power to all the plant process areas via the main 12-kilovolt switchgear in parallel with San Diego Gas & Electric. The Renewable Energy Project to be included as part of the Project is described in Section 6.2.2.2.r.

Title 22 of the CCR requires that plant power be provided with one of the following reliability features:

- Alarm and standby power source;
- Alarm and automatically actuated short-term retention or disposal provisions as specified in Article 60341; or
- Automatically actuated long-term storage or disposal provisions as specified in Article 60341.

The NCWRP meets the power reliability criteria for an EPA Class I plant, which is more stringent than the first criterion listed above. The EPA Class I criteria requires that standby power have capacity sufficient to operate all vital components, during peak wastewater flow conditions, together with critical lighting and ventilation.

6.2.2.2.r North City Renewable Energy Project

The Project includes new power generation facilities to be located at the NCWRP. The North City Renewable Energy Project, which will capture landfill gas to generate energy and help meet the City's Climate Action Plan targets for reducing Greenhouse Gas Emissions will provide the additional power required for the expanded NCWRP, NCPWF, and associated pump stations.

The expanded power generation facility includes a total of 15.4 megawatts of new generation capacity combined with 5 megawatts of capacity currently produced at the existing NCWRP. The new power generation facility consists of 6.3 megawatts of new capacity in a small power producing facility that uses 100 percent landfill gas as fuel. The additional 9.1 megawatts of new power generation capacity within the facility will use landfill gas supplemented with natural gas or green gas.

The small power producing facility system requires a total of three new internal combustion engines and generator units, two duty units and one backup spare unit. Each of these are 3.8 megawatts Caterpillar Model CG260-16 IC internal combustion engines and generator units (or equal). The remaining power generation capacity requires a total of four new internal combustion engines and generator units, three duty units, and one new backup spare unit. Each of these units consists of a 3.8 megawatts Caterpillar Model CG260-16 IC internal combustion engines and generator (or equal). The engines will be placed inside a building located immediately south of the new circular secondary clarifiers and north of the existing power generation system at the NCWRP. Power from each set of engines will be metered separately in accordance with San Diego Gas & Electric requirements.

A skid mounted equipment package consisting of a natural gas compressor system, air receivers, and oil storage will be located on the site adjacent to the power generation building. Two additional buildings will be included on the site for controls equipment and storage. The facility will also include a gas cleaning and cooling equipment skid and an electrical switch yard.

The facility layout includes relocation of the City's existing 1.6 megawatts engine to a new location on the site near the existing power generation equipment at the NCWRP in order to accommodate the layout of the new power generation facility. Figure 6-11 illustrates a preliminary layout for the new power generation facilities at the NCWRP.

The new power generation facility will receive landfill gas from the City's Miramar Landfill gas collection system via a new 12-inch-diameter gas line. The new gas line will parallel an existing 10-inch gas line and will be constructed within the limits of the City's existing 40-ft utility easement that runs from the existing landfill north along the western end of the Marine Corps Air Station Miramar property to the NCWRP site.

6.2.2.2.s Instrumentation and Control

Title 22 of the CCR (CCR, 2014) Section 60335 requires that

> *"(b) All required alarm devices shall be independent of the normal power supply of the reclamation plant."*

At the NCWRP, the distributed control system will have the following reliability features:

- The distributed control system will be provided with redundant internal direct current power supplies;
- The distributed control system components will be powered from alternating current uninterruptable power supplies; and
- The distributed control system will be connected with dual data communication links.

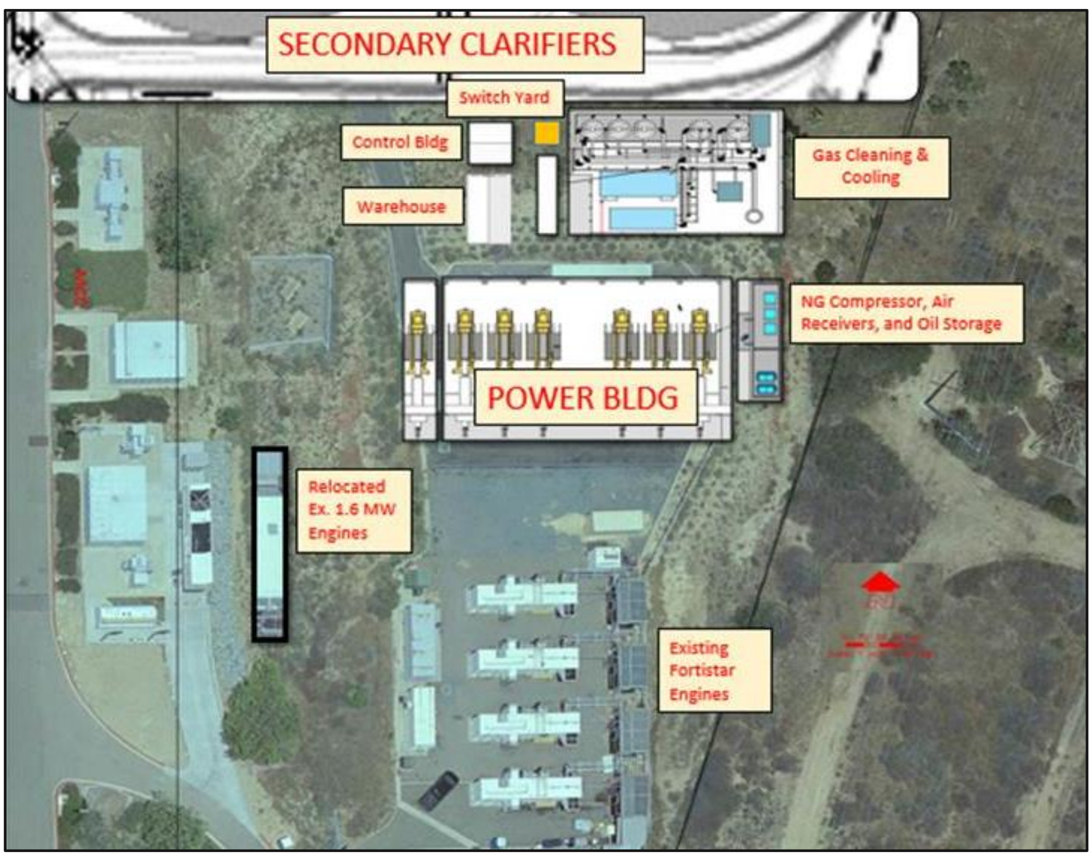


Figure 6-11: Layout of North City Renewable Energy Project

Additionally, the distributed control system functions will be backed up in one of the following ways:

- Local manual controls;
- Redundant control processors in process control modules for critical equipment and processes that cannot be controlled manually; or
- Separate and independent process control modules for each process or equipment train for systems with multiple trains. An example would be the tertiary filters and backwash controls.

6.2.2.3 Plant Hydraulics

A hydraulic model of the existing NCWRP was developed and compared to levels on the hydraulic profile record drawing of the existing plant. Then, the recommended plant upgrades were modeled along with future operating scenarios. The model identified several hydraulic restrictions in the existing plant that need to be resolved to maintain the plant's hydraulic performance at future flow rates. Model results also helped to establish the diameters of the new yard piping required for the plant expansion and identified several existing weir elevations that need to be adjusted.

The most significant change to process head loss as a result of the plant expansion is in greater head loss through the secondary clarification process. The additional secondary head loss has been accommodated locally by reducing the head loss requirement of the immediately downstream filter influent structure and immediately upstream aeration basins. As a result, the expanded NCWRP processes will operate within the same general elevation band of the current operations, although the secondary process will require a wider elevation band.

6.2.2.3.a Flow equalization

The equalization tanks will provide primary effluent storage to augment flow to the aeration basins during the lowest-flow periods and store excess flow during high-flow periods. This allows constant flow to the secondary treatment process, tertiary filters, and the NCPWF.

6.2.2.3.b Diversion of Purified Water for Non-Potable Reuse via Blending Pipeline

The connection of a new, 24-inch-diameter gravity line from the NCPWF to the NPR water wetwell is required for the diversion of purified water for NPR. This line will be provided to feed purified and disinfected water from the NCPWF to the NPR water wetwell to satisfy TDS requirements (1,000 mg/L for irrigation), and as-needed augmentation of NPR water flow required to satisfy variable NPR demands. The blending pipeline will discharge above the high-water level in the wetwell to mix with the NPR water, providing an air gap for the pipe. A flow control valve and flow meter will be installed above grade, or in a vault, outside and adjacent to the penetration to the wetwell to monitor the volume of purified water conveyed to blend with the NCWRP NPR water in the wetwell.

Continuous monitoring of TDS levels will be required at the NPR water wetwell with feed back to the flow control valve and flow meter on the 24-inch-diameter process water augmentation line. This TDS and NPR water augmentation control loop will be based on continuous sampling and conductivity sensing of the NPR water, and provided with a standby conductivity sensor and a soft-sensor technology to automatically provide self-diagnostic of the TDS monitoring, TDS control, and NPR demand augmentation. If the NCPWF disinfection system does not operate within specifications such that the RO permeate does not receive proper disinfection, the blending/augmentation water flow will be diverted to the influent channel of the CCTs for disinfection while maintaining continuous sampling and conductivity monitoring of the NPR water. Under these circumstances, the daily coliform sample for NPR will be collected in the effluent channel of the CCTs.

Compliance with Title 22 Water Recycling Criteria (CCR, 2014) and the NCWRP permit (RWQCB Order R9-2015-0091, 2015) is required for any purified water from the NCPWF that are returned for NPR. All diversions must support and comply with the NCWRP monitoring and discharge requirements, provided in the RWQCB Order R9-2015-0091, Attachment D (RWQCB, 2015). The NCPWF diversions to meet NPR demands are anticipated to be infrequent, and should be monitored on at least the same frequency required for the NCWRP's NPR use when they occur. Where the NCPWF return flow is combined with the NCWRP NPR water, the NCWRP permit discharge limits and monitoring requirements will apply to the combined discharge.

6.2.2.4 NCWRP Waste, Side Streams, and Solids Disposal

This section describes the waste, side streams, and solids disposal pertaining to the NCWRP. Note that the NCPWF side stream descriptions can be found in Section 6.3.1. A process flow diagram depicting the NCWRP primary and side streams is illustrated on Figure 6-12.

Table 6-13 presents the existing and proposed pertinent waste and side streams and their respective disposal location based on the preliminary design of the NCWRP expansion.

Table 6-13: Pertinent Waste and Side Streams

Fluid Service	Final Disposal Location
Screenings and grit	Landfill
Primary sludge	MBC
Return activated sludge, pumped	MBC
Return activated sludge, gravity	MBC
Waste activated sludge	MBC
Blended sludge	MBC
Tertiary filter waste backwash	NCWRP Raw Wastewater Pump Station
NCPWF purified water blending	NCWRP NPR Water Pump Station Wetwell
Combined waste (from NCPWF, excluding brine)	NCWRP Raw Wastewater Pump Station/Sewer to PLWTP
NCPWF brine	Sewer to PLWTP
Microfiltration backwash	NCWRP Raw Wastewater Pump Station/Sewer to PLWTP

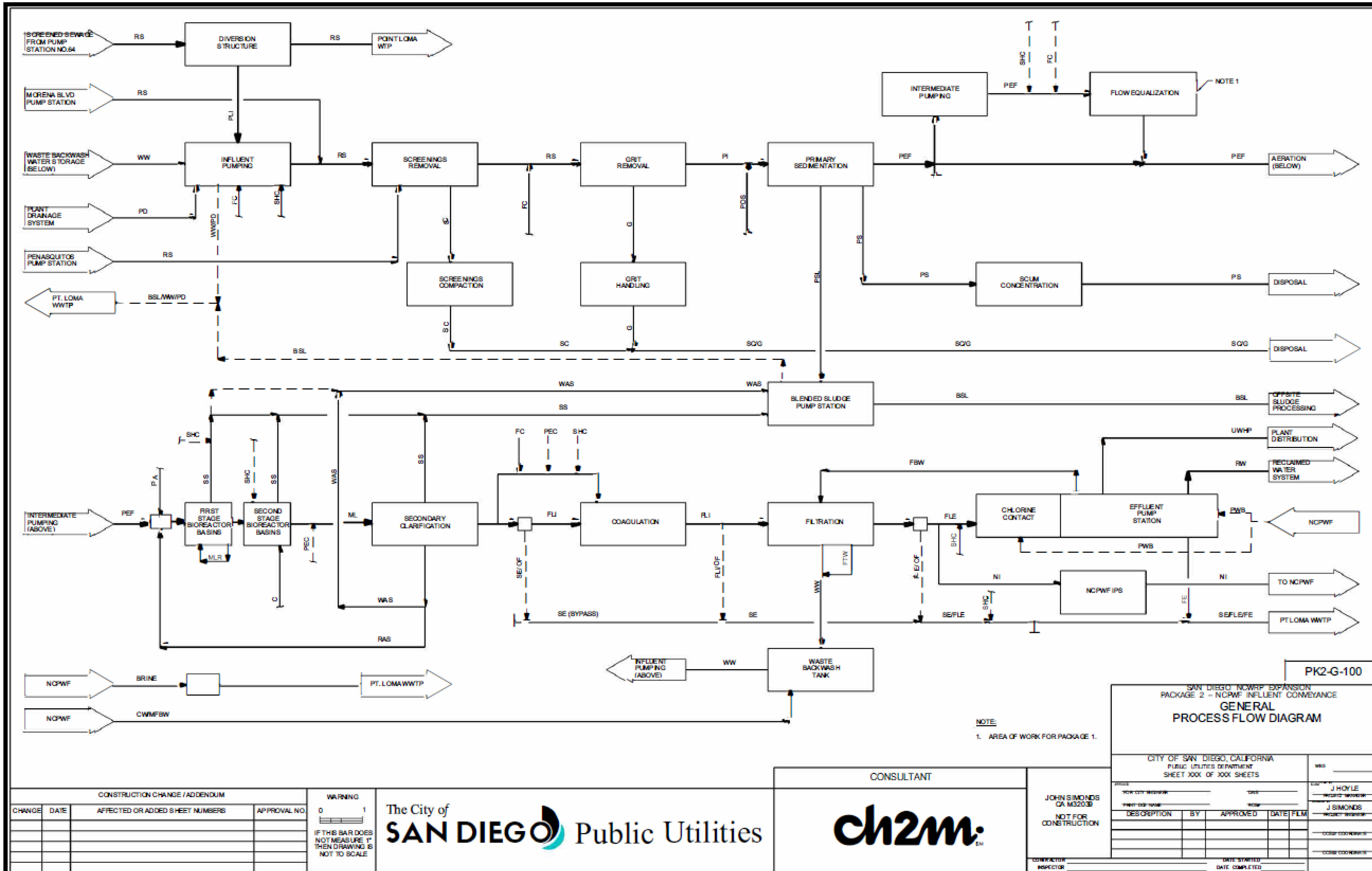


Figure 6-12: NCWRP Primary and Side Stream Process Flow Diagram

6.2.2.4.a Screenings Processing

The Project will equip each bar screen with an individual screenings washer/press. The washer/presses will be auger-type with sprays. With the finer screens, the quantity of screenings is expected to increase from about 8 cubic-ft-per-day to more than 200 cubic-ft-per-day. Installation of screening compactors will reduce the screenings volume by about 50 percent, optimizing the storage bin space in the headworks building. Dewatered screenings will be hauled to disposal at a City-owned landfill. Wash water and drainage from the screenings processing will be returned to the NCWRP Raw Wastewater Pump Station and eventually to the headworks.

6.2.2.4.b Grit Processing

At the two existing grit chambers, two grit classifiers with three cyclones for each classifier provide grit dewatering and removal of organic material from the grit. One grit roll-up bin receives dewatered grit through the grit hopper in the headworks building. City staff dispose of dewatered grit at a City-owned landfill. Wash water and drainage from the grit processing is returned to the NCWRP Raw Wastewater Pump Station and eventually to the headworks.

6.2.2.4.c Primary Sludge

New primary sludge pumps will be installed for the additional primary sedimentation tanks. Primary sludge pumps will continuously pump sludge from the primary sedimentation sludge hoppers to the blended sludge pump station wetwell. From the blended sludge pump station wetwell, the sludge will be conveyed to the MBC for solids processing.

New scum removal equipment will be installed with the new primary sedimentation tanks. Scum from the primary sedimentation tanks will be conveyed to two existing scum concentrators, each capable of producing 40 percent to 50 percent concentrated scum. The concentrated scum will then be stored in a holding tank prior to being hauled offsite in trucks for disposal as needed.

6.2.2.4.d Waste Activated Sludge

A portion of the return activated sludge will be removed as waste activated sludge to eliminate excess biomass. Mixed liquor biological foam and secondary scum also be conveyed to the blended sludge pump station and, ultimately, to the MBC for solids processing.

6.2.2.4.e Blended Sludge

Primary sludge, waste activated sludge, mixed liquor biological foam, and secondary scum will discharge into the plant’s raw sludge pumping station valve vault next to the blended pump station. Two variable frequency driven, custom-engineered horizontal centrifugal non-clog pumps draw from the wetwell and convey blended sludge produced at the NCWRP to the MBC via an existing 16-inch-diameter, 5-mile-long sludge pipeline.

Process liquids from the MBC are not returned to the NCWRP, but are instead discharged to the sewer to the PLWTP. Centrate will be combined with the brine and conveyed directly to Pump Station No. 2, which is a large lift station located on North Harbor Drive, serving the Metropolitan Sewerage System. This design will prevent any recirculation to the NCWRP via the Morena Pump Station. From the Pump Station No. 2, the centrate and brine will be pumped along with raw wastewater to the PLWTP for final treatment prior to being discharged into the ocean.

6.2.2.4.f Tertiary Filter Waste Backwash

Tertiary filter waste backwash is typically returned to the NCWRP and retreated, but it can be discharged to the sewer for treatment at the PLWTP. During tertiary filter backwash cycles, waste backwash water is conveyed from the upper gullet of each filter via an existing 36-inch filter backwash discharge valve to a 660,000-gallon waste backwash tank located in the NCWRP Raw Wastewater Pump Station. The existing backwash pumps provide low- and high-rate backwashing to the filters. The planned high-rate backwash flow is approximately 26,700 gpm, resulting in a backwash loading rate of 24 gpm/sf. It is proposed to backwash only one filter at a time to ensure sufficient backwash capacity and avoid overloading the waste backwash tank located at the NCWRP Raw Wastewater Pump Station. It is estimated that each filter will require backwashing every two to three days, depending on loading rates and number of filters on-line; this corresponds to approximately three total backwash cycles per day.

6.2.2.4.g North City Pure Water Facility Combined Waste Pipeline

The new 54-inch-diameter NCPWF Combined Waste Pipeline will convey multiple process waste streams from the NCPWF site, across Eastgate Mall, to the existing Raw Wastewater Pump Station building on the NCWRP site. The NCPWF process waste streams conveyed by the NCPWF Combined Waste Pipeline will include:

- BAC waste backwash;
- MF clean-in-place waste;
- MF waste backwash;
- Ozone/BAC and/or MF overflow;
- RO clean-in-place waste;
- RO overflow;
- UV/AOP overflow;
- NCPW Pump Station overflow and off-spec water; and
- Wash down from various NCPWF buildings.

It should be noted that RO brine is not returned to the NCPWF Combined Waste Pipeline. After mixing with the centrate from the MBC, RO brine is conveyed via a separate pipeline to the sewer downstream of the Morena Pump Station Diversion Structure that flows to the PLWTP.

The NCPWF Combined Waste Pipeline will flow by gravity to a new waste diversion structure at the NCWRP. The new waste diversion structure will have two outlets:

- A low-flow outlet that sends combined waste streams to the NCWRP Raw Wastewater Pump Station wetwell for plant recycling; and
    - The low-flow outlet connects to a new 12-inch-diameter pipeline that connects to an existing 24-inch-diameter wastewater pipeline that flows to the NCWRP Raw Wastewater Pump Station wetwell.
    - Low flows conveyed to the waste backwash tank will typically be treated at the NCWRP.
    - If necessary, the waste backwash tank can also drain to the effluent drop structure for conveyance to the PLWTP.

- A high-flow outlet that sends unusually high waste flow rates (e.g., an off-spec event) to an existing drop structure that flows off-site to the PLWTP;
    - The high-flow outlet connects to an existing 42-inch-diameter pipeline out of the existing drop structure.
    - The drop structure discharges to a 54-inch-diameter pipeline that flows to an offsite diversion structure, through the City sewer system, and eventually to the PLWTP.

The 54-inch-diameter NCPWF Combined Waste Pipeline will terminate at the new waste diversion structure. If the level in the new waste diversion structure rises above an overflow weir within the structure, the excess flow will proceed to the drop structure and the PLWTP.

6.2.2.4.h NCPWF Membrane Filtration Backwash

Waste backwash from the MF units at the NCPWF will be discharged to the 54-inch NCPWF Combined Waste Pipeline as described above. The MF units at the NCPWF will produce an average daily flow of approximately 1.3 mgd of waste backwash. The peak backwash rate of 3.9 gpm is generated when two units are in backwash mode during a two-stage, 90-second backwash cycle.

The process flow diagram of the NCWRP Raw Wastewater Pump Station depicting waste streams is illustrated on Figure 6-13.

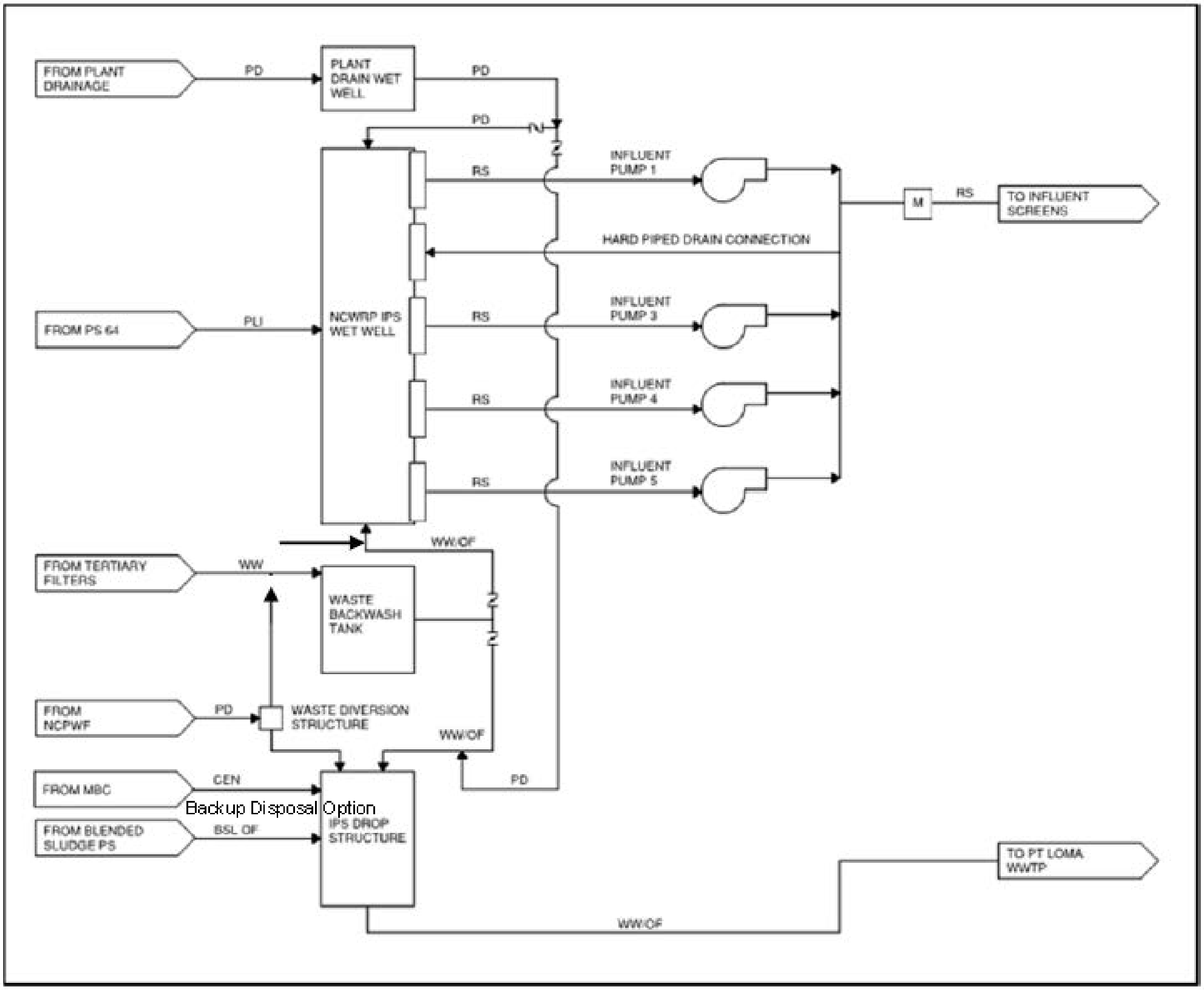


Figure 6-13: Process Flow Diagram of NCWRP Raw Wastewater Pump Station depicting Waste Streams

6.2.3 Non-Potable Reuse Water Conveyance System

The City operates an extensive NPR water system that serves two main areas: (1) Northern Service Area, and (2) Southern Service Area. For the Northern Service Area the City operates the NCWRP and NPR water system in compliance with RWQCB Order No. R9-2015-0091, which is a "Master Recycling Permit" (RWQCB, 2015). The NCWRP produces disinfected tertiary recycled water as defined in Section 60301.230 of Title 22 Water Recycling Criteria (CCR, 2014). The NCWRP will allow the City to meet NPR water demands for the Northern Service Area as described in Section 6.2.2.

6.2.3.1 Non-Potable Reuse Water Pump Station

The NPR Water Pump Station is located at the NCWRP site, as illustrated earlier and shown as "EPS" on Figure 6-10. The NPR Water Pump Station houses the NPR water wetwell, as well as the filter backwash, and utility water pumps. The facility was originally designed to receive a filtration/disinfection peak day flow of 54 mgd and, with the improvements described below, it is adequate for the expanded NCWRP.

The NPR Water Pump Station will be expanded to accommodate higher NPR water flows of up to 21.6 mgd versus the current maximum capacity of 17.2 mgd, which is achieved with two of the three existing pumps in operation and one in standby mode. One additional NPR water high-pressure pump, identical to the existing NPR water pumps, will be provided to have three pumps in service and one in standby mode.

The five existing utility water high-pressure pumps will be cross-connected to the 48-inch-diameter NPR water high-pressure main to satisfy low NPR water demand scenarios that are less than the preferred operating range of a single NPR water pump. Hydraulic modeling of different NPR water distribution scenarios has indicated that low NPR water demand scenarios could be satisfied by using the small utility water high-pressure pumps, thus providing substantial energy savings. Backflow preventer valves will be provided on the utility water high-pressure line to prevent plant utility water from entering the NPR system. Design criteria are presented in Table 6-14.

Table 6-14: NCWRP NPR Water Pump Station and Utility Water Pump Station Design Criteria

Parameter	Units	Existing NCWRP	Modified NCWRP
NPR Water Pump Station			
Design flow	mgd	17.2	21.6
Number of pumps			
Total	units	3	4
Duty	units (avg/peak)	2 / 2	2 / 3
Standby	units (avg/peak)	1 / 1	2 / 1
Type	--	Vertical turbine	Vertical turbine
Rated capacity, each	gpm	6,000	6,000
Rated total discharge head	ft	390	390
Horsepower, each	hp	800	800
Continues on next page...			

Parameter	Units	Existing NCWRP	Modified NCWRP
Drive type	--	Variable Frequency Drive	Variable Frequency Drive
Flow metering	--	Magnetic	Magnetic
Utility Water Pump Station			
Design flow	mgd	6.2	6.2
Number of pumps			
Total	units	5	5
Duty	units (avg/peak)	4	4
Standby	units (avg/peak)	1	1
Type	--	Vertical turbine	Vertical turbine
Rated capacity, each	gpm	1,330	1,330
Rated total discharge head	ft	260	260
Horsepower, each	hp	125	125
Drive type	--	Variable Frequency Drive	Variable Frequency Drive
Flow metering	--	Magnetic	Magnetic

Reliability and redundancy criteria for the NPR Water Pump Station requires that the pumps be able to handle the peak flows with the largest unit out of service. As described above and presented in Table 6-14, this criterion is met.

The following conditions at the NPR Pump Station are alarmed to the distributed control system: wet well level low, NPR water pump/drive fail, NPR water pump fail, hydraulically actuated pump discharge valve fail, pump discharge pressure fail, pump discharge pressure high, NPR water sample jar full, NPR water turbidity high, and NPR water total chlorine residual low.

6.2.3.2 Non-Potable Reuse Water Distribution System

As of 2015, the NPR water system supplied by the NCWRP comprised approximately 94 miles of pipelines, two storage tanks, and two pump stations. The system supplies NPR water to retail customers in the City of San Diego and two wholesale customers: City of Poway and Olivenhain Municipal Water District.

Figure 6-14 illustrates a map of the existing NPR water distribution system served by the NCWRP. The purple lines on that map represent City of San Diego pipelines; the black lines represent pipelines operated by the City of Poway and Olivenhain Municipal Water District.

6.2.3.3 Non-Potable Reuse Water Uses and Demands

NPR water is approved for irrigation of parks, playgrounds, school yards, residential landscaping, common areas, nurseries, freeway landscaping, cemeteries, and golf courses. NPR water may also be used for recreational water bodies, industrial process water and cooling water, dust control, soil compaction and similar construction purposes, as well as all other Title 22-designated uses. The City has Rules and Regulations for Recycled Water Systems (City, 2016d) that specify the terms and conditions for NPR water service.

The number of customers and NPR water use has gradually increased in the past decade. Figure 6-15 illustrates the historic volume of NPR water produced by the NCWRP through 2016. NPR water from the NCWRP is supplied to approximately 500 retail customer service meters in the City. Two wholesale customers purchase NPR water from the City and provide service to users within their service areas. Approximately 99 percent of the retail and wholesale customers use NPR water for irrigation, with the remaining customers using NPR water for cooling towers, construction, ornamental fountains, and toilet/urinal flushing.

The City PUD has a Recycled Water Site Supervisor Certification Program to train customers in the safe and efficient operational practices of NPR water. The training program educates customers how to identify potential and direct cross-connection and explains appropriate preventive measures. Courses for site supervisors are held monthly.

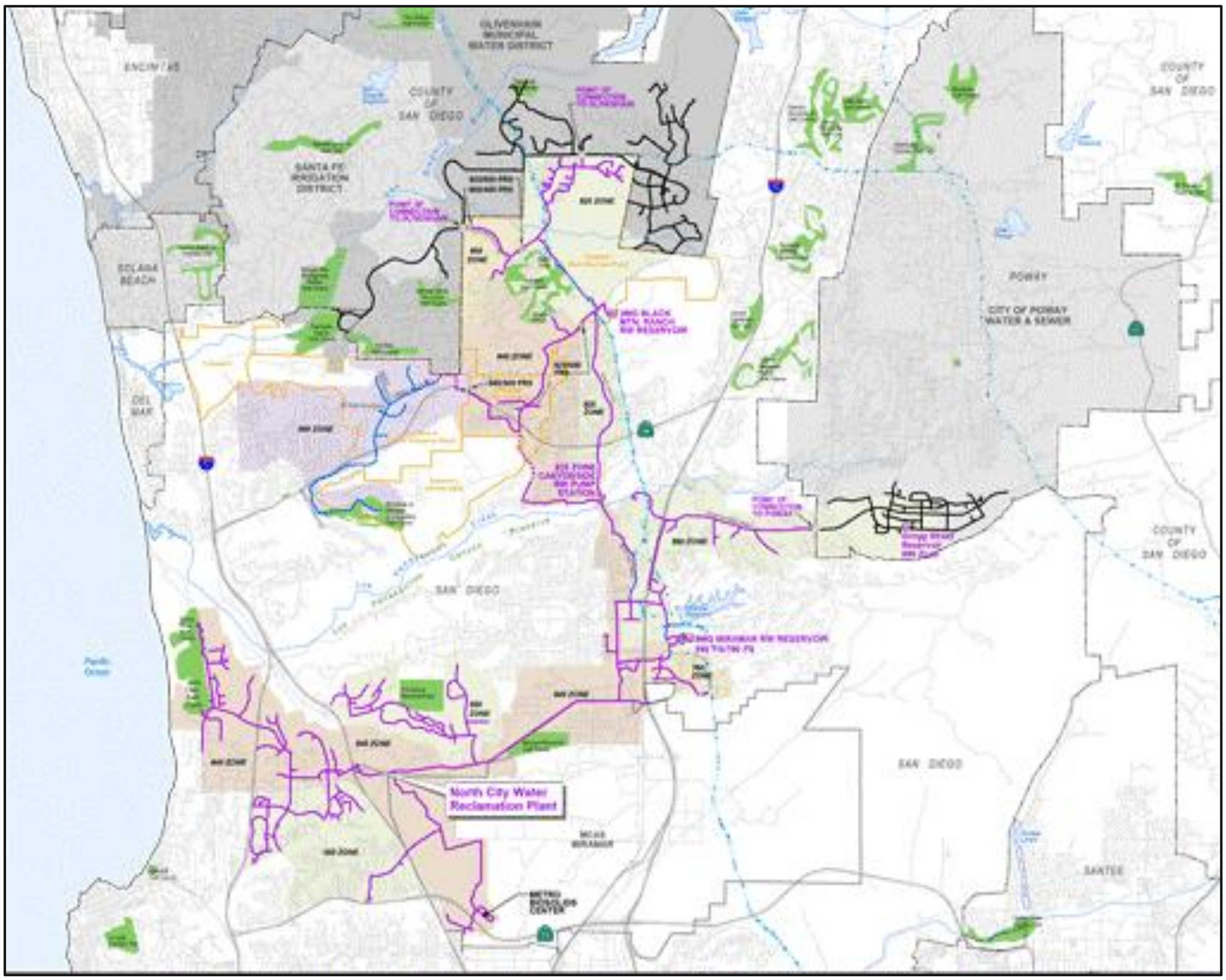
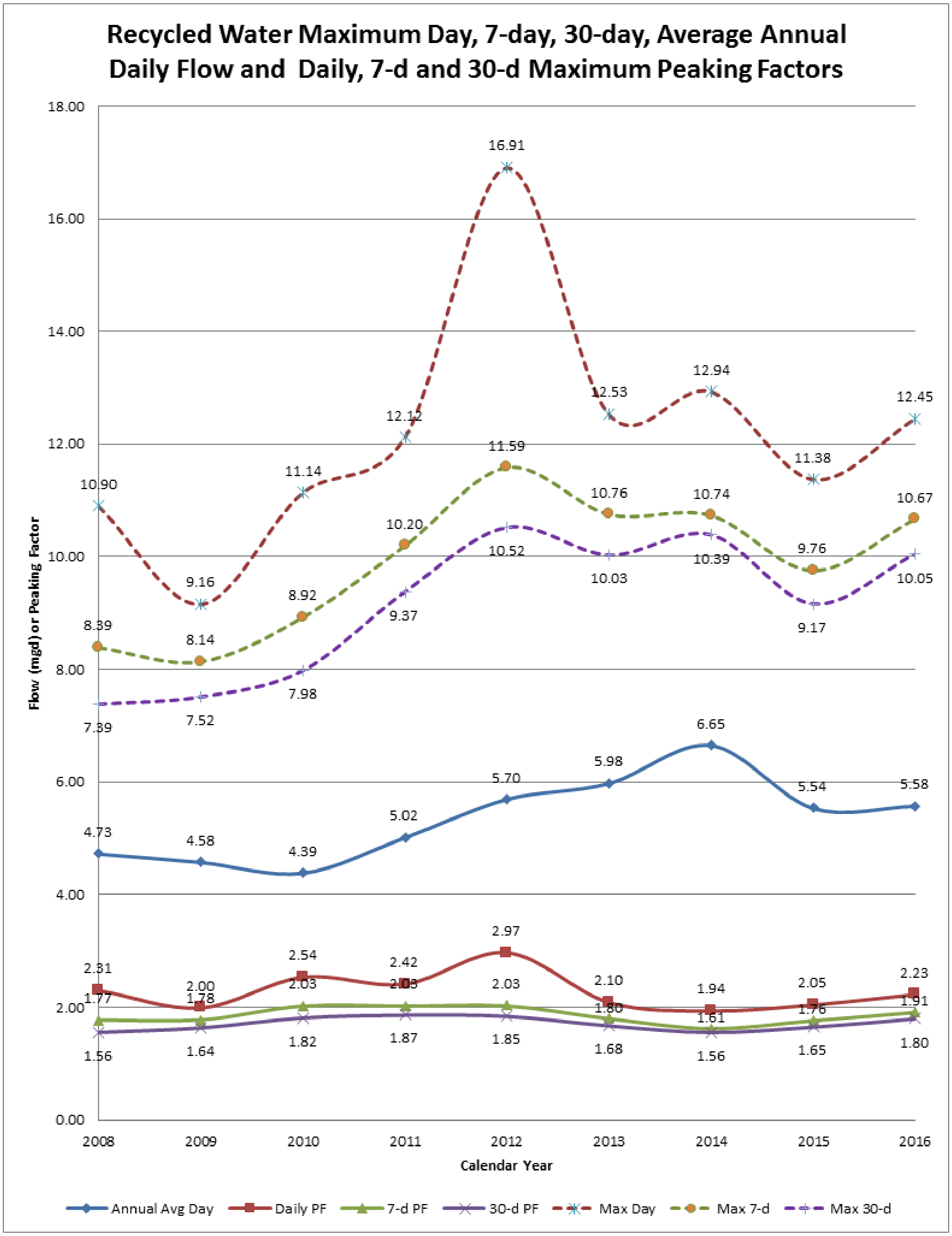


Figure 6-14: Existing Northern Service Area NPR Water Distribution System



(Source: "Recycled Water Master Plan", Final, dated August 2011 by B&C, B&V and CDM. Figure 202 "Historical NCWRP Beneficial Recycled Water Use (CY 1998-2010) – (BC, et al. 2011)

Figure 6-15: Historical NCWRP NPR Water Use

6.2.4 Tertiary Treated Water Conveyance System

The Tertiary Treated Water Conveyance System comprises the Tertiary Treated Water Pump Station and the Tertiary Treated Water Pipeline that will convey tertiary treated water from the NCWRP to the NCPWF.

The Tertiary Treated Water Pump Station will be located at the north end of the NCWRP and will convey a maximum of 42.5 mgd of non-chlorinated tertiary treated water to the NCPWF, which is located across Eastgate Mall. Figure 6-16 illustrates the location of the new Tertiary Treated Water Conveyance System relative to the existing NCWRP and more details of the system are illustrated on Figure 6-17. Four duty and one standby pumps will be located in a new structure to be built south of the existing CCTs.

6.2.4.1 Tertiary Treated Water Pump Station

The design criteria for the Tertiary Treated Water Conveyance System are presented in Table 6-15.

The Tertiary Treated Water Pump Station design is based on vertical-turbine pump types because they allow for a shallower pump station and smaller footprint. Four duty and one standby pumps will be located in a new structure to be built south of the existing CCTs.

The tertiary treated water pumps will operate off of a flow diversion clearwell that will be connected to the CCT influent conduit with a new channel using existing openings from the conduit. These openings were constructed for connection to future CCTs that are no longer needed for the NCWRP expansion. The tertiary effluent chlorine injection points will be relocated downstream of this diversion channel because flow to the NCPWF needs to be non-chlorinated, as chlorine residual may increase ozone demand, impact the biofilm in the BAC filters, and damage membrane filters (if any pass through the first two processes) at the NCPWF.

The Tertiary Treated Water Pump Station will operate continuously and at a relatively constant flow of 42.5 mgd to maintain the treatment objectives of the NCPWF; however, there will be times during which lower flows from one or more pumps will be needed for equipment start-up, maintenance, or other reasons. In addition, the dynamic losses through the downstream equipment will vary between backwash events; therefore, variable frequency drives for all tertiary treated water pumps will be installed for operational flexibility.

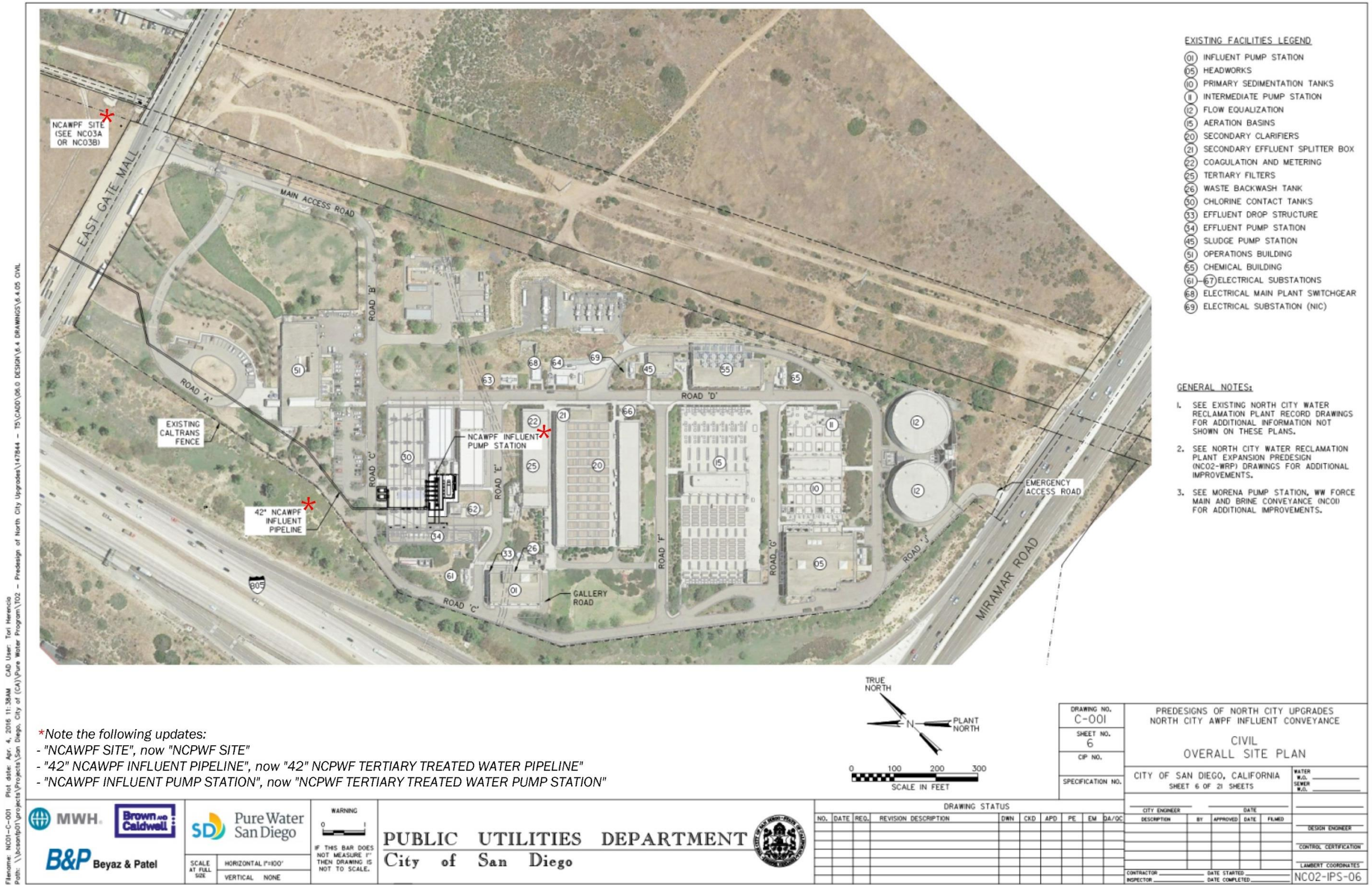


Figure 6-16: NCWRP Site Plan and Location of Tertiary Treated Water Conveyance System

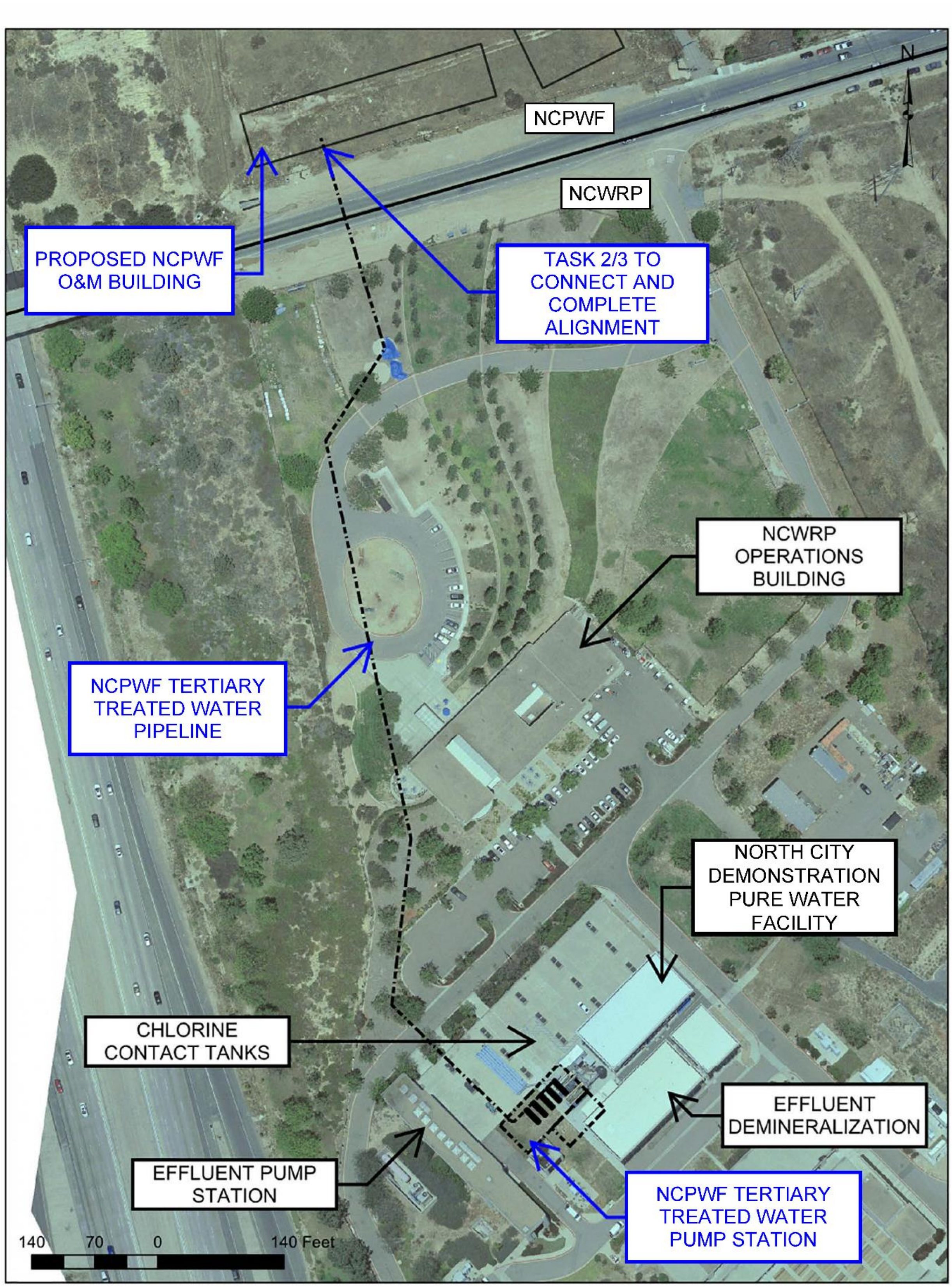


Figure 6-17: Tertiary Treated Water Conveyance System Location

Table 6-15: Tertiary Treated Water Conveyance System Design Criteria

Description	Units	Value
Tertiary Treated Water Pump Station		
Number of pumps		
Total	units	5
Duty	units	4
Standby	units	1
Type	--	Vertical turbine
Design flow (maximum)[a]	mgd	42.5
Design flow (minimum)[b]	mgd	6
Design total discharge head	ft	55-94
Drive type	--	Variable frequency
Tertiary Treated Water Conveyance Pipeline		
Pipeline length	ft	1,600
Pipeline size	inches	42

6.2.4.2 Tertiary Treated Water Pipeline

The Tertiary Treated Water Pipeline will convey flow to the inlet of the ozone contactors, which is the supply for the NCPWF. The 42-inch-diameter pipeline will be installed from the NCWRP to the NCPWF sites in accordance with City's standards. Design criteria are presented above in Table 6-15. Design details about the pipeline are available in the Tertiary Treated Water Conveyance System 10% Engineering Design Report (MWH/BC, 2016c).

Flow to the NCPWF will be measured by a magnetic flow meter installed downstream of the pumps. The amount of tertiary treated water flow required at the NCPWF will depend on the operator-controlled setting for the RO system.

Water from the existing tertiary treated water channel will flow passively to the Tertiary Treated Water Pump Station influent channel. Gates located at the diversion points will be automated to allow remote operation from the distributed control system.

The flow diverted into the Tertiary Treated Water Pump Station influent channel will be conveyed to its wetwell and/or pump cans. The four operational pumps will be staged on or off as required to match the feed water flow demands of the NCPWF and maintain the level in the NCPWF MF feed tank within an operator-selected range of acceptable levels. In general, the flow demand at the NCPWF is anticipated to be a constant value of about 42.5 mgd. Each pumping configuration (one, two, three, or four pumps in operation) will operate over a designated range of flows.

6.3 Potable Reuse Facilities

6.3.1 North City Pure Water Facility

The NCPWF will be capable of producing 34 mgd of purified water from the tertiary treated water produced by the NCWRP. The NCPWF will include the following key processes: ozone disinfection, BAC filtration, MF using microfiltration/ultrafiltration membranes, RO, UV/AOP, and product water stabilization. The product water leaving the NCPWF will be chlorinated to maintain a set residual in the pipeline, and then dechlorinated prior to discharge into Miramar Reservoir. The facility description provided within this section was extracted from the NCPWF 30% Engineering Design Report (MWH/BC et al., 2016) and the NCPWF 60% Submittal (Carollo, 2017), which are the basis for final design. Layout drawings and piping and instrumentation diagrams of these key processes are also provided in the NCPWF 60% Submittal (Carollo, 2017).

6.3.1.1 Facility Location and Site Plan

The location of the proposed NCPWF is illustrated on Figure 6-18. The NCPWF site is located in the University City community of San Diego at the intersection of I-805 and Eastgate Mall, and consists of an approximately 10-acre, undeveloped parcel of land owned by the City.

The site is roughly trapezoidal in shape with the longer axis running northwest to southeast. The elevation of the site ranges from 365 to 383 ft above mean sea level, with the highest elevations observed in the middle of the parcel, and the site generally sloping north. The hydraulic facilities have been sited to allow gravity flow through the NCPWF process units and then to the NCPW Pump Station. The Tertiary Treated Water Pump Station needed to convey influent to the NCPWF process units will be located at the NCWRP site.

Figure 6-19 illustrates the preliminary NCPWF site plan. The facilities will include an O&M building, ozone injection and contactors, ozone generation system, liquid oxygen facility, BAC filtration system, a combined process building (including an MF system, RO system, and UV system), chemical system and storage facility, main electrical building, product water tank, NCPW Pump Station, and provisions for future addition of a testing facility.

6.3.1.2 Facility Capacity and Peaking Factors

The required capacity of the NCPWF was determined by considering the projected need for purified water and NPR water, as well as individual process recoveries and minor plant losses within the NCPWF. The amount of purified water available to be sent to Miramar Reservoir will be equal to the product of the NCPWF, less the portion that is returned to the NCWRP for reducing the TDS concentration of the NPR water to 1,000 mg/L, a level suitable for irrigation. The amount of water that will be sent to Miramar Reservoir is estimated to be about 32.8 mgd as a maximum and 23.4 mgd as a minimum (as determined by NPR water demand) with an annual daily average of 29.8 mgd. The tertiary filtered feed water sent from the NCWRP to the NCPWF will be maintained constant throughout the year, thus improving performance of the processes at the NCWPF. A summary of the NCPWF capacity flows as they relate to average and peak NPR water demands is presented in Table 6-16.

Table 6-16: Facility Flows Required to meet NPR Water Demands

Flow Location	Average Annual Daily Flow (mgd)	Peak Daily Flow (mgd)
NPR Water Demand	11.8	21.62
Tertiary-Filtered Feed to the NCPWF	41.49	41.49
Backwash Waste	2.07	2.07
RO Brine to Sewer	5.91	5.91
Loss Due to In-Plant Use	0.3	0.3
Purified Water Returned for NPR Blending	3.44	9.82
Purified Water to Miramar Reservoir	29.76	32.8

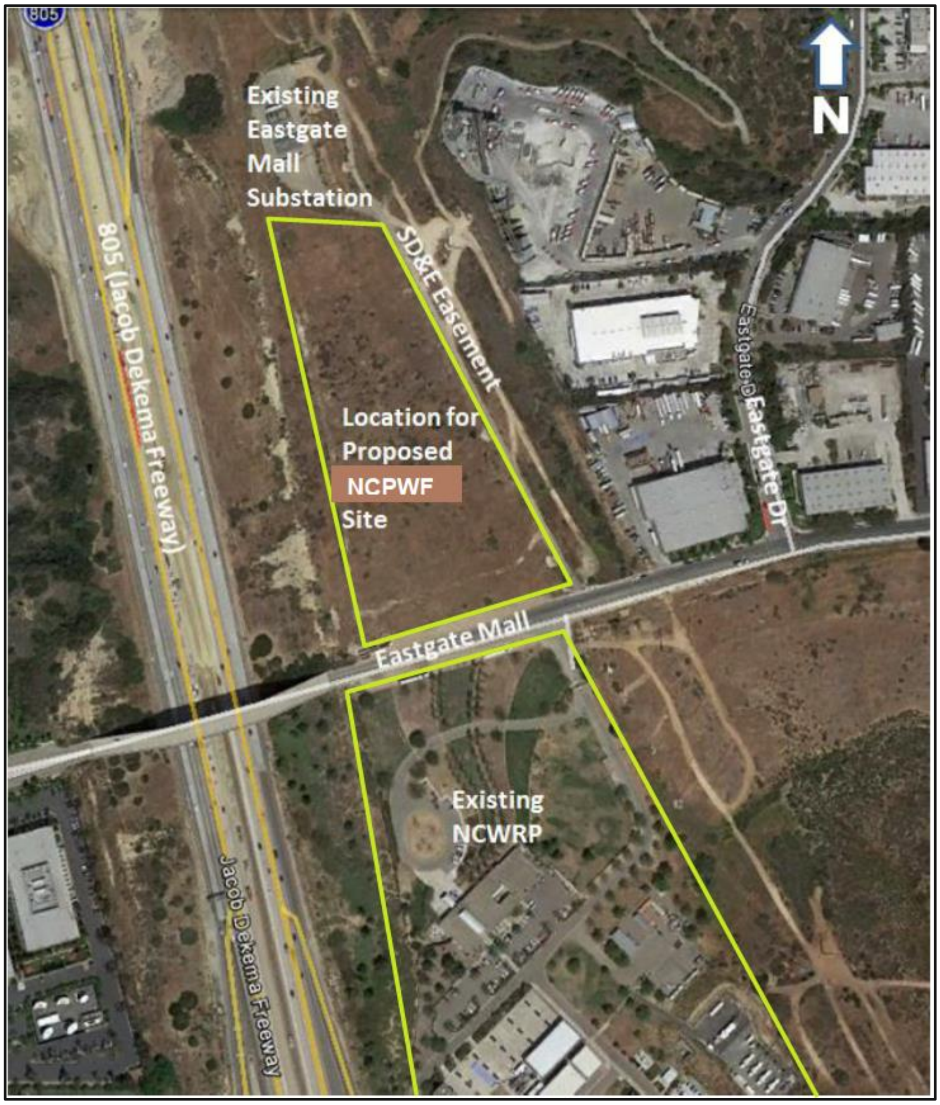


Figure 6-18: Location Details of the NCPWF

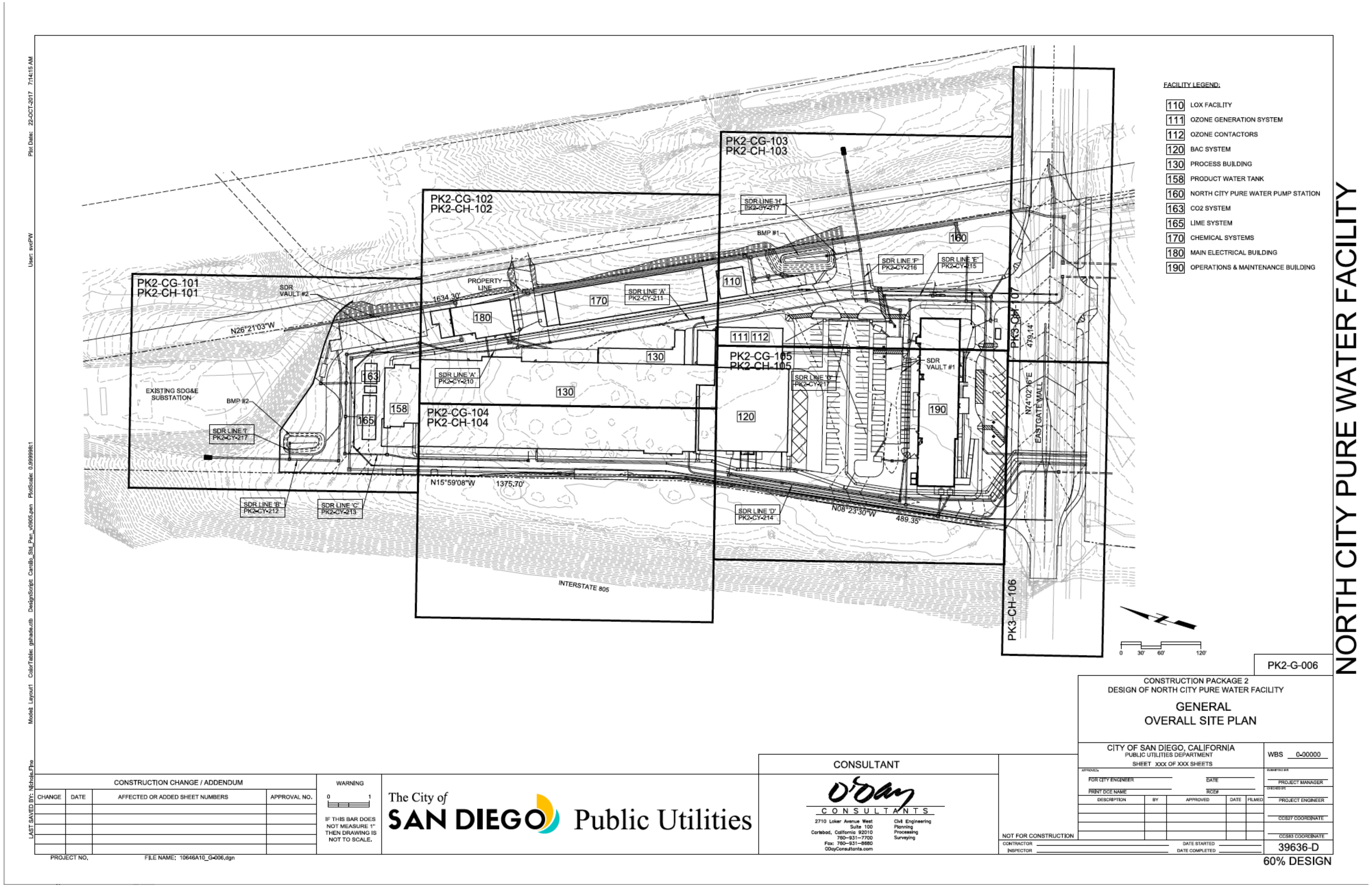


Figure 6-19: Overall Site Plan for the NCPWF

6.3.1.3 Description of Processes and Facilities

Figure 6-20 illustrates an overview of the NCPWF treatment train process. The main processes are ozone disinfection, BAC filtration, MF using Toray ultrafiltration membranes, three stages of RO, UV reactors with sodium hypochlorite as oxidant, lime and carbon dioxide for product water stabilization, and product water chlorination complete with necessary auxiliary systems. A detailed process flow diagram for the NCPWF is illustrated on Figure 6-21.

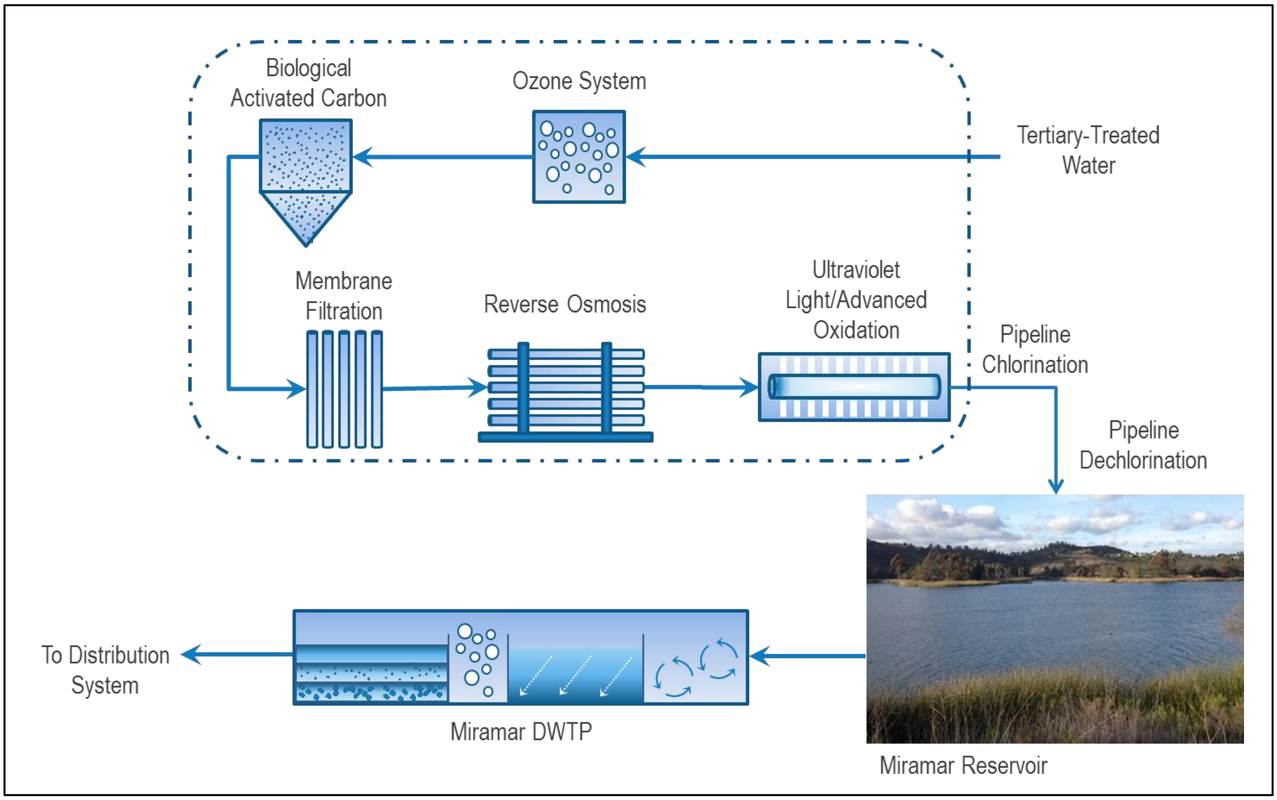


Figure 6-20: Proposed Treatment Processes

6.3.1.3.a Interties and Return Flows

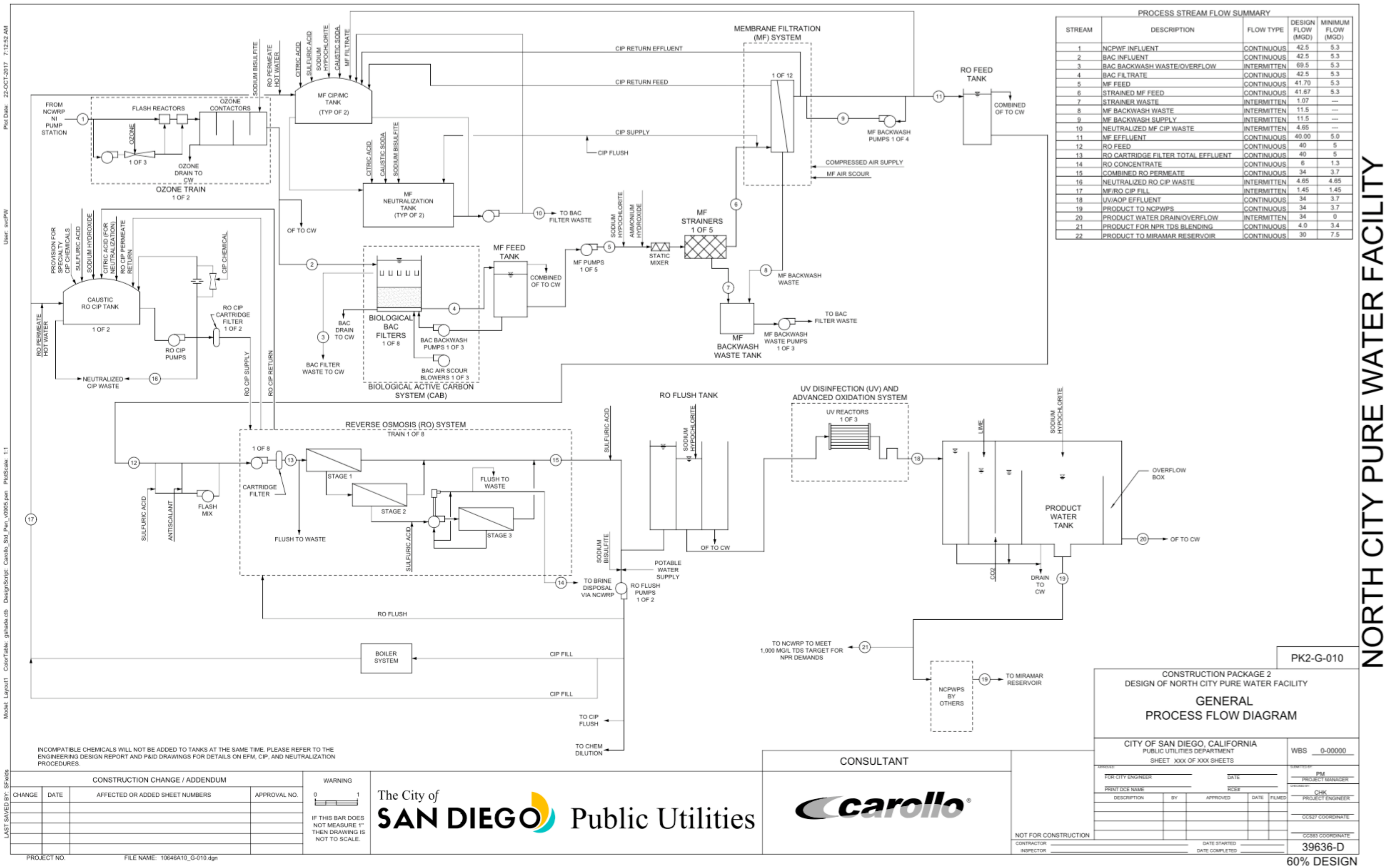
This section presents background information, considerations, and proposed materials for major yard piping and other utilities for the NCPWF. Drawings CY-101 through CY-105 of the civil drawings in Volume 5 of the NCPWF 60% Submittal (Carollo, 2017) show the proposed NCPWF yard piping plans, which include major electrical ductbanks.

All return flows to the NCWRP will be monitored. A flow meter will be provided on the combined waste line to measure return waste flows. The following are all return flows to the NCWRP through the combined waste line:

- BAC filter backwash waste/overflow (from the BAC filters);
- MF feed tank drain/overflow (from the MF feed tank);
- Process building miscellaneous/flood drainage (from drain sump pumps);
- Lime and CO_2 area miscellaneous drainage (from lime and CO_2 area);

- Strainer backwash waste (from membrane filtration system);
- RO feed tank drain/overflow (from RO feed tank);
- RO flush waste (from RO system);
- RO flush tank overflow (from RO flush tank);
- Neutralized MF CIP waste (from membrane filtration CIP system);
- Neutralized RO CIP waste (from RO system);
- Product water tank drain/overflow (from product water flow diversion structure overflow, CO_2 injection boxes, and lime mixing boxes); and
- MF backwash waste (from membrane filtration system).

All MF backwash headers will be equipped with flow meters, and total backwash flow will be calculated summing these flows. The NPR Water Blending Pipeline will be provided with a flow meter at the NCWRP. All waste lines will be connected upstream of these flow measurement points, and all flow measurements retained.



PROCESS STREAM FLOW SUMMARY

STREAM	DESCRIPTION	FLOW TYPE	DESIGN FLOW (MGD)	MINIMUM FLOW (MGD)
1	NCPWF INFLUENT	CONTINUOUS	42.5	5.3
2	BAC INFLUENT	CONTINUOUS	42.5	5.3
3	BAC BACKWASH WASTE/OVERFLOW	INTERMITTEN	69.5	5.3
4	BAC FILTRATE	CONTINUOUS	42.5	5.3
5	MF FEED	CONTINUOUS	41.70	5.3
6	STRAINED MF FEED	CONTINUOUS	41.67	5.3
7	STRAINER WASTE	INTERMITTEN	1.07	---
8	MF BACKWASH WASTE	INTERMITTEN	11.5	---
9	MF BACKWASH SUPPLY	INTERMITTEN	11.5	---
10	NEUTRALIZED MF CIP WASTE	INTERMITTEN	4.65	---
11	MF EFFLUENT	CONTINUOUS	40.00	5.0
12	RO FEED	CONTINUOUS	40	5
13	RO CARTRIDGE FILTER TOTAL EFFLUENT	CONTINUOUS	40	5
14	RO CONCENTRATE	CONTINUOUS	6	1.3
15	COMBINED RO PERMEATE	CONTINUOUS	34	3.7
16	NEUTRALIZED RO CIP WASTE	INTERMITTEN	4.65	4.65
17	MF/RO CIP FILL	INTERMITTEN	1.45	1.45
18	UV/AOP EFFLUENT	CONTINUOUS	34	3.7
19	PRODUCT TO NCPWPS	CONTINUOUS	34	3.7
20	PRODUCT WATER DRAIN/OVERFLOW	INTERMITTEN	34	0
21	PRODUCT FOR NPR TDS BLENDING	CONTINUOUS	4.0	3.4
22	PRODUCT TO MIRAMAR RESERVOIR	CONTINUOUS	30	7.5

Figure 6-21: NCPWF Process Flow Diagram

42-inch-diameter Tertiary Treated Water Pipeline

The 42-inch-diameter Tertiary Treated Water Pipeline will run parallel with the 24-inch-diameter NPR Water Blending Pipeline, 54-inch-diameter Combined Waste Pipeline, and 24-inch-diameter Brine Pipeline along the west property line, and will cross Eastgate Mall from the NCWRP.

54-inch-diameter Combined Waste Pipeline

The 54-inch-diameter Combined Waste Pipeline will convey multiple new process waste streams from the NCPWF site, across Eastgate Mall, to the existing NCWRP Raw Wastewater Pump Station building on the NCWRP site. The primary purpose of the Combined Waste Pipeline will be to drain water from the treatment processes that exceed control limits (for an explanation of control limits refer to Sections 13 and 15) from the NCPWF, various locations along the NCPWF treatment train, and the NCPW Pipeline back to the NCWRP. The 54-inch-diameter pipe will originate at the product water tank and have several lateral connections prior to measuring flow. Discharges from treatment processes exceeding control limits are discussed in more detail in Sections 6.3.1.6 and 16.4 of this report.

24-inch-diameter NPR Water Blending Pipeline

From the NCPW Pump Station, the 24-inch-diameter NPR Water Blending Pipeline will be routed west across the visitor parking lot where it will cross under Eastgate Mall to the NCWRP and discharged into the existing NPR Water Pump Station building, located on the NCWRP site. The purified water will be blended into the NPR water wetwell to achieve the target TDS level for NPR water. Blending water will be diverted from the NCPW Pump Station and controlled by a flow meter and flow control valve.

The 42-inch-diameter Tertiary Treated Water Pipeline, 24-inch-diameter NPR Water Blending Pipeline, 54-inch-diameter Combined Waste Pipeline, and 24-inch-diameter Brine Pipeline will run parallel across Eastgate Mall.

24-inch and 30-inch-diameter Brine Pipeline

The 24-inch-diameter Brine Pipeline will convey a new waste stream from the NCPWF site through the NCWRP site (no connection). The Brine Pipeline then increases in size to a 30-inch-diameter pipe and conveys the waste stream to the offsite sewer near the new Morena Pump Station. The Brine Pipeline will discharge to the North Metro Interceptor adjacent to the Morena Pump Station versus connecting to the sewer at the NCWRP. The brine flows to the North Metro Interceptor will be downstream of the Morena Pump Station withdrawal, which will allow the brine to flow directly to the PLWTP without recycling flow back to the NCWRP.

From the NCPWF site, the Brine Pipeline will run parallel with the 24-inch-diameter NPR Water Blending Pipeline, 54-inch-diameter Combined Waste Pipeline, and 42-inch-diameter Tertiary Treated Water Pipeline across Eastgate Mall to the NCWRP site along the west property line.

18-inch-diameter Microfiltration/Ultrafiltration Backwash Pipeline

The 18-inch-diameter MF Backwash Pipeline will convey waste backwash from the MF units at the NCPWF to the 54-inch Combined Waste Pipeline to the NCWRP. The MF units at the NCPWF will produce an average daily flow of approximately 1.3 mgd of waste backwash. The peak backwash rate is generated when two units are in backwash mode during a 90-second backwash cycle.

Alternative concepts were evaluated, including sending the MF backwash to the primary effluent or the front of the primaries. Diverting the MF waste backwash into the combined waste pipeline was selected to avoid the need for a dedicated 18-inch diameter MF Backwash Pipeline and to allow for some of the returned solids to be removed to reduce the solids loading to the secondary treatment.

12-inch-diameter Fire Protection Main

The 12-inch-diameter fire protection main will connect to the existing 36-inch-diameter waterline in Eastgate Mall, with the main looped around the site along the main access road of the NCPWF.

Other Utilities

The NCPWF required utilities, including drinking water, gas, and sewer connection will be tapped from the existing utilities running along Eastgate Mall. Existing utilities along Eastgate Mall include 10-inch and 4-inch gas lines, 36-inch and 12-inch water lines, and a 10-inch sanitary sewer line and sewer manhole near the southeast corner of the project site on Eastgate Mall. Additional 30-inch and 16-inch gas lines are observed running from north to south, east of the property within the 200-ft-wide San Diego Gas & Electric right-of-way.

6.3.1.3.b Treatment Train Water Quality Profile

Table 6-17 presents the entire set of projected water quality parameters before and after each unit process, starting with the tertiary treated water produced at the NCWRP, which serves as the NCPWF plant influent.

Table 6-17: Treatment Train Water Quality Profile

Quality at 34.0 mgd Treated Water Production		NCPWF Feed Water		Ozone Effluent		BAC Filtrate		MF Feed		MF Filtrate		RO Cartridge Filter Effluent	
		Stream 1[a]		Stream 3		Stream 4		Stream 6		Stream 11		Stream 13	
Parameter	Units	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median
pH[b]	-	6.7 - 7.7	7.3	6.7 - 7.7	7.3	6.6 – 7.6	7.2	6.7 – 7.7	7.3	6.7 - 7.7	7.3	6.2 – 6.7	6.5
Alkalinity[c]	mg/L as $CaCO_3$	143 – 197	173	143 - 197	173	139 - 196	171	143 - 205	178	143 - 205	178	41 - 174	111
Turbidity[d]	NTU	0.1 – 1.0	0.2	0.1 – 1.0	0.2	0.06 – 0.75	0.12	0.06 – 0.75	0.12	0.01 - 0.08	0.03	0.01 - 0.08	0.03
Calcium[b]	mg/L as $CaCO_3$	238 – 263	250	238 - 263	250	238 – 263	250	238 – 263	250	187 - 206	197	187 - 206	197
Sodium[b]	mg/L	187 – 238	198	188 - 239	199	188 – 239	199	188 – 239	199	189 - 242	202	189 - 242	202
TOC[e]	mg/L	6.2 - 8.6	7.2	5.1 – 9.1	7.2	3.9 – 7.0	4.5	3.9 – 7.0	4.5	3.9 – 7.0	4.5	3.9 – 7.0	4.5
TDS[f]	mg/L	700 – 1320	1170	700 - 1320	1170	700 - 1320	1170	700 - 1320	1170	700 - 1320	1170	700 - 1320	1170
LSI[g]	-	-0.6 – 0.6	0.1	-0.6 – 0.6	0.1	-0.6 – 0.6	0.1	-0.6 – 0.6	0.1	-0.7 – 0.5	0.0	-1.9 – -0.5	-1.0
Free Chlorine[h]	mg/L as Cl_2	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)
Chloramines[h]	mg/L as Cl_2	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	2.0 - 5.0	3.0	2.0 - 5.0	3.0	2.0 - 5.0	3.0
Total Chlorine[h]	mg/L as Cl_2	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	2.0 - 5.0	3.0	2.0 - 5.0	3.0	2.0 - 5.0	3.0
Bromide[i]	mg/L	0.2 – 0.5	0.3	0.1 – 0.4	0.2	0.1 – 0.4	0.2	0.1 – 0.4	0.2	0.1 – 0.4	0.2	0.1 – 0.4	0.2
Bromate[j]	µg/L	ND (5)	ND (5)	130 – 165	138	130 – 165	138	130 – 165	138	130 – 165	138	130 – 165	138
HAA5[k]	µg/L	1 – 20	2.2	1 – 31	6.5	ND (2)	ND (2)	1.0 – 5.6	4.4	1.0 – 5.6	4.4	1.0 – 5.6	4.4
TTHM[k]	µg/L	1.1 – 6.4	2.6	0.7 – 16	2.1	1.7 – 4.7	2.8	2.7 – 13	10	2.7 – 13	10	2.7 – 13	10
NDMA[l]	ng/L	2 – 41	3.8	18 – 55	31	2 – 24	2	2 – 28	2	2 – 28	2	2 – 28	2
1,4-dioxane[m]	µg/L	1	1	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)
Nitrate[c]	mg/L as N	5.4 – 11.2	7.7	5.4 – 11.2	7.7	5.5 – 11.8	7.9	5.5 – 11.8	7.9	5.5 – 11.8	7.9	5.5 – 11.8	7.9
Ammonia[c]	mg/L as N	0.1 – 0.5	0.15	0.1 – 0.5	0.15	ND (0.03)	ND (0.03)	0.7 – 1.6	0.8	0.7 – 1.6	0.8	0.7 – 1.6	0.8
Total Nitrogen[c]	mg/L	7.8 – 13.9	10.4	7.8 – 13.9	10.4	7.8 – 13.9	10.4	8.5 – 15.5	11.2	8.5 – 15.5	11.2	8.5 – 15.5	11.2
Total Phosphorus[c]	mg/L	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78

Quality at 34.0 mgd Treated Water Production		RO Permeate		UV/AOP Feed After NaOCl Addition		UV/AOP Effluent		Finished Water		
		Stream 17		Not defined		Stream 19		Post-Conditioning	Post-Chlorination	Post-Dechlorination
Parameter	Units	Range	Median	Range	Median	Range	Median			
pH[b]	-	4.8 - 5.7	5.0	5.0 – 5.9	5.2	4.1 – 5.0	4.3	7.5 - 8.5	7.5 - 8.5	7.5 - 8.5
Alkalinity[c]	mg/L as $CaCO_3$	0 – 13	6	2 – 15	8	2 – 15	8	>100	>100	>100
Turbidity[d]	NTU	0.01 - 0.08	0.03	0.01 - 0.08	0.03	0.01 - 0.08	0.03	5	<5	<5
Calcium[b]	mg/L as $CaCO_3$	4 – 4.4	4.2	4 – 4.4	4.2	4 – 4.4	4.2	92 - 146	92 - 146	92 - 146
Sodium[b]	mg/L	5 - 20	9	7 – 22	11	7 – 22	11	8 - 23	9 - 24	10 - 25
TOC[e]	mg/L	0.02 – 0.07	0.03	0.02 – 0.07	0.03	0.02 – 0.07	0.03	0.03	0.03	0.03
TDS[f]	mg/L	14 – 69	36	14 – 69	36	14 – 69	36	50 - 195	50 - 195	50 - 195
LSI[g]	-	-6.2 – -4.3	-5.4	-5.5 – -3.5	-4.7	-5.5 – -3.5	-4.7	0 – 0.5	0 – 0.5	0 – 0.5
Free Chlorine[h]	mg/L as Cl_2	ND (0.03)	ND (0.03)	2.0	2.0	1.0	1.0	1.0	1.5 – 4.0	ND (0.03)
Chloramines[h]	mg/L as Cl_2	1.5 - 3.0	2.0	1.5 - 3.0	2.0	0.7 – 1.5	1.0	1.0	1.0	ND (0.03)
Total Chlorine[h]	mg/L as Cl_2	1.5 - 3.0	2.0	3.5 – 5.0	4.0	1.7 – 2.5	2.0	2.0	2.5 – 5.0 [n]	ND (0.03) [n]
Bromide[i]	mg/L	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Bromate[j]	µg/L	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)
HAA5[k]	µg/L	ND (2)	ND (2)	ND (2)	ND (2)	1.5 - 5.3	3.3	3.3	3.3	3.3
TTHM[k]	µg/L	1.4 – 5.3	2.7	1.4 – 5.3	2.7	2 – 5	3.8	3.8	3.8	3.8
NDMA[l]	ng/L	2 – 29	2	2 – 29	2	2 – 12	ND (2)	ND (2)	ND (2)	ND (2)
1,4-dioxane[m]	µg/L	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)
Nitrate[c]	mg/L as N	0.71 – 1.52	1.02	0.71 – 1.52	1.02	0.52 – 1.12	0.75	0.75	0.75	0.75
Ammonia[c]	mg/L as N	0.27 – 0.62	0.31	0.27 – 0.62	0.31	0.27 – 0.62	0.31	0.31	0.31	ND (0.03)
Total Nitrogen[c]	mg/L	1.0 – 2.1	1.3	1.0 – 2.1	1.3	0.8 – 1.7	1.1	1.1	1.1	0.8
Total Phosphorus[c]	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

[a] Stream numbers are consistent with the process flow diagram provided in the Water Quality Technical Memorandum included as a part of the NCPWF 30% Engineering Design Report (MWH/BC et al., 2016).

[b] Feed water ranges provided for pH, calcium, and sodium represent operating conditions at the NCDPWF from September 2013 to June 2014 and daily samples of new sewer sources for two weeks in June 2015. Subsequent ranges result from calculations after each treatment process.

[c] Feed water ranges provided for alkalinity, nitrate, ammonia, total Nitrogen, and total Phosphorus represent BioWin wastewater treatment plant modeling predictions. Subsequent ranges result from calculations after each treatment process.

[d] The feed water range and BAC effluent range provided for turbidity represent operating conditions at the NCDPWF from an on-line turbidimeter sampling daily from August 2014 to September 2015. The upper limit is set by the NCWRP tertiary treated water goal of 1.0 NTU or less. The BAC filtrate upper limit is from a conservative estimate of 25 percent removal, as informed by NCDPWF data. The MF filtrate turbidity range is taken from 500 samples in 2014 and 2015. Lime addition will contribute to an increase in turbidity which was estimated using bench-scale test results from similar facilities. Settling and dissolution will result in a subsequent decrease in turbidity upon conveyance to Miramar Reservoir. Turbidity is not of regulatory concern upon discharge to Miramar Reservoir.

[e] The feed water range provided for TOC represents tertiary treated water samples collected in November and December 2014. Ozone effluent and filtrate TOC ranges are taken from NCDPWF samples between April 2015 and March 2016. RO permeate ranges result from measurements taken at the NCDPWF from October 2014 to November 2015.

[f] The feed water range provided for TDS represents the NCWRP raw wastewater data from January to June 2015 and daily samples of new sewer sources for two weeks in June 2015. Subsequent ranges result from calculations after each treatment process.

[g] Ranges provided for LSI represent calculations using Standard Method 2330 B with a modification for errors at high pH (Kenny et al., 2015).

[h] Ranges provided for chlorine species represent calculations made along each step of the treatment process, including expected NaOCl design doses and reactions in the treatment train.

[i] The feed water range provided for bromide represents tertiary treated water data from 33 samples ranging from 2013 to 2016, as well as daily samples of new sewer sources for two weeks in June 2015. The expected ozone effluent range of bromide is taken from 14 samples at the NCDPWF in November and December of 2014. The expected BAC effluent range of bromide is taken from 19 samples in November and December of 2014 and various months throughout 2015 and 2016. The RO permeate value comes from five of five non-detects (ND) from November to December of 2015.

[j] Feed water values provided for bromate represent 20 of 20 ND samples of tertiary treated water taken from 2013 to 2016. The ozone effluent range is provided from 6 samples at the NCDPWF in November and December of 2014 (not including NDs). The RO permeate value comes from 11 of 11 NDs from November 2014 to September 2015.

[k] The feed water HAA5 and TTHM ranges come from 21 NCPWF feed samples from 2014 to 2016 (and conservatively do not reflect five ND measurements for HAA5). The ozone effluent ranges come from 20 samples collected at the NCDPWF throughout 2014, 2015 and 2016. The BAC filtrate values come from 19 samples throughout 2014 to 2016. The MF filtrate ranges were provided by 18 samples throughout 2014 to 2016. The RO permeate and UV/AOP effluent ranges were taken throughout 2014 to 2015 from 19 and 20 samples, respectively.

[l] The feed water NDMA range comes from the 14 NCPWF feed samples from 2014 to 2016. The ozone effluent and effluent ranges come from 13 samples collected at the NCDPWF throughout 2014, 2015 and 2016. The MF filtrate range was provided by nine samples throughout 2014 to 2016. The RO permeate and UV/AOP effluent ranges were taken throughout 2014 to 2015 from 17 and 20 samples, respectively.

[m] The feed water 1,4-dioxane range comes from eight ND samples and a single 1 µg/L sample from the NCPWF feed in November and December of 2014. The ozone effluent and effluent ranges come from six samples collected at the NCDPWF during November and December of 2014. The MF filtrate and RO permeate ranges were provided by five samples in November and December of 2014. The UV/AOP effluent ranges was from six NDs in November and December of 2014

[n] Total chlorine residual (present as free chlorine) is expected to be around 2.5 mg/L as chlorine just prior to the NCPW Dechlorination Facility after complete chloramine breakpoint and chlorine decay through the NCPW Pipeline to Miramar Reservoir.

6.3.1.3.c Purified Water Quality Goals

Table 6-18 presents purified water quality goals, which are for the purified water just prior to discharge to Miramar Reservoir.

Table 6-18: Purified Water Quality Goals

Parameter	Unit	Finished Water Quality Goal	Basis
Title 22 of CCR			
Primary Drinking Water Standards	--	< pMCL	Title 22 CCR
Secondary Drinking Water Standards	--	< sMCL	
Notification Level Contaminants	--	< Notification Level	
Pathogens			
Virus	Log reduction	See Table 6-19	Title 22 CCR
Giardia	Log reduction		
Cryptosporidium	Log reduction		
Organics			
TOC	mg/L	< 0.5	Title 22 CCR
1,4-dioxane	Log treatment with UV/AOP	> 0.5-log	Title 22 CCR
NDMA	ng/L	0.69	CTR
Inorganics			
Nitrogen, total	mg/L	< 2.0	Basin Plan
Phosphorus, total	mg/L	< 0.025	
Finished Water Stabilization			
pH	--	7.5–8.5	Corrosion Minimization
Alkalinity	mg/L as $CaCO_3$	> 100	pH Stability for Downstream Water Treatment
LSI	--	0–+0.5	Corrosion Minimization
$CaCO_3$ precipitation potential	mg/L as $CaCO_3$	0–10	

The finished water pathogen treatment goals of the NCPWF are presented in Table 6-19. It should be noted that these pathogen reductions do not include removals that would normally be credited to the Miramar DWTP, namely 4-log reduction for viruses, 3-log reduction for *Giardia,* and 2-log reduction for *Cryptosporidium*.

Table 6-19: Finished Water Pathogen Treatment Goals

Pathogen	NCWRP[a]	Ozone/ BAC	MF	RO[b]	UV/ AOP	Pipeline Cl_2	Total Prior to Discharge to Reservoir	Required Prior to Discharge to Reservoir
Virus	0.7	6	0	2.5	6	6	21.2	10
Giardia	3.2	6	4	2.5	6	1	22.7	9
Cryptosporidium	0.9	1	4	2.5	6	0	14.4	10

[a] Subject to change upon additional pathogen monitoring
[b] RO credits based on Tier 1 and may exceed this value.

6.3.1.3.d Ozone System

The ozone system will provide disinfection to achieve the expected pathogen log-removal credits (expected LRVs are 6-log virus, 6-log *Giardia*, and 1-log *Cryptosporidium*), and provide chemical oxidation to reduce CEC concentrations and facilitate biological treatment through the BAC filters. Combined with BAC, ozonation will also improve MF performance beyond what could be achieved without this pretreatment step.

Process Overview

Components of the ozone system will include the liquid oxygen system, ozone generators, ozone dissolution and contactor, ozone off-gas destruction, and instrumentation and controls. Two total liquid oxygen tanks, three vaporizers, three ozone generators, and two ozone contactors, along with required auxiliary systems, will be provided. There will be three distinct ozone facilities as described below:

- ***Liquid Oxygen Facility.*** The liquid oxygen facility design includes two vertical liquid oxygen storage tanks, three vaporizers, a pressure regulating station, a truck fill-station with a concrete apron for truck deliveries, and associated pipes and valves. All equipment will be mounted on a concrete slab north of the Pure Water Pump Station and south of the chemical storage facility.
- ***Ozone Generation System.*** The ozone generation system design incorporates a three-room building that contains three ozone generators, three power supply units, a particulate filter skid, a fine-pressure regulating station, a nitrogen boosting system, a cooling water system, and associated valves and piping.
- ***Ozone Injectors and Contactors.*** This facility will contain six ozone side-stream injection skids, six side-stream injection pumps, two ozone contactors, three ozone destruct units, three cooling water pumps (open loop), ozone residual sampling system with residual analyzers, and associated valves and piping.

Process Design Criteria

The primary design criteria for the ozone system is to apply a CT of 3.8 mg-min/L (at 20.5 degrees Celsius° (°C)) of ozone to the full NCPWF tertiary treated water flow to achieve 6-log inactivation credit of both virus and *Giardia* and achieve 1-log inactivation credit of *Cryptosporidium.* The design will also enhance biological treatment by the BAC filters. Water quality parameters of the NCWRP tertiary treated water, which serves as the NCPWF influent, are presented in Table 6-17.

Liquid Oxygen System

The oxygen for the ozone generators will be supplied by a liquid oxygen system providing a total liquid oxygen storage capacity of 30,000 gallons, three vaporizers to convert liquid oxygen to gaseous oxygen, and a coarse pressure regulating station located at the liquid oxygen storage facility.

Two vaporizers with minimum capacities of 35,000 cubic feet per hour will be required so that one vaporizer can operate at the design gaseous oxygen flow while the other vaporizer is deicing. A third vaporizer provides full redundancy. Design criteria for the liquid oxygen system are presented in Table 6-20.

Table 6-20: Liquid Oxygen System Design Criteria

Parameter	Value
Liquid oxygen Tanks	2
Liquid Oxygen Tank Volume (each)	15,000 gallons
Liquid Oxygen Tank Orientation	Vertical
Liquid Oxygen Tank supplier	Chart Industries or Taylor Wharton
Vaporizers	3
Minimum Vaporizer Capacity (each)	35,000 cubic ft per hour
Suggested Vaporizer Supplier	Cryoquip
No. of Duty Gaseous Oxygen Particulate Filters	1
No. of Standby Gaseous Oxygen Particulate Filters	1
Pressure Regulating Valves	2

Liquid oxygen storage tanks are pressurized tanks generally operating around 50 to 75 pounds per square inch (psi), but having a working pressure up to 175 psi. When liquid oxygen is vaporized, gas pressures will exceed the pressures of the oxygen in the liquid state. Pressure regulation of the gaseous oxygen is required to provide a safe pressure for interior gaseous oxygen piping and reduce the pressure to a level acceptable for the ozone generators as specified by the ozone system supplier. Particle filters and a dew point analyzer located after the pressure regulating system will help protect the downstream ozone generators from damage.

A concrete apron will be provided for truck delivery, and a truck filling station located on the west side of the facility for easy access during filling. The pressure regulating station will be located close to the entrance gate for easy access.

Ozone Generators

The ozone system design includes two duty and one standby ozone generators with a minimum production capacity of 2,481 pounds of ozone per day at an ozone concentration at 12 percent by weight (2,940 pounds of ozone per day at a concentration of 7 percent by weight). The ozone system will be capable of satisfying the design ozone dose of 14 mg/L at the design flow of 42.5 mgd with turndown capability to a dose of 5 mg/L at a flow of 5.3 mgd. Each ozone generator will have its own power supply unit. The power requirements for the ozone system will be <6.0 kilowatt hours per pound of ozone produced. Design criteria for the ozone generators are presented in Table 6-21.

Table 6-21: Ozone Generators Design Criteria

Parameter	Value
Ozone Dose, Design	14 mg/L
Ozone Dose, Minimum	5 mg/L
Flow, Design	42.5 mgd
Flow, Minimum	5.3 mgd
Number of Duty Ozone Generators	2
Number of Standby Ozone Generators	1
Generator Capacity, Each (12% Ozone Concentration)	2,481 pounds per day
Ozone Gas Concentration Range at Design Dose	6 – 12%
Power Supply Units per Generator	1
Oxygen Supply	liquid oxygen system
Maximum Power Requirements (12% Ozone Concentration)	< 6.0 kilowatt hours per pound Ozone
Maximum Feed Gas Dew Point	- 62.2 °C (- 80 °F)

The three ozone generators will be located in the Ozone Generation Building, along with their power supply units, the particulate filters, and the fine pressure regulating station located upstream.

Cooling Water System

Excess heat generated during the production of ozone in both the ozone generators and the power supply units will be removed by a closed-loop cooling water system containing conditioned water. The closed-loop flow will pass through a plate and frame heat exchanger, where the water heat in the closed loop is wasted to water in an open-loop, single-pass system. Water for the open loop will be supplied from, and returned to, the RO permeate. Design criteria for the cooling water system are presented in Table 6-22.

Table 6-22: Cooling Water System Design Criteria

Parameter	Value
Number of Duty Open Loop Cooling Water Pumps	2
Number of Standby Open Loop Cooling Water Pumps	1
Number of Duty Closed Loop Cooling Water Pumps	2
Number of Standby Closed Loop Cooling Water Pumps	1
Number of Duty Heat Exchangers	2
Number of Standby Heat Exchangers	1
Source of Open Loop Cooling Water	RO Permeate
Open Loop Flow per Pump	750 gpm
Motor hp per Open Loop Pump	20
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Parameter	Value
Source of Closed Loop Makeup Water	Stabilized RO permeate
Max Temperature of Open Loop Supply	86 °F (30 °C)
Max Temperature Rise across Open Loop	10 °F (5.6 °C)
Minimum Heat Transfer Efficiency	90%
Pressure Differential between Loops	5 psi

Nitrogen Boost System

Generating ozone at high gas concentrations is more reliable when the feed gas includes a small percentage of nitrogen. A nitrogen boost system, which is a standard component of large ozone systems, conditions ambient air by removing particulates, moisture, and other impurities. The nitrogen boost system will be designed and provided by the ozone system supplier. At a minimum, the nitrogen boost system will include an air compressor, receiver tank, after-cooler, desiccant dryer, particulate and oil coalescing filters, dew point analyzer, and flow control valve that is typically controlled by the master ozone control panel to regulate the amount of nitrogen added to the gaseous oxygen. Design criteria for the nitrogen boost system are presented in Table 6-23.

Table 6-23: Nitrogen Boost System Design Criteria

Parameter	Value
Number of Nitrogen Boost Systems	1
Gas Supply for Nitrogen Boost System	Ambient air
Capacity of Nitrogen Boost System	0.5 to 2% of the gaseous oxygen flow to the ozone generators
Maximum Nitrogen Gas Dew Point	- 65 °C

Ozone Injection System

Before the addition of ozone gas by side stream injection, the water flow will split into two pipes that feed one ozone contactor each. A portion of the NCPWF feed water (the side stream flows) will be pumped through Venturi injectors that draw the ozone gas produced by the ozone generators into the water. After ozone addition, these side stream flows will be mixed with the main process flow in each pipe using two stainless steel flash reactors. A static mixer will be provided downstream of the flash reactors for additional gas mixing. In order to prevent any gas entry into the side stream injection system inlet pipe, an air dam with a vent will be installed upstream of the nozzle assembly.

Per contactor, the side-stream system will include two duty injection skids, one standby injection skid, and two flash reactors. A pump with variable frequency drive on each skid will allow control of pressure and flow of water in order to maximize ozone transfer efficiency. Design criteria are presented in Table 6-24.

Table 6-24: Ozone Injection System Design Criteria

Parameter	Value
Number of Ozone Contactors	2
Injection Type	Side stream
Number of Duty Skids, Per Contactor	2
Number of Standby Skids, Per Contactor	1
Number of Injectors per Skid	1
Number of Pumps per Skid	1
Pump Capacity - gpm	2,400
Pump Pressure – psi	80
Number of Pipeline Flash Reactors, Per Contactor	2
Minimum Ozone Transfer Efficiency	90%

Computational fluid dynamic modeling has been performed by a side-stream injection system manufacturer, Mazzei (Bakersfield, California), to ensure sufficient mixing is provided when using their proposed system design.

Ozone Contactors

The ozone contactors will provide contact time for the dissolved ozone to achieve the desired disinfection CT credits and chemical oxidation. After the side-stream injection, the liquid-gas mixture will be introduced into the contactor and into a chimney to allow for leftover gas bubbles to be vented at atmospheric pressure to the ozone destruct system. Ozone contractor's configuration is illustrated on Figure 6-22.

There will be two vertically stacked serpentine contactors; each of which will be designed to achieve a CT of 3.8 mg-min/L (at 20.5°C), and provide a minimum *Cryptosporidium* log-removal credit of 1.0. T_{10} is the effective hydraulic retention time (HRT) at which 10 percent of the water passes through the contactor. The use of T_{10} ensures that 90 percent of the water has a longer HRT than the T_{10}. The minimum T_{10} required to achieve this contact time based on data from the NCDPWF is six minutes.

A hydraulic efficiency value of 79 percent is assumed; however, this value may be changed based on results of tracer studies of the ozone contact basins. Given the contactor volume and at maximum flow, it will achieve a T_{10} of 8.7 minutes (calculated by design HRT x hydraulic efficiency) and provide additional volume for ozone quenching before the BAC filters. The contactor design criteria are presented in Table 6-25.

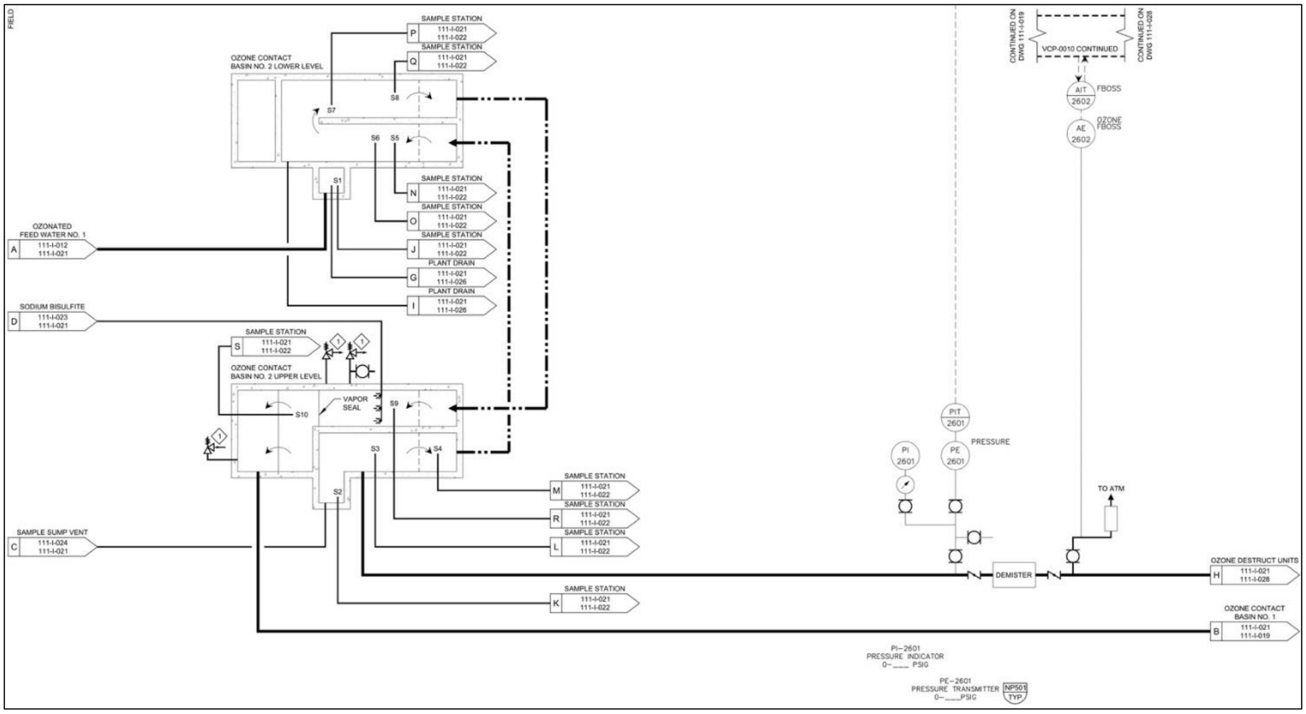


Figure 6-22: Ozone Contactors Design

Table 6-25: Ozone Contactors Design Criteria

Parameter	Value
Type of Ozone Contactor	Four-Pass Serpentine, vertically stacked
Number of Ozone Contactors	2
Flow, Design	42.5 mgd
Flow, Minimum	5.3 mgd
Flow, Design (per Contactor)	21.25 mgd
Flow, Minimum (per Contactor)	5.3 mgd
Total HRT	11.03 minutes
T_{10}/HRT	0.79
Effective HRT (T_{10})	8.7 minutes
Design CT (at 20.5 ^{o}C)	3.8 mg-min/L

Quenching System

The capability to add sodium bisulfite to the ozone contactor effluent to quench residual ozone before it enters the BAC system will be provided. This system will be able to provide a maximum sodium bisulfite dose of 3 mg/L in order to quench the ozone residual under worst-case conditions (high ozone/TOC ratio). The actual dose of sodium bisulfite will be determined from readings by the oxidation reduction potential meter on the contactor effluent piping, which will verify that no dissolved ozone is present. Design criteria for the sodium bisulfite quenching system are presented in Table 6-26.

Table 6-26: Sodium Bisulfite Quenching System Design Criteria

Parameter	Value
Injection Point	Ozone contactors
Design HRT for Quenching Ozone Residual in Ozone Contactors	2.07 minutes
Concentration	25% by weight
Maximum Dose, Design	3 mg/L

Dissolved Ozone Monitoring

This section describes the instrumentation and controls for determining the applied ozone dose required to achieve the minimum CT required to satisfy the disinfection goals for the ozone system. The system will use four dissolved ozone sensors per contactor; these sensors will be located in their own flow-through cells at a sampling station. Water samples will be supplied continuously to the sampling station by sample lines that limit the travel time from the sample location to the dissolved ozone sensor to less than 10 seconds. There will be more sample locations in each contactor that will have piping to the sensors in order to provide flexibility to the operations staff to choose the optimal sample locations for on-line monitoring and take grab samples at different locations as needed. This is included in the design due to the uncertainty in the ozone demand and decay curves. All water samples will be drawn from the center of the ozone contactor channel.

The ability to continuously and reliably monitor dissolved ozone is critical for verifying log removal credits based on the contact time calculation; however, some full-scale plants with similar ozone-in-tertiary wastewater applications have struggled to achieve reliable dissolved ozone measurement. The quick decay kinetics are one aspect of this challenge; however, biofilm accumulation on sample piping has been observed at one full-scale facility and could be a cause of a significantly lower (or even “zero”) ozone residual measurement taken at the dissolved ozone sensor, which is not representative of the actual ozone residual present at the sample pipe intake location. A few design provisions have been incorporated to help mitigate this potential issue:

- All ozone residual measurements (especially the most critical at the beginning of the contactor) have been designed to have as short of sample piping as possible from the sample point to the dissolved ozone sensor;
- The sample piping has been designed with larger piping than usual and a high flow rate and velocity to help scour the pipe walls to prevent/reduce biofilm, and provide a larger cross section of bulk flow that is less affected by any biofilm that may develop; and
    - The sample lines will discharge to an ozone sample sump that will recycle flow back to the raw water feed
    - A portion of the sample flow will be taken as a sidestream to the dissolved ozone sensor.
- Pipe connections will be provided on the sample piping for future testing of additional dissolved ozone measurement devices, if needed.

Extended testing conducted at the NCDPWF demonstrated continuous, reliable dissolved ozone measurements (Trussell et al., 2015). Additional analysis was also performed at the NCDPWF site to evaluate the most reliable dissolved ozone analyzers commercially available. The findings of this additional analysis will be considered in the final design.

The estimated location of the four “primary” sample locations originally planned for use with the four dissolved ozone sensors (with addition of redundant sensors to provide back up for the primary ones) are as follows:

- Ten ft downstream of the baffle wall in the first leg of each ozone contactor;
- Approximately halfway between the first sample location and the third sample location;
- Placed within ½ of contactor’s HDT at design flow; and
- Eighty feet before the effluent pipe and 10 feet before SBS addition point.

Redundant dissolved ozone sensors should be installed for the first, and, either second or third sensors.

The first three dissolved ozone sensors will be used to calculate dissolved ozone CT for disinfection credits. The fourth sensor will measure the ozone residual once the required CT is achieved. The ozone CT will be continuously calculated; if the ozone CT falls below an operator-specified set point, the ozone system will increase the applied ozone dose until that set point is achieved. If the contactor effluent oxidation reduction potential sensor measures an ozone residual, sodium bisulfite addition will be initiated or increased as needed, with a trim on the fourth ozone residual. If the sodium bisulfite dose cannot be increased, then the applied ozone dose will be decreased to protect downstream systems.

In addition to the four sample locations mentioned above, additional sampling taps extending to the center of the contactor will be provided at the following locations:

- Two sample taps equally spaced between the first and second “primary” sample locations mentioned above;
- Two sample taps equally spaced between the second and third “primary” sample locations mentioned above; and
- Two sample taps equally spaced between the third and fourth “primary” sample locations mentioned above.

These additional sample taps will provide intermediate sampling locations for water quality or dissolved ozone grab samples, as well as alternative sample connections for the sample pumps located at the primary sampling station. In addition, the ozone system will include analyzers to continuously monitor the ozone influent pH, TOC, turbidity, NO_2, and UV transmittance. The combined contractor effluent will be analyzed for pH, oxidation reduction potential, UV transmittance, turbidity, and TOC.

Ozone Off-Gas Destruct System

Off-gas from the enclosed headspace of the ozone contactors will be piped to the ozone destruct system. Blowers will create a negative gage pressure of at least -4.0 inches of water column in the enclosed headspaces to evacuate ozone into the thermal-catalytic ozone destruct units. At a minimum, the ozone destruct system will include demisters, a condensate trap following demisters, and at any low points in the off-gas header piping, preheaters, ozone destruct units, blowers, and silencers. Each ozone destruct unit will be capable of reducing the off-gas ozone concentration to a maximum of 0.08 mg/L parts per million when the ozone system is operating at the design ozone dose of 14 mg/L and half the design water flow of 42.5 mgd. Design criteria for the ozone off-gas destruct system are presented in Table 6-27.

Table 6-27: Ozone Off-Gas Destruct Design Criteria

Parameter	Value
Number of Duty Destruct Units	2
Number of Standby Destruct Units	1
Type of Destruct Units	Thermal-catalytic
Maximum Ozone Concentration in Destruct	0.08 parts per million
Minimum Pressure at Basin Headspace	-4.0 inches

6.3.1.3.e Biologically Active Carbon Filters

The ozone process will be followed by biological filtration using GAC, also known as BAC filtration, to provide additional treatment before the MF system.

Process Overview

Biological filtration is a fixed film biological process that uses filter media as the surface for biological growth. With BAC, the GAC filter media is important mainly because its micro- and meso-porosity make it conducive to biofilm growth. This GAC is not regenerated, leading to the slow exhaustion of its adsorption capacity and making BAC a biological and filtration process more than an adsorption process. During the filtration cycle, BAC removes both dissolved organics and suspended solids from the water by a combination of biological uptake and depth filtration. As the filtration cycle continues, biomass growth and suspended solids entrainment create additional headloss in the filter bed. The backwash cycle is then used to flush out the entrained solids and slough off some biomass from the media, thereby controlling the rate of biomass growth.

BAC filtration downstream of ozonation of tertiary treated water will provide removal of TOC, NDMA, and CECs. Ozonation increases the bioavailability of organic molecules by breaking them down. This allows BAC filtration to remove these organic molecules readily. During the testing at the NCDPWF, under typical operating conditions with an empty-bed contact time of 16 minutes, TOC reduction was usually 35 percent to 40 percent. The removal of organic matter reduced fouling and improved the performance of downstream MF membranes (Pearce et al., 2015). BAC reduced NDMA concentrations by more than 90 percent and decreased the concentration of CECs such as iohexol, sucralose and tris(2-carboxyethyl)phosphine (TCEP) along with important membrane foulant metals such as iron and manganese.

The BAC system design includes gravity filters with GAC media, backwash pumps, air scour blowers, and associated instrumentation and controls. Required backwash water will be drawn from the MF feed tank. Ozonated tertiary treated water flow will be distributed evenly to the BAC filters by an influent channel and filter effluent valves and meters will be used for rate of flow control operation.

The BAC facility will be directly adjacent to the process building on the NCPWF site. The BAC filter structure will have a 3-inch seismic separation from the process building on the north side and share a common wall with the ozone contactor facility on the east side. The facility will have eight filters arranged in two rows on each side of a common filter gallery with each filter cell approximately 15 ft by 50 ft in size.

The underdrain laterals and wash water troughs will extend the 15 ft width of the filter area. The filter gallery will be located below the influent channel. The filter gallery and process building basement, which will share a common floor elevation, will be connected with a large coil door and smaller doorway to allow ease of access between the two areas.

The vertical profile of the filter cells was designed to allow for sufficient space for media bed expansion below the backwash troughs. A filter effluent weir at the entrance into the MF feed tank will be provided to avoid negative pressures in the filter bed when the filters approach their terminal headloss of 7.5 ft. During filtration, water will enter each filter and be kept at a constant effluent flow by the modulating effluent control valve. Filtered water will exit through the lower gullet. During backwash, wash water will enter the filter from the lower gullet through the underdrains, and exit the filter through the backwash troughs. Figure 6-23 illustrates a typical section of the proposed filter design.

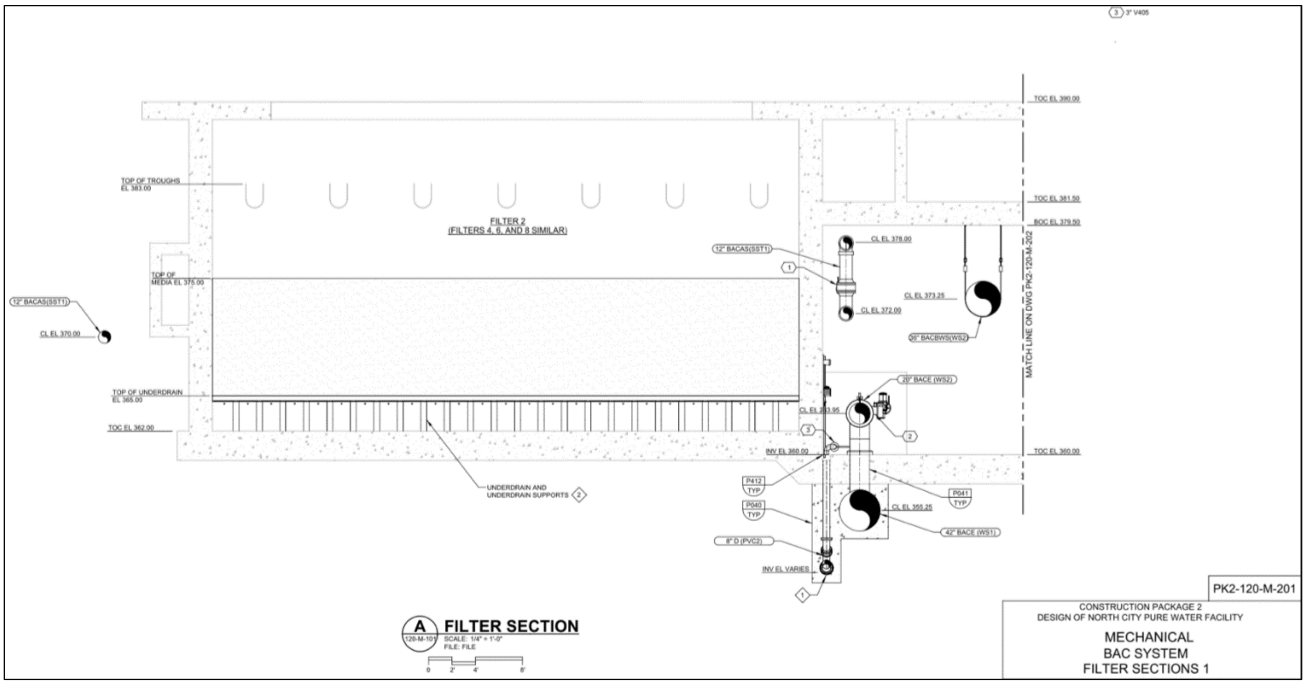


Figure 6-23: Section of Typical BAC Filter

Process Design Criteria

Table 6-28 below presents the key water quality parameters in the BAC influent. These parameters are assumed to be the same as the tertiary treated water influent to the NCPWF, with the exception of NDMA and bromate, which are formed during ozonation. Refer to NCPWF Feed Water in Table 6-17 for additional water quality parameters.

Table 6-28: BAC Influent Water Quality

Parameter	Units	Minimum	Maximum	Average
Alkalinity, total	mg/L as $CaCO_3$	143	197	173
Nitrogen, total	mg/L	7.8	13.9	10.4
NDMA	ng/L	18	55	31
Bromate[a]	µg/L	130	165	138
pH	pH	6.7	7.7	7.3
Phosphorus, total	mg/L	0.78	0.78	0.78
Temperature	°C	19.0	28.7	25.0
Continues on next page...				

Parameter	Units	Minimum	Maximum	Average
TOC	mg/L	6.27	8.64	7.24
Turbidity	NTU	0.1	1.0	0.2

[a] Bromate is reported from water quality obtained from the NCDPWF when operated to achieve a CT of greater than 8 mg/L-minute at all times (WRRF 14-12 Study). Lower bromate concentrations are anticipated with the reduced design CT of 3.8 mg/L-minute.

Design criteria of the BAC system are presented in Table 6-29 below.

Table 6-29: BAC System Design Criteria

Parameter	Unit	Value
Number of Duty Filters	number	7
Number of Standby Filters	number	1
Media Depth	ft	10
Feed Flow, Design	mgd	42.5
Net Filter Effluent Flow, Design	mgd	42.1
Filter Effluent Flow, Minimum	mgd	5.3
Filtrate Flow, Design (per filter)	mgd	6.01
Water Recovery	percent	99.1%
Filter Surface Area (per filter)	sf	750
Average Empty Bed Contact Time, 7 Filters	minute	13.31
Average Empty Bed Contact Time, 8 Filters	minute	15.21
Filter Loading Rate, 7 Filters	gpm/sf	5.62
Filter Loading Rate, 8 Filters	gpm/sf	4.92
Backwash Frequency per Filter	per week	1
Backwash Water Supply Source	-	MF Feed Tank
High Rate Backwash	gpm/sf	25
High Rate Backwash Flow	mgd	27.0
Estimated Backwash Time	minute	10
Estimated High Rate Backwash Volume per Filter	gallon	187,500
Air Scour Rate	cubic ft per minute per sf	4
Air Scour Flow Rate	cubic ft per minute	3,000
Estimated Air Scour Duration	minute	6
Hydraulic Pause Duration	second	90
Hydraulic Pause Frequency, Per Filter	per day	12

Design criteria of the GAC media bed are presented in Table 6-30: GAC Media Bed Design Criteria.

Table 6-30: GAC Media Bed Design Criteria

Parameter	Value
Media Product	Filtrasorb 816-M or Norit GAC816
Media Type	Virgin bituminous coal-based GAC
Iodine Number, Minimum	900 milligrams per gram
Effective Size	1.3 to 1.5 millimeter
Retained on #8 Sieve, Maximum	15%
Passing through #16 Sieve, Maximum	5%
Uniformity Coefficient, Maximum	1.4
Abrasion Number, Minimum	75
Apparent Density	0.5 grams per cubic centimeter
Moisture Content, Maximum	2% by weight
Media Bed Depth	10 ft
Media Bed Length-to-Diameter Ratio	2,177
Predicted Clean Bed Headloss	1.8 to 2.1 ft
Predicted Fluidized Headloss	2.4 ft
Media Quantity per Filter	278 yd3 / 117 ton
Media Quantity per Filter with Excess	292 yd3 / 123 ton

Filtration Cycle

The BAC filters will normally be run in filtration mode with all eight filters on-line, but sufficient filter area is provided to treat the full required flow with only seven filters, if one filter is off-line for backwash or maintenance. At lower plant flows, filters should be taken off-line to maintain a filtration rate of at least 2 gpm/sf. If the filtration rate is too low, suspended solids may be entrained by surface removal instead of depth removal, which leads to less efficient operation. During a filtration cycle, super-saturated dissolved oxygen from the ozonation process may off-gas in the media, increasing headloss and reducing available pore space for solids entrainment. To mitigate this effect, “hydraulic pauses” will be employed periodically throughout the filtration cycle. During these pauses, the control system will automatically take the filters off-line one at a time for 90 seconds each so that dissolved gases can escape the bed in the absence of downflow velocity.

Backwash Cycle

Backwashes will typically be triggered by operator-specified set points for filter runtime or head loss across the filter media, or they may be triggered manually. The recommended maximum filter runtime will be seven days (168 hours) based on the experience at the NCDPWF. The rate of headloss observed at the NCDPWF resulted in week long filter runs. The control system will prevent backwashes and hydraulic pauses from occurring simultaneously.

During a backwash, the air scour blowers and backwash pumps will come on-line to provide compressed air and wash water, respectively. The backwash sequence is designed for a three step process of air scour, concurrent air scour plus low-rate wash water, then high-rate wash water. The design air scour rate is 4 cfm/sf. This is comparable to values used in fixed-film biological applications to achieve biomass sloughing that is effective, but not excessively vigorous.

A range of backwash rates are provided in the design to provide flexibility to adjust and optimize the wash rate during operation. Only one filter will be permitted to backwash at a time, and the filtration rate through the other filters will increase proportionately to maintain water production during a backwash. BAC backwash waste will be conveyed to the NCWRP Raw Wastewater Pump Station. If the filtered water turbidity is elevated after backwash, the filter may be run in filter-to-waste mode before returning to filtration mode. The filter-to-waste flow will be conveyed through the backwash supply header to the MF feed tank overflow pipe to drain.

Activated Carbon Media

The selected GAC media will have an effective size around 1.4 millimeter to provide sufficient pore space for biomass development and suspended solids entrainment. It will also have good uniformity (uniformity coefficient ≤ 1.4) in the typical range for granular media filtration. This uniformity will reduce the number of very coarse and very fine particles in the media size distribution. The lack of very coarse particles, which are difficult to fluidize, leads to better bed expansion at a given backwash rate and allows for effective cleaning at low air scour rates. The media in this design is more uniform than the GAC media used in the NCDPWF, which is what enabled a lower air scour rate to be selected. The design media is also expected to perform well during the filtration cycle; all else equal, coarser and more uniform media will reduce both the clean-bed headloss and the rate of headloss accumulation, compared to finer or less uniform media that would have smaller pores and lower porosity.

The length-to-diameter ratio of a media bed characterizes its effectiveness for depth filtration. It is the ratio of the overall bed depth to the length scale of the pore spaces in the media, and it is correlated to the probability that a suspended particle will collide with a media particle on its way through the filter. Length-to-diameter ratios around 1,000 are common for drinking water filter design, so the length-to-diameter ratio over 2,000 in these filters should provide for very effective depth filtration and biomass development. The length-to-diameter ratio in this design is similar to the design used in the NCDPWF, which had shallower filter beds with finer media. With both the NCDPWF filters and the design filters having length-to-diameter ratios much greater than 1,000, similar depth removal performance is expected.

The final design specification for the GAC media will include the following requirements to ensure the quality and suitability of the media product:

- ***Size and Uniformity.*** To ensure that the media is coarse and uniform, the specification includes effective size, maximum uniformity coefficient, and sieve analysis parameters.
- ***Activation.*** To verify that the carbon has been well activated, the specification will include a minimum iodine number and trace capacity number.
- ***Mineral Suitability.*** The specification will require the GAC to be produced from virgin bituminous coal, and it will stipulate an abrasion number along with a guideline for apparent density. This will ensure that the GAC will have the intended mineral composition and that it will be sufficiently durable for use in media filtration.
- ***Material Quality.*** To verify the quality of the GAC, the specification will include other material quality requirements such as maximum ash content and maximum moisture.
- ***Applicable Standards.*** The GAC will be required to meet the American Water Works Association B604 standard for activated carbon media (AWWA, 2012), and it will also be required to have National Sanitation Foundation 61 (NSF/ANSI, 2013) certification for use in drinking water systems.

Refer to Table 6-30 for the specific values associated with the above GAC media bed design criteria.

Backwash Equipment

The BAC backwash pumps were sized to provide the required lift from the MF feed tank to the backwash troughs in the BAC filters, along with overcoming headlosses in the piping, through the underdrain, and across the fluidized media. The air scour blowers for the BAC system were sized to deliver the design airflow under a backpressure equal to the water depth in the filter boxes. The pumps are provided in a two duty and one standby configuration, and the blowers are provided in a one duty plus one standby configuration for redundancy, so that the backwash and air scour design flow can be achieved with one unit off line. Table 6-31 presents the backwash equipment for the BAC system.

Table 6-31: BAC System Backwash Equipment Design Criteria

Parameter	Value
Number of Backwash Pumps, Duty/Standby	2+1
Backwash Pump Flow, Each	9,375 gpm
Total Dynamic Head	37 ft
Backwash Pump Power	150 hp
Backwash Pump Type	Vertical Short Setting
Number of Air Scour Blowers, Duty/Standby	1+1
Air Scour Blower Flow, Each	3,000 cubic ft per minute
Air Scour Blower Discharge Pressure	9.1 psi
Air Scour Blower Power	200 hp
Air Scour Blower Type	Multi-Stage Centrifugal

6.3.1.3.f Membrane Filtration

The MF treatment system will remove particulate matter from the RO feed water that would otherwise foul the RO membranes. The MF process is expected to achieve 4-log of *Giardia* removal and 4-log of *Cryptosporidium* removal and is not being relied upon for virus removal.

Process Overview

The pre-design considered membrane systems from Toray (packaged by H_2O Innovation) and Pall because those are the only systems that have been prequalified for pre-selection testing. Final selection of the MF system was determined through pre-selection testing and a present worth based selection process and assigned bids. The NCPWF 30% Engineering Design Report (MWH/BC et al., 2016) accommodated both membrane suppliers. The final design is proceeding with the pre-selected membrane system from Toray (packaged by H_2O Innovation).

The MF process design includes pretreatment with automatic strainers upstream of the membrane modules. During filtration mode, water will pass through the automatic strainers and the membrane modules, and will discharge into the RO feed tank. The MF system has backwash, cleaning, and direct integrity testing cycles that individual racks will go through on a daily basis. The strainers, MF racks, clean-in-place pumps, clean-in-place tanks, and associated piping will be located on the first floor of the process building. The backwash system, clean-in-place neutralization tanks, blowers, compressed air system, and associated piping will all be located on the basement level. Water piping to and from the MF skids will be hung from mounted supports on the basement ceiling. To contain noise, the blowers and compressed air system will be enclosed in a separate blower room within the basement

Process Design Criteria

The feed water quality for the MF system, prior to the automatic strainers, is expected to be similar to that of the NCPWF feed (i.e., the NCWRP tertiary treated water) with the exception of the parameters presented in Table 6-32, which will be altered through ozonation and BAC treatment. Refer to Table 6-17 for additional water quality parameters. Sodium hypochlorite and aqueous ammonia will be added just prior to the automatic strainers to form chloramines, which will help control biological fouling of the downstream membranes, and a static mixer will be installed downstream of the injection points to ensure proper chemical mixing.

Table 6-32: MF Influent Water Quality

Parameter	Units	Minimum	Maximum	Average
Iron	mg/L	0.09	0.44	0.14
Manganese	mg/L	0.02	0.04	0.03
NDMA	ng/L	<2 (ND)	24	<2
Bromate	ug/L	130	165	138
TOC	mg/L	3.0	7.0	4.5
Turbidity	NTU	0.03	1.0	0.12
Total Nitrogen	mg/L	8.5	15.5	11.2
Chloramines	mg/L as Cl_2	2	5	3
UV Transmittance	percent	64.9	97.6	90.3

Table 6-33 presents the MF system filtrate water quality goals.

Table 6-33: MF System Filtrate Water Quality Goals

Parameter	Unit	Limit
Silt Density Index	Silt Density Index units (0.45-micron filter for 15 minutes at 30 psig)	Less than 3
Turbidity, Average	NTU	0.1[a]
Turbidity, Maximum	NTU	0.15[a]

[a] Minimum 95% success rate.

MF Feed Tank

The MF feed tank will serve as an equalization tank between the BAC filters and the membrane system; it will also serve as water storage for the backwashing of BAC filters. The MF feed tank must have adequate storage to supply water for BAC backwashes while not interrupting the feed to the MF system. Additionally, the MF feed tank is sized to prevent overflows when the feed to the MF system is decreased due to MF backwashes, integrity tests, and cleans. The flow into the MF feed tank is from the BAC filter effluent channel. Flows out of the MF feed tank include the feed flow to the MF automatic strainers and the backwash flow to the BAC filters.

The MF feed tank water level is lowered when water is pumped out of the tank for BAC backwashes. Additionally, frequent backwash and cleaning cycles associated with the membrane system can affect the feed flow into the MF system. For these reasons, there is a requirement for feed water storage in the MF feed tank to ensure that adequate, continuous feed is provided to the MF system during BAC backwashes and sufficient storage is available during scenarios of decreased feed to MF system. An analysis was performed and determined that the minimum available volume required for operational equalization was approximately 260,000 gallons. This analysis was based on modeling 24 hours of operation, with backwashes every 27 minutes, enhanced flux maintenance cleans does every 2 weeks, and integrity tests occurring daily. The variations in feed tank volume were calculated on a per minute basis throughout the 24-hour duration of the model. There are times when the system performs two backwashes, an enhanced flux maintenance clean, and an integrity test simultaneously. Table 6-34 presents a summary of the design criteria for the MF feed tank.

Table 6-34: MF Feed Tank Design Criteria

Parameter	Value
No. of Tanks	1
Available Volume for Operational Equalization, Minimum	260,000 gallons
Residence Time, Minimum	10.4 minutes
Available Volume Required for Minimum Residence Time	305,000 gallons
Total Water Volume (Including Submergence)	470,000 gallons
Total Residence Time, Minimum	16 minutes
Tank Material	Reinforced Concrete

MF Feed Pumps

The MF feed pumps will be vertical turbine pumps equipped with variable frequency drives, mounted on the roof of the MF feed tank. In order to achieve appropriate submergence, the vertical turbine suction cans will extend below the tank floor. The pumps will be controlled by the MF system. The capacity of each pump will meet the design flowrate of 10.5 mgd. The variable frequency drives will provide turndown in the case that lower flows are required. If the flow rate of the MF feed pumps is operating at the lowest speed possible and exceeds the RO process demand, the excess flow will overflow at the RO feed tank downstream. This will be acceptable since the duration of any such operating condition is expected to be very short. Table 6-35 presents the design criteria of the MF feed pumps.

Table 6-35: MF Feed Pump Design Criteria

Parameter	Value
Pump Type	Vertical Turbine
Number of Duty Pumps	4
Number of Standby Pumps	1
Capacity per Pump	10.5 mgd
Total Dynamic Head, Max	150 ft
Motor Horsepower per Pump	400 hp
Drive Type	Variable Frequency Drive

Automatic Strainers

The automatic strainers will provide particulate removal ahead of the MF units and protect the membranes from physical and structural damage. This screening upstream of the membrane modules is a warranty requirement of MF suppliers. Automatic strainers with a screen aperture of 200 microns are the basis for this design. The design criteria for the automatic strainers are presented in Table 6-36.

Table 6-36: Automatic Strainers Design Criteria

Parameter	Unit	Value
Manufacturer/Model	-	Amiad Mega EBS or Omega, SP Kinney AFW-1, Eaton 2596, Fluid Engineering 723 Eliminator
Type	-	Auto-backwash strainer
Design Flow	mgd	41.67
Clean Head Loss, Minimum[a]	psi	< 1
Duty Units	number	4
Standby Units	number	1
Excess Capacity Required[b]	percent	25
Capacity per Strainer	mgd	13.3
Screen Pore Size, Minimum	microns	200
Strainer Recovery[c]	percent	99.93

[a] Clean head loss is defined as head loss between the inlet flange and outlet flange.

[b] Excess capacity is a risk mitigation factor to not need to reduce MF capacity if the standby unit is down. This was informed by NCDPWF performance of the strainers.

[c] Strainer recovery percentage based on NCDPWF operation.

Membrane Filtration System

The design criteria for the MF system are based on the operation of the Toray HFU-2020N membrane modules at the NCDPWF. H_2O Innovation is the system package provider for the Toray membrane module. Both Toray and Pall modules were the pre-qualified technologies for the full-scale NCPWF MF system and pre-selection testing was completed in December, 2016 and the draft report submitted to the City in March, 2017. Final selection of the H_2O Innovation Toray MF system was made through a present worth based life-cycle cost selection process and assigned bids.

The total number of racks installed, N, varies between vendor due to differences in rack capacity. The design criteria for membrane flux are instantaneous design flux based on design feed flow with N-3 racks in operation and a maximum instantaneous flux based on design feed flow with N-4 racks in operation. This reflects the operating philosophy of operating the MF system with all available racks on-line at a constant feed flow set point, trimmed based on the RO feed tank water level.

There will be no true “standby” racks that are off-line, if it is possible to operate with the most MF area available. The scenario of three racks off-line is a periodic occurrence when two racks are in backwash, and either one rack is undergoing a PDT or a clean-in-place. The scenario of four racks off-line is a worst-case periodic occurrence when two racks are in backwash and either one rack is in PDT and one rack is in clean-in-place, or two racks are in clean-in-place. During operation, there will be times when fewer racks are off-line (i.e., when cleans or PDTs are not being performed or only one backwash is being performed). The scenarios of three and four racks off-line are unavoidable given the backwash, cleaning, and PDT durations and frequencies in the design criteria. Table 6-37 presents the design criteria from the MF system.

Table 6-37: MF System Design Criteria

Parameter	Value
Manufacturer	Toray
Module Model Number	HFU-2020N
Membrane Nominal Pore Size	0.01 µm
Membrane Area	775 sf
System Rated Capacity (Filtrate Flow)	40.0 mgd
Feed Flow	41.67 mgd
Minimum System Recovery	96%
Maximum Transmembrane Pressure (TMP)	29 psi
Number of Total Racks	12
Number of Membrane Modules per Rack, Installed	90
Number of Membrane Modules per Rack, Total Available	120
Design Flux, Instantaneous (3 Racks Off-line)	66.4 gpd/sf
Maximum Instantaneous Flux (4 racks Off-line)	74.7 gpd/sf
Backwash Water Supply	MF filtrate
Backwash Type	Reverse flow with air scour
Backwash Interval	31.7 minutes
Design NaOCl Enhanced Flux Maintenance Frequency	Not necessary[a]
Design $C_6H_8O_7$ Enhanced Flux Maintenance Frequency	Not necessary[a]
Design Clean-In-Place Frequency	1 per month
Direct Integrity Test Method	Daily PDTs
Indirect Integrity Testing Method	Continuous filtrate turbidity monitoring

[a] Per pilot testing as part of the pre-selection process.

The MF system will be controlled by a master programmable logic controller provided by the MF supplier. The master MF programmable logic controller will feed back to the NCPWF distributed control system.

Backwash Pumps

There will be two sets of backwash pumps, each with one duty and one standby pump. Each set of backwash pumps will be dedicated to one of the two groups of MF racks. Each backwash pump will have the capacity to backwash one rack; however, each set of backwash pumps will be connected to both groups of MF racks so that either set of pumps can be used to backwash any rack in the entire MF system, if necessary.

The backwash pump motor power is estimated as 125 hp each. The pumps were sized to convey 3,916 gpm, at a total dynamic head of 83 ft (see Table 6-38). The total dynamic head includes the static elevation difference, as well as head losses through the piping and the MF racks.

Table 6-38: MF Backwash Pumps Design Criteria

Parameter	Value
Pump Type	Horizontal centrifugal
Number of Sets	2
Number of Pumps per Set (Duty + Standby)	1 + 1
Flow Rate, Each Pump	3,916 gpm
Total Dynamic Head	83 ft
Backwash Pump Motor Power	125 hp

Backwashing the MF system will generate about 2 mgd of backwash waste, which will be sent to the NCWRP influent pump station via the 54-inch-diameter Combined Waste Pipeline. Table 6-39 presents the backwash residuals.

Table 6-39: MF Residual Estimates

Manufacturer	Unit	Toray
Backwash Cycles per Day	number	46
Total Volume of Backwash Waste per Day per Module	gallons	1,375
Backwash Flow per Module	gpm	34.8

Air Scour Blowers

There will be two sets of air scour blowers, each with one duty and one standby pump. Each blower has the capacity to provide air scour for one MF rack. Like the backwash systems, each set of blowers will be connected to both groups of racks, so that either set of blowers can be used to service either group of racks. Table 6-40 presents the design criteria for the MF blowers.

Table 6-40: MF Air Scour Blowers Design Criteria

Manufacturer	Unit	Toray
Backwash Cycles per Day	number	46
Total Volume of Backwash Waste per Day per Module	gallons	1,375
Backwash Flow per Module	gpm	34.8

Clean-in-Place

The clean-in-place system will consist of clean-in-place and neutralization tanks and associated pumps. Like the backwash/air scour equipment, two clean-in-place will service the two groups of membrane racks. Each clean-in-place will have piping to both groups of membrane racks to allow for cleans on any of the racks. Table 6-41 presents typical MF system cleaning criteria.

Table 6-41: Clean-In-Place

Parameter	Clean-In-Place
Typical Duration, Each Rack, Each Clean	4–6 hours
Design Frequency	1 per month
Make-Up Water	RO permeate
Solution Temperature, Typical	100°F

Clean-in-place cleans will use heated RO permeate as the make-up water. Clean-in-place fill pumps will pump RO permeate from the RO flush tank to both the MF and RO clean-in-place tanks. The make-up water will be heated by a natural gas-fueled boiler system that also supplies the RO CIP system. The clean-in-place pumps will recirculate the heated make-up water from the clean-in-place tanks to the MF racks for CIPs. Table 6-42 presents the general design criteria for the clean-in-place.

Table 6-42: Clean-in-Place Design Criteria

Parameter	Value
Clean-In-Place Systems, Total	2
Clean-In-Place Sodium Hypochlorite Transfer Pumps per System (Duty + Standby)	1 + 1
Clean-In-Place Sodium Hypochlorite Transfer Pump Flow Rate, Each	20 gpm
Clean-In-Place Citric Acid Transfer Pumps per System (Duty + Standby)	1 + 1
Clean-In-Place Citric Acid Transfer Pump Flow Rate, Each	3.2 gpm
Clean-In-Place Tanks per System	1
Clean-In-Place Tank Volume, Each	6,000 gallons
Clean-In-Place Pumps per System (Duty + Standby)[a]	1+1
Clean-In-Place Pump Flow Rate, Each	1,615 gpm
Clean-In-Place Pump Total Discharge Head	103 ft
Clean-In-Place Pump Motor Power, Each	60 hp

[a] Clean-in-place fill pumps will provide water to both MF and RO clean-in-place tanks.

After clean-in-place cleans are performed, the chemical solutions and associated rinse water will be sent to neutralization tanks and then back through a drain line to the NCWRP. The waste streams will need to be neutralized before being sent to the NCWRP if the pH is below 5, or above 12.5, or if chlorine is present. The neutralization will be performed within the neutralization tanks. The CIP pumps will be used to supply the neutralization system. Table 6-43 presents details of the neutralization system design.

Table 6-43: Neutralization System Design Criteria

Parameter	Value
Neutralization Systems	2
Neutralization Tanks per System	1
Neutralization Tank Volume, Each	19,200 gallons

Waste streams may need to be neutralized depending on the criteria mentioned previously (pH above 12.5, pH below 5, or any appreciable chlorine present). Table 6-44 presents a summary of the clean-in-place residuals.

Table 6-44: MF Clean-in-Place Residuals Estimates

Manufacturer	Parameter	Toray
Average Clean-In-Place Waste Flow[a]	gpd	6,300
Clean-In-Place Duration, Total	hours	4–6
Clean-In-Place Chemical Solutions, per clean		1. NaOCl 2. $C_6H_8O_7$
Clean-In-Place Waste Volume per Clean-In-Place Chemical Solution	gallons	11,100
Clean-In-Place Waste Volume per Clean-In-Place, Total	gallons	22,200

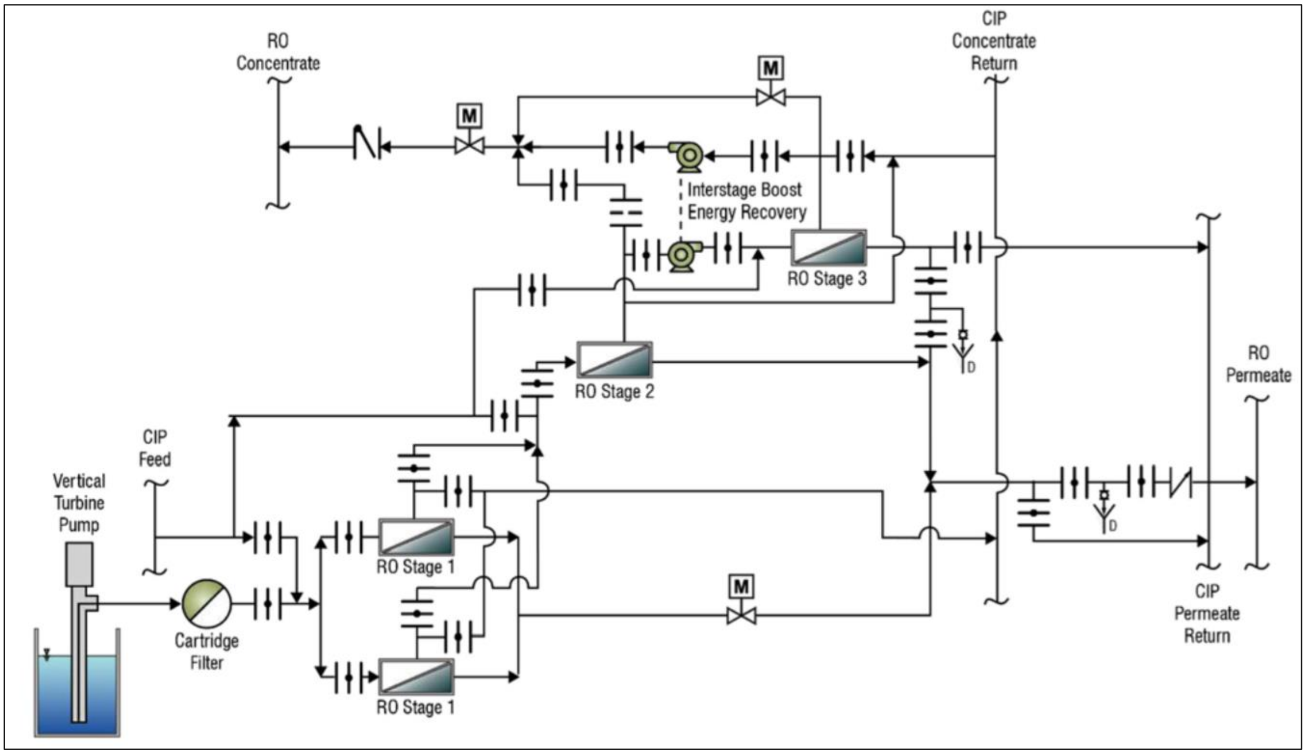
[a] Clean-in-place will not occur every day; this is an average flow rate over an entire month, reported in per day units.

6.3.1.3.g Reverse Osmosis System

The RO process will remove dissolved constituents from the influent water to achieve salinity control for the system, as well as additional removal of dissolved organic constituents and pathogen log removal credits. The RO system is expected to achieve 2.5-log of virus, *Giardia* and *Cryptosporidium* removal (if comply with Tier 1 requirements). As part of the RO process, water will be conditioned with strong acid and antiscalant to control scaling and then pre-treated with cartridge filters to protect the RO membranes against damage by large suspended particles. Finally, water will be pressurized and passed through three stages of RO membrane elements, with a separate pressure boost before the third stage to achieve flux balance.

Process Overview

A conceptual overview of the RO is illustrated on Figure 6-24.



ERD = Energy Recovery Device

Figure 6-24: Overview of RO System

The RO system consists of the following components

- RO feed tank;
- RO feed pumps;
- Cartridge filters;
- Pretreatment dosing, with acid and antiscalant;
- 7+1 RO trains with 3 stages each;
- 3rd stage RO boost pumps/energy recovery devices;
- Clean-in-place system; and
- Flush system.

Overall operation of the RO system includes the following steps:

- The plant operators confirm the tertiary treated water quality and the available flow for the NCPWF to treat and coordinate with the staff at the NCWRP before making changes to the NCPWF flow rate;
- Based on the above, the operators select a number of RO skids on-line for the amount of product water that is to be produced. Typical operation will use the maximum (seven) skids on-line, which produces the design plant capacity;
- The plant control system calculates the required total RO feed flow based on the selected skid configuration, and brings the RO feed pumps on-line; cartridge filters are also brought on-line;

- Strong acid and antiscalant are dosed upstream the RO feed pumps. The RO feed pH is kept between 6.2 and 6.7, and the operators select the proper antiscalant dose based on the particular antiscalant product and the selected target feed pH;
- Each RO skid runs on a constant feed flow and recovery set point. Each skid will monitor its own feed, permeate, and concentrate flow rates and calculate its own recovery on-board. Each skid adjusts its own RO feed pump and concentrate valve to achieve the set points; and
- Permeate from the three stages flows into a combined permeate header. Concentrate from the 3rd stage from each skid flows through an ERD then to the combined RO concentrate header to the brine line.

Allowable configurations for the RO System are presented in Table 6-45.

Table 6-45: Allowable Configurations for the RO System

Product Flow (mgd)	RO Skids On-line	Effective Recovery (percent)	Required RO Feed Flow (mgd)
34.0	7	85	40.0
29.2	6	85	34.3
24.3	5	85	28.6
19.5	4	85	22.9
14.6	3	85	17.2
9.8	2	85	11.5
4.8	1	85	5.7

Process Design Criteria

Table 6-46 presents the expected RO system feed water quality. Refer to Table 6-17 for additional water quality parameters.

Table 6-46: RO Feed Water Quality

Parameter	Unit	Minimum	Maximum	Average
Aluminum	µg/L	5	10	5
Calcium	mg/L	74.8	82.4	78.8
Iron	mg/L	0.09	0.44	0.14
Magnesium	mg/L	32	53	37
Manganese	mg/L	0.02	0.04	0.03
Chloramines	mg/L as Cl_2	2	5	3
TOC	mg/L	3.9	7.0	4.5

Table 6-47 presents the permeate water quality goal for the RO system. The permeate water quality of the RO system is expected to be extremely good in terms of minerals, disinfection byproducts, and CECs; and the RO process plays a key role in controlling all of these contaminants at a system level. The specific finished water quality goal for TOC of less than 0.5 mg/L is met through the RO system. Although this is the main permeate water quality goal of the RO system, the primary drivers for the RO system design are membrane scaling and fouling control.

Table 6-47: RO Permeate Water Quality Goal

Parameter	Unit	Permeate Goal
TOC	mg/L	< 0.5

RO Feed Tank

The RO feed tank will act as an equalization tank between the MF system upstream and the RO system downstream. MF filtrate will flow into the tank and feeds the cartridge filters. The total volume of the RO feed tank will be approximately 380,000 gallons. This assumes a 1-ft minimum operating depth of the tank. Table 6-48 presents the RO feed tank design.

Table 6-48: RO Feed Tank Design Criteria

Parameter	Value
Number of Duty Tanks	1
Available Volume for Operational Equalization, Minimum	245,000 gallons
Available Volume Residence Time, Minimum	~8.7 minutes
Total Volume	380,000 gallons
Total Residence Time	13.5 minutes
Tank Material	Reinforced concrete

Pretreatment and Scaling Control

Calcium phosphate was the controlling scaling constituent shown by autopsies performed on RO membrane elements as part of the extended testing at the NCDPWF and confirmed by solubility modeling and empirical observations (Trussell et al. 2015; Adelman et al. 2016). Scaling models found that no other constituents were expected to be close to their solubility limits for RO antiscalant, although the presence of silica must be considered in selecting a suitable antiscalant. The RO feed conditioning system has been sized for acid and antiscalant dosing to control the maximum anticipated concentration of phosphate in the RO feed. Table 6-49 presents a summary of anticipated pH ranges for various flow streams entering and leaving the RO system and required chemical doses.

Table 6-49: Anticipated pH Ranges and Chemical Dosing

Parameter	Unit	Range
pH Ranges		
MF Filtrate	pH units	6.7–7.7
RO Feed (Dosed)	pH units	6.2–6.7
RO Permeate (Typical)	pH units	4.8–5.7
RO Concentrate	pH units	7.0–7.5
Chemical Dosing		
Antiscalant	mg/L	1–5
H_2SO_4	mg/L	30–100

Cartridge Filters

All feed flow for the RO system will pass through the RO cartridge filters to protect the RO system from suspended particles that might damage the surface of the RO membranes. A cartridge filter will be dedicated to each RO train. A cartridge filter will also be provided for the clean-in-place system to protect the membranes against particulates from clean-in-place solution make-up. The design criteria for the cartridge filters are presented in Table 6-50.

Table 6-50: Cartridge Filters Design Criteria

Parameter	Unit	Main	Clean-In-Place
Vessels	number	7+1	2
Flow per Vessel	gpm	3,400 to 4,500	1,125 to 2,250
Vessel Configuration	-	Horizontal	Horizontal
Vessel Pressure Rating	psi	150	150
Cartridges per Vessel	number	26	15
Cartridge Rating	µm	5	5
Cartridge Material	-	Polypropylene	Polypropylene
Outside Diameter	inches	6	6
Cartridge Length	inches	40	40
Filter Loading Rate	gpm/40 inch filter length	175	75-150

RO Feed Pumps

Each RO skid will have its own dedicated feed pump. This pump will pressurize the feed water to the level required to achieve the desired permeate flow and recovery from the 3 stages of the RO system, with the help of the boost pump before stage 3. The sizing of these pumps is presented in Table 6-51.

Table 6-51: RO Feed Pumps Design Criteria

Parameter	Unit	Value
Pumps, Duty/Standby	number	7+1 (1 per train)
RO Feed Pump Flow, Each	gpm	4,500
RO Feed Pressure	psi	100–225
RO Feed Pump Power	hp	800
RO Feed Pump Type	-	Canned vertical-turbine

Each RO feed pump will be tied to a single RO skid and controlled automatically by that skid. Variable frequency drives will modulate speed of each RO feed pump to maintain the target permeate production at the associated RO skid.

Turbine Assisted Interstage Boost Pump

For each RO skid, the concentrate from the second RO stage will be pressurized by the turbine assisted interstage boost pump before entering the third RO stage. Part of this interstage boost will be achieved by recovering pressure from the Stage 3 concentrate through a turbine, and any additional required boost will be provided by the pump. The concentrate from the third stage is passed through a control valve/energy recovery turbine before entering the brine disposal waste line. The sizing of the RO interstage boost pump is presented in Table 6-52.

Table 6-52: Interstage Boost Pumps/Energy Recovery Devices Design Criteria

Parameter	Unit	Value
Devices, Duty/Standby	number	7+1
Device Type	-	Energy recovery device with integral motor
ERD Flow	gpm	1,700
Design Capacity	gpm	121 to 500
Design downstream pressure	psi	20
Minimum Boost (at 450 gpm)	psi	100
Design Recoverable Energy per Unit	kW	10-15

Membrane Elements

The recommended RO membrane elements for this system are low-fouling, low-pressure polyamide elements for brackish water use. Examples of suitable RO membrane elements are manufactured by DOW, Hydranautics and Toray. These are standard 8-inch-diameter elements with 400 sf of filtration area each. Six of these elements will be mounted in pressure vessels that hold seven elements. Elements similar to the proposed models were tested at the NCDPWF. In addition, the suitability of these elements for this system was verified by the integrated three-stage RO system models.

A Request for Statement of Qualifications was used to solicit Statement of Qualifications from RO membrane element suppliers to supply RO membrane elements for the full-scale NCPWF. Two qualification's packages were submitted in response to the request, one from Hydranautics for its ESPA2-LD RO Element, and one from Toray for its TMG20D-400 RO Element. Both were accepted for prequalification testing. The testing plan included an initial and final wet test of the RO elements before and after 12 months of operations at the NCDPWF. The wet test results were used to evaluate performance of the RO elements. The Toray TMG20D-400 RO Element passed both the initial and final wet tests and will be included in the specifications for construction of the NCPWF.

RO Trains

A three-stage RO system with third stage isolation consolidates production stages 1 and 2 with recovery stage 3. The configuration allows the third stage to be isolated and cleaned/repaired while stages 1 and 2 are in operation to maintain redundancy. Each train or skid will have a pressure vessel array of 100:50:25 with six installed RO elements per vessel, and it will treat 5.8 mgd of feed flow at 85 percent recovery to produce 4.9 mgd of permeate. Each skid will also have its own valves, instrumentation, and remote input/output panel. A diagram showing the sizing and layout of the three stage RO skid is illustrated on Figure 6-25, and section is illustrated in Figure 6-26.

The RO skids will operate with constant feed and recovery set points. Establishing a constant RO feed flow and a constant permeate recovery at each skid implies constant flow rates of permeate and concentrate as well. Each skid will have integral flow meters to measure the feed flow and concentrate flow; the permeate flow is calculated from these measured values. To achieve the constant feed flow and recovery set points, each skid will automatically vary its feed pressure by modulating the variable frequency drive on its associated pump, and the concentrate pressure by modulating its on-board concentrate control valve.

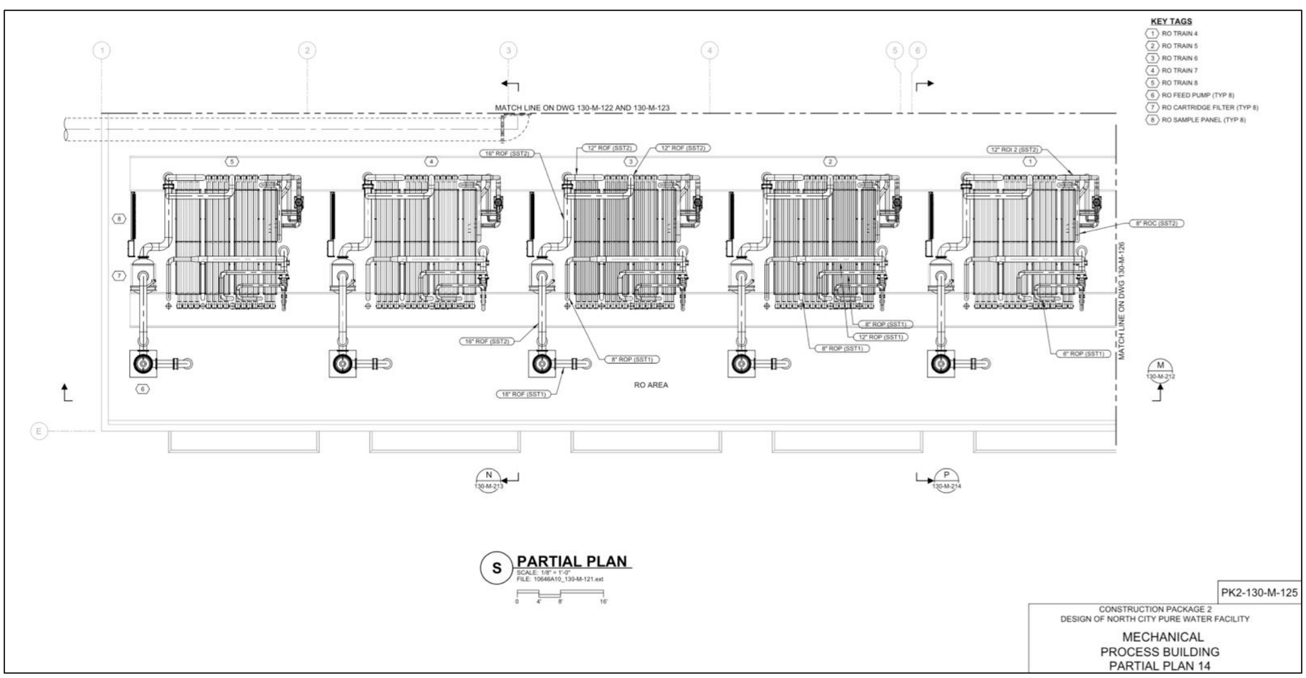


Figure 6-25: RO Skid Sizing and Layout (5 of 8 trains)

Clean-in-Place System

The clean-in-place system for the RO process will be used to make up and recirculate either high pH or low pH cleaning solution to clean RO elements when lightly fouled. This solution will enter the skids via a common flush/clean-in-place fill header, and return to the clean-in-place tanks via a common flush/clean-in-place return header. The RO skids will be cleaned individually, one stage at a time. The systems are configured so that one of the trains 1 through 4 and one of the trains 5 through 8 can be cleaned at the same time. The design clean-in-place frequency is once per six months for Stage 1 and 2 elements and once per month for Stage 3 elements. The clean-in-place system is presented in Table 6-53.

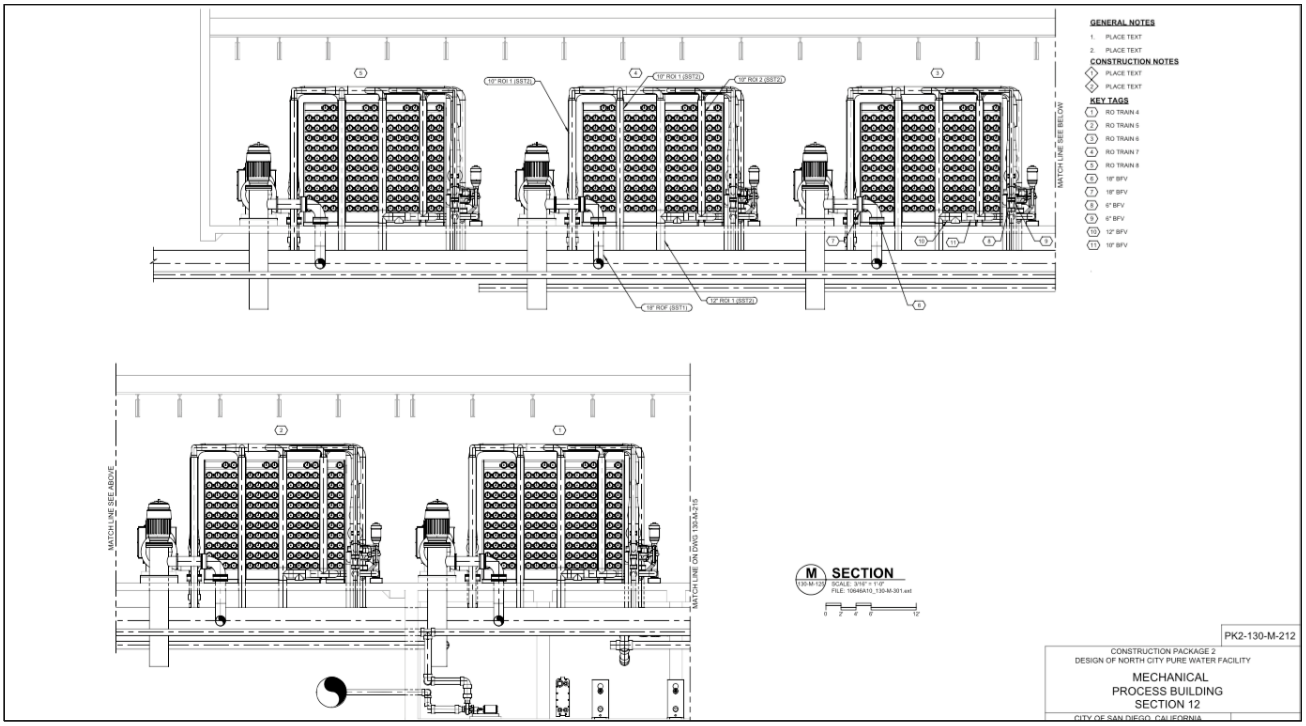


Figure 6-26: RO Skids Section

Table 6-53: RO Clean-In-Place System Design Criteria

Parameter	Unit	Value
Clean-In-Place Tanks	number	1+1
Clean-In-Place Tank Volume	gallons	10,700
Clean-In-Place Tank Diameter	ft	12
Clean-In-Place Tank Total Height	ft	14
Heaters per Clean-In-Place Tank	number	1
Clean-In-Place Heater Power	kilowatt	200
Target Clean-In-Place Solution Temperature	°C	45
Clean-In-Place Solution Heating Time	hour	2
Target Clean-In-Place Solution pH	pH units	>5 and <12.5
Clean-In-Place Pumps (Duty + Standby)	number	1+1
Clean-In-Place Pump Capacity	gpm	2,250
Clean-In-Place Pump Pressure	psi	71.5
Clean-In-Place Pump Power	hp	150

RO Flush System

The flush system for the RO process will be used to flush the RO skids with permeate when they are taken on or off-line so that the RO membranes are wetted and do not dry out, and so that they are not left sitting in concentrate. Flush water will be stored in the RO flush tank upstream the UV/AOP process and will enter the skids via a common flush/clean-in-place fill header and return to the drain via a common flush/clean-in-place return header. The RO skids will be flushed individually (i.e., one at a time). The RO flush system will be connected to the potable system to provide enough water to flush every RO skid twice, as would be required for a full plant shutdown and restart or in the event of loss of power. The flush system is presented in Table 6-54.

Table 6-54: RO Flush System Design Criteria

Parameter	Unit	Value
Total Flush Volume	gallons	30,000
Flush Volume Required per Train	gallons	13,125
Flush Time: RO Skid	minute	13.1
Flush Pumps (Duty + Standby)	number	2
Flush Pump Flow Rate	gpm	1,000
Flush Pump Pressure	psi	65
Flush Pump Power	hp	60

The flush cycle will be initiated under the following conditions:

- Before any RO skid is brought on-line;
- During shutdown of any RO skid and when it is to be stored off-line; and
- Before and after a clean-in-place cycle.

6.3.1.3.h Advanced Oxidation (Ultraviolet plus Hypochlorite)

The UV/AOP system will be used to generate hydroxyl radicals to facilitate oxidation of organic compounds. This process will also be used to achieve an additional 6-log inactivation/removal of viruses, *Giardia,* and *Cryptosporidium* from the product water stream.

Process Overview

The UV/AOP system will be fed from the combined permeate from the 7 RO trains. Free chlorine from sodium hypochlorite addition will be used as the oxidant to generate the hydroxyl radicals. The effluent from the UV/AOP system will flow to the product water tank located to the north of the process building.

A header pipe (located below the process building lower level) will convey the combined RO permeate to the UV process area. Sufficient pipe length will be provided in the header pipe upstream of the individual UV reactors to ensure a stable flow. Turbulent flow into the UV reactors will impact the ability of the UV light to pass through the water column. The pipe length upstream of the UV reactors will provide the necessary upstream/downstream distances for the combined RO permeate flow meter. Sodium hypochlorite and sulfuric acid will be injected in the header pipe. Influent flow to the individual reactor trains will be provided from lateral piping off of the RO permeate header. Individual flow meters will be located along the straight run of the influent piping for each UV reactor in the process building basement. The lateral pipe lengths have been sized to account for the necessary upstream/downstream distances for the flow meters. The influent piping for the individual reactor trains will then pass up through the process building floor to the ground floor level before connecting to the influent side of the UV reactor.

Process Design Criteria

Table 6-55 presents the design and expected water quality parameters for the UV/AOP influent. It should be noted that the design values are upper bounds used as a design basis, whereas actual values in the UV/AOP feed are expected to be much lower based on past data collected at the NCDPWF. Refer to Table 6-17 for additional feed water quality parameters.

Table 6-55: UV/AOP Feed Water Quality

Parameter	Design Value	Expected Value
1,4-dioxane (µg/L)	≤ 3	≤ 1 (ND)
NDMA (ng/L)	≤ 15	≤ 2 (ND)
Bromate (µg/L)	≤ 10	≤ 5 (ND)
UV Transmittance at 254 Nanometer	≥ 95.0%	≥ 96%
Alkalinity (mg/L as $CaCO_3$)	≤ 20	2 - 15
TOC (mg/L)	≤ 0.50	0.02 – 0.07
TDS (mg/L)	≤ 60	14 - 69
TSS (mg/L)	≤ 1	≤ 1
pH	5.0–6.5	5.0–6.5
Calcium Hardness (mg/L as $CaCO_3$)	≤ 5	4.0 – 4.4
Iron (mg/L)	≤ 0.1	≤ 0.1
Manganese (mg/L)	≤ 0.02	≤ 0.02
Temperature (°C)	15–30	15–30

Table 6-56 presents the UV/AOP water quality goals. Further detailed discussion may be found in the NCPWF 30% Engineering Design Report (MWH/BC et al., 2016).

Table 6-56: UV/AOP Water Quality Goals

Parameter	Design Goal
1,4-dioxane Log-Removal	≥ 0.5
1,4-dioxane (µg/L)	< 1
NDMA (ng/L)	0.69[a]

[a.] Compliance for NDMA is expected if it is below the Detection Limit for Reporting of 2 ng/L.

Manufacturers must use UV in their design basis. A minimum UV dose of 850 mJ/cm^2 has been established based on testing conducted at the NCDPWF. Testing and equipment pre-selection was conducted and Wedeco Xylem MiPro K143 was selected for assignment. Table 6-57 presents the updated design criteria for the Xylem technology. The design approach was further developed following a validation and the equipment pre-selection process, where testing occurred at pH levels ranging from 5.0 to 6.5 at varying doses of free chlorine, and at varying levels of power/UV dose. The final selected influent pH range of 5.0-6.0 will be maintained by dosing sulfuric acid to the UV/AOP feed water, after the addition of sodium hypochlorite.

Table 6-57: UV/AOP Design Criteria

Parameter	Unit	Wedeco
Reactor Model		MiPRO™ (K-143)
Reactor Configuration	-	2+1
Oxidant Type	-	HOCl
Flow, Design	mgd	34
Flow, Minimum	mgd	3.75
Flow Capacity per Duty Train	mgd	17.3
Minimum UV Dose	mJ/cm^2	850
Maximum Power Draw for Duty Trains[a]	kilowatt	283
Lamps per Reactor	number	276
Lamp Configuration in Each Reactor	-	12 x 23
Sensors[b]	-	1 per row
Lamps, Duty	number	552
Lamps, Standby	number	276
Maximum Operating Pressure	psi	30
Max Allowable Head Loss at Full Flow	feet	4.5
Minimum UV transmittance	Percent/cm at 254 nm	95

[a] Power draw is at 90 percent ballast power level.
[b] Shall be calibrated to reference sensors provided by UV system supplier and certified to international standards (e.g., öNORM, DVGW).

Oxidant Feed System

Testing at the NCDPWF showed that at a UV transmittance of 95.0 percent and UV dose of 850 mJ/cm^2, the system could meet UV design goals with a free chlorine dose of 2.0 mg/L as Cl_2. Table 6-58 presents the design criteria for the UV oxidant feed system.

Table 6-58: UV Oxidant Feed System Design Criteria

Parameter	Unit	Design Criterion
Oxidant	-	HOCl
Oxidant Dose, Design	mg/L as Cl_2	2.0
Oxidant Dose, Minimum	mg/L as Cl_2	2.0
Oxidant Dose, Maximum	mg/L as Cl_2	4.0
Chemical Addition	-	NaOCl
Strength of NaOCl Solution	percent	6.9

6.3.1.3.i Product Water Conditioning

After RO treatment, the low TDS and low pH water must be stabilized to reduce its corrosive nature as it is conveyed from the NCPWF to Miramar Reservoir. Lime addition increases alkalinity, pH, and hardness. Carbon dioxide addition lowers the pH and encourages carbonate alkalinity production from lime addition. Sodium hypochlorite addition minimizes any remaining chloramine and maintains a free chlorine residual in the distribution system to Miramar Reservoir. Prior to release into Miramar Reservoir, the purified water will be dechlorinated. The dechlorination process/system is discussed in Section 6.3.2.8.

Process Overview

The major design components of the product water conditioning include the product water tank, hydrated lime system, and carbon dioxide system.

Process Design Criteria

RO permeate quality depends on the NCPWF influent tertiary treated water quality and the RO membrane's performance. Membrane performance is affected mainly by water temperature and by the age of the membranes. Expected UV/AOP effluent water quality parameters that impact the stabilization are presented in Table 6-59. Refer to Table 6-17 for additional water quality parameters.

Table 6-59: Water Quality before Stabilization

Parameter	Value
TDS (mg/L)	14 – 69
pH	4.1 – 5.0
Total Alkalinity (mg/L as $CaCO_3$)	2 – 15
Calcium (mg/L)	4.0 – 4.4
Water Temperature (°C)	19 – 28.7
Chloride (mg/L)	2 – 15
Sulfate (mg/L)	1 – 3
Magnesium (mg/L)	0.4 – 1.6

Bench-scale studies indicate that sufficient alkalinity (at least 86 mg/L as calcium carbonate) is required in the stabilized water when blended with Miramar Reservoir water to avoid impacts on the downstream Miramar DWTP operations (MWH/BC, 2016d). Assuming the stabilized water Langelier Saturation Index (LSI) is positive, and that some calcium carbonate precipitation occurs in the NCPW Pipeline (lowering the alkalinity), a conservative minimum alkalinity of 100 mg/L was selected as a post-stabilization finished water quality target. An average pH of 8 for Miramar Reservoir water was used, and a pH range of 7.5 to 8.5 was selected accordingly. Post-treatment water quality targets to be achieved after stabilization are presented in Table 6-60.

Table 6-60: Post-Treatment Design Goals

Parameter	Design Goal
pH	7.5–8.5
LSI	0.0–+0.5 (typical 0.2)
$CaCO_3$ Precipitation Potential	0–10 mg/L
Alkalinity	>100 mg/L as $CaCO_3$

Product Water Tank

The product water tank has several hydraulically isolated sections, as illustrated on Figure 6-27:

- ***Inlet Box.*** Serves to store and hydraulically isolate UV/AOP effluent from the downstream stabilization processes (lime and carbon dioxide injection) with a weir to prevent backflow to the UV/AOP system.
- ***Lime Mixing Boxes 1 and 2.*** Provide hydraulic mixing for lime injection.
    - Lime is injected above a weir gate, and the weir head loss provides the required hydraulic mixing. Lime is mixed in two separated parallel boxes.
    - During normal operations, both boxes are on-line; each box can be taken off-line for cleaning and maintenance as needed without shutting down the facility and each box can be hydraulically isolated with upstream and downstream weir gates.
- ***Carbon Dioxide Injection Box.*** Provides sufficient contact time for carbon dioxide dissolution.
    - Carbon dioxide is injected downstream of the lime mixing boxes at the bottom of the structure to take advantage of the higher hydrostatic pressure to enhance gas transfer.
- ***Product Water Tank.*** Serves as a forebay for the NCPW Pump Station. The product water provides about 9 minutes of HRT.
- ***Overflow Box.*** Diverts off-spec water to waste. A weir provides diversion capabilities for off-spec water to the NCPWF drain. For a definition and the handling of off-spec water, refer to Sections 13 and 16.4.
- ***Hypochlorite In-line Injection.*** Sodium hypochlorite for final chlorination is injected in the product water tank effluent pipe.

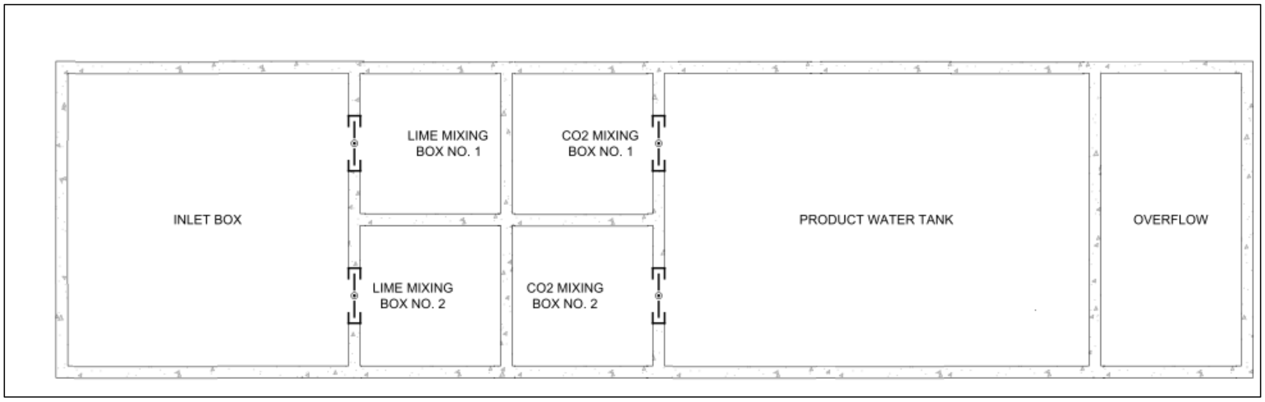


Figure 6-27: Product Water Tank Sections

HRT values for each section of the product water tank are presented in Table 6-61.

Table 6-61: Product Water Tank HRT Summary

Box	Approximate Volume (gal)	Approximate HRT (min)
Inlet Tank	3,500	0.1
Lime Injection Box: 2 Boxes On-line	17,000	0.7
Carbon Dioxide Injection Box: 2 Boxes On-line	34,000	1.4
Product Water Tank	196,000	8.3

Hydrated Lime System

The hydrated lime system will consist of two hydrated lime silos, two feeders, two batch tanks, four lime slurry transfer pumps, two lime slurry day tanks, and three lime metering pumps. The solid hydrated lime will be dosed from the silo to the batch tank with a feeder and mixed with UV/AOP effluent water to form a lime slurry. Once the batch is completed and sufficiently mixed, it will be transferred to a lime slurry day tank where it is continuously mixed before being dosed to the lime injection box by the lime metering pumps. Lime will be added over a weir in one of the two lime injection boxes using a trough or pressurized pipe. Two troughs/feed pipes will be installed (one per box) and lime slurry feed piping will be designed so that the box used for lime injection can be selected with valves.

The system was designed assuming a high lime-slurry concentration (30 percent). In this case, the slurry is a paste that does not plug lines, and does not require the installation of a lime recirculation line. Metering pumps will be used to directly dose the lime-slurry from the batch tank to the product water.

The required lime dose is between 65 and 90 mg/L to comply with the water quality target depending on the UV/AOP water quality. Under normal conditions, 83 mg/L of lime is required; hence, it is used as a design dose for lime storage sizing. Two lime silos will provide storage redundancy. The design criteria for lime storage are presented in Table 6-62.

Table 6-62: Lime Storage Design Criteria

Design Criterion	Unit	Value
Design Storage	days	14
Material Density	Pounds per cubic ft	30
Available Strength	percent	95
Design Dose	mg/L	83
Required Storage	cubic ft	11,666
Number of Silos	number	2
Diameter	ft	14
Height	ft	40
Storage Capacity per Tank	cubic ft	6,158
Design Total Storage Capacity	cubic ft	12,315

The silos will be mounted on load cells to track hydrated lime inventory.

- ***Lime Batch Tank.*** The lime batch tank will be designed by the system provider, and will prepare batches with consistent strength.
  - A mixer is required to provide sufficient mixing in the batch tank and to ensure all the slurry batches are prepared at the same strength to inject a consistent slurry into the process.
  - Load cells and a level sensor are also installed on the batch tank to measure and confirm the slurry strength.
  - Lime slurry strength typically varies from 0.5 percent to 30 percent by weight.
  - Low-strength lime slurries have low viscosity, and tend to scale and settle in conveyance systems when systems are shut down, requiring flushing and generally more maintenance.
  - High-strength lime slurry (typically 30 percent) is similar to a paste, scales less, and requires less cleaning and flushing, and less maintenance; a high-strength slurry system is recommended.
- ***Day Tanks.*** Two day tanks will be provided for redundancy.
  - This will ensure sufficient lime slurry storage to handle flow and dose variations and store batches from the batch reactor mounted on load cells to check the slurry strength.
  - They will be provided with mixers.
- ***Transfer and Metering Pumps.*** Hose pumps with variable frequency drives, well suited to pump slurries, will allow transferring of the slurry from the batch tanks to the day tanks and will be used to dose from the day tanks directly into the process.
  - Two transfer pumps (one duty, one standby) per batch tank will be provided, and three metering pumps (two duty, one standby) for dosing.

Design criteria for the lime slurry system are presented in Table 6-63.

Table 6-63: Lime Slurry System Design Criteria

Design Criterion	Unit	Value
Design Lime Slurry Strength	percent	30
Number of Batch Tanks	number	2
Number of Day Tanks	number	2
Number of Transfer Pumps, Duty/Standby	number	1+1
Number of Metering Pumps, Duty/Standby	number	2+1

Carbon Dioxide System

The carbon dioxide system for pH adjustment will consist of the following main components: storage equipment, injection equipment, and instrumentation and controls. A bulk carbon dioxide storage unit typically stores carbon dioxide under pressure, at low temperature, in liquid form. The injection equipment will take carbon dioxide from the storage tank and dose it in gaseous form into the water, forming carbonic acid (H_2CO_3) once it is dissolved. Depending on the pH, carbonic acid forms carbonate and bicarbonate. For full redundancy, the carbon dioxide system will incorporate two tanks, two vaporizers, and two sidestream injection systems.

Carbon Dioxide Injection System, Required Dose, and Feed Rates. A sidestream injection system will mix gaseous carbon dioxide with treated water pumped from the RO flush tank to increase the carbon dioxide concentration and control the finished water pH. The sidestream injection system technology equipment will be provided by TOMCO which disperses supersaturated carbon dioxide solution into the water source through a diffuser. The carbon dioxide mass transfer efficiency is expected to be greater than 95 percent. Two carbon dioxide injection systems (one duty, one standby) will be provided.

The dose of carbon dioxide required will depend on many parameters: feed RO pH, water temperature, and age of the RO membranes (among others). Two extreme cases illustrate the two ends of the required carbon dioxide dose range:

- Almost all carbonate species are rejected by the RO and there is almost no dissolved inorganic carbon in the RO permeate; and
    - This would typically happen at low sulfuric acid doses for RO pre-treatment, resulting in a high RO feed pH with most of the carbon species present in the water as bicarbonate.
    - Going through RO, bicarbonate is rejected at high rejection rates, resulting in a high RO permeate pH, no carbonic acid in solution, and very low bicarbonate concentration.
    - In that case, carbon dioxide addition is required to help dissolve the lime and maintain the effluent pH within the target.
- High carbon dioxide concentration in the RO permeate;
    - This would typically happen at low RO feed pH (high sulfuric acid dose), where carbon species are mostly present as carbonic acid, removed by the RO with low rejection rates.
    - RO permeate pH is low, with high carbonic acid concentrations. In that case, no carbon dioxide addition is required to control the pH, and lime addition only allows the pH to raise its targeted range while adding the required amount of alkalinity.

Carbon Dioxide Storage. Two pressurized vertical tanks will be used to store bulk carbon dioxide as liquid. The insulation for these tanks will be 4 inches of polyurethane with pre-painted aluminum wrapped skin and dish heads.

These storage tanks are also fitted with skid mounted refrigeration system to maintain the necessary conditions to store liquid carbon dioxide. In addition to refrigeration, a vaporizer is used to maintain proper operating pressure in both types of tanks. If foam-jacketed storage tanks incur damage to their outer jacket and are not repaired immediately, the insulation can get saturated with moisture and need to be replaced.

The decision between a horizontal and vertical storage tank is based primarily on the availability of space, size of tank needed for the application, and system life cycle costs. Vertical storage tanks take up less area than horizontal tanks, have a lower life-cycle cost and have been selected for this limited footprint design.

The required storage capacity is based on a worst-case scenario dose of 90 mg/L and a four-day on-site storage (long weekend). This worst-case scenario is defined as the absence of any dissolved carbon dioxide (carbonic acid) in the RO permeate, the most extreme water quality the carbon dioxide system would have to respond to in order to maintain the effluent and alkalinity within the target ranges. Because this scenario would require unnecessarily large storage capacity if it was designed with 14 days of on-site storage, and is not representative of normal conditions, a four-day storage capacity was selected instead. The four-day storage at the maximum carbon dioxide dose corresponds to 12 days of storage at the carbon dioxide dose of 30 mg/L that is required for median water quality conditions. The design criteria of the carbon dioxide system are presented in Table 6-64.

Table 6-64: Carbon Dioxide System Design Criteria

Design Criterion	Unit	Value
Storage Time: Worst-Case Conditions	days	4
Storage Tanks	number	2
Carbon Dioxide Transfer Efficiency (Assumed)	% utilized	95
Flow Rate	mgd	34
Carbon Dioxide Dose, Maximum	mg/L	90
Carbon Dioxide Capacity (per Injection System)	Pounds per day	11,400
Net Capacity: Maximum Conditions, per Tank	metric ton	30
Number of Vaporizers	number	2
Number of Sidestream Injection Systems	number	2
Number of Carrier Water Pumps	number	2

Carbon dioxide off-gassing may occur when no carbon dioxide is consumed and the pressure increases inside the vessel. When installed outside, those systems do not typically require oxygen monitors.

Pipeline Chlorination

The sodium hypochlorite dose upstream of the UV reactors for AOP oxidant may need to be limited to 5 mg/L because of potential corrosion of metals in the UV system. The expected chlorine residual from the UV/AOP is approximately 1 mg/L as free chlorine. If sufficient chlorine is not present in the product water as residual from the UV/AOP process, additional sodium hypochlorite will be added at the Product Water Tank discharge for residual chlorine. Sodium hypochlorite dosage for residual chlorine will be based on a minimum chlorinated pipeline retention time. A post-chlorination product water free chlorine range of 1.5 to 4.0 mg/L is planned for a 2.5 mg/L residual upstream of the NCPW Dechlorination Facility. Free chlorine residual will be monitored at the discharge from the Product Water Tank and the NCPW Pump Station discharge header.

Dechlorination of the product water will occur at the NCPW Dechlorination Facility, just upstream from Miramar Reservoir prior to discharge. The NCPW Dechlorination Facility is described in Section 6.3.2.8.

6.3.1.4 Equipment Standby Philosophy

Standby units will be provided for the major pieces of equipment and treatment units. Table 6-65 presents the number of duty and standby units, along with the associated required and the anticipated on-line times for comparison. The required on-line time is the number of duty units divided by the total number of units provided. The anticipated on-line time was developed using estimated maintenance, repair, and membrane cleaning requirements.

Table 6-65: NCPWF Duty and Standby Units

Process	Design Criterion (duty + standby)	Required On-line (per design basis)		Anticipated On-line (based on Demonstration Project performance)		
		On-line Factor	Off-line days Allocated per Year per Train	On-line Factor	Off-line Days Expected per Year per Train	On-line Factor
Ozone Generators	2+1	67%	122	99%	3.5	7 days per 2 years per generator for scheduled maintenance
Ozone Contactors	2+0	99%	5	99%	5	5 days per year per contactor for inspection (potentially at the same time as when generators are off-line)
BAC Filters	7+1	88%	46	99.5%	1.9	½ day per year per filter for filter coring; 7 days per 5 years per filter for media addition/replacement
BAC Backwash Pumps	2+1	67%	122	99%	4.2	21 days per 5 years per pump
BAC Blowers	1+1	50%	183	99%	2	2 days per year per blower
MF Feed Pumps	4+1	80%	73	99%	4.2	21 days per 5 years per pump
Strainers	4+1	80%	73	97%	14	14 days per year per strainer
MF System[b]	12	100%	See Section 6.3.1.3.f	98%	9.0	2 days per year per skid for clean-in-place; 7 days per year per skid for general maintenance
Continues on next page...						

Process	Design Criterion (duty + standby)	Required On-line (per design basis)		Anticipated On-line (based on Demonstration Project performance)		
		On-line Factor	Off-line days Allocated per Year per Train	On-line Factor	Off-line Days Expected per Year per Train	On-line Factor
RO Feed Pumps	7+1	88%	46	99%	4.2	21 days per 5 years per pump
Cartridge Filters	7+1	88%	46	99%	4.0	1 day per 3 months per cartridge filter
RO System	7+1	88%	46	97%	10.8	1 day per skid per year for clean-in-place; 28 days per 5 years per skid for maintenance (including membrane replacement and pump maintenance); 21 days per 5 years per pump
RO Flush Tank[a]	1+0	100%	0	99%	5.0	5 days per tank for inspection and maintenance
RO Flush Pumps	1+1	50%	183	99%	4.2	21 days per 5 years per pump
UV/AOP	2+1	67%	122	96%	14.0	14 days per year per unit for bulb, sleeve, ballasts replacement

[a]A potable water supply to the RO flush tank effluent will provide a redundant supply or water should the RO flush tank be off-line.

[b] Unlike the other processes, the MF system does not have true standby racks; under typical operating conditions, all 12 racks will be online at once. However, the design assumes that four of the 12 racks can be offline at one time, and the system continues to operate and meet performance goals. Section 6.3.1.3.f has further discussion of this under the Membrane Filtration System subsection where the N-3 and N-4 concepts are described.

6.3.1.5 Standby Power

Power requirements for the new NCPWF, including the NCPW Pump Station, are estimated at 24 megawatts and will be supplied by a 12-kilovolt feed originating at the existing Eastgate Mall substation, which also provides power to the NCWRP. Furthermore, a standby diesel generator unit will be provided to maintain power to critical processes such as RO flush pumps during an interruption of the primary utility feed.

The North City Project also includes two new power generations facilities. The Project's power needs will also be satisfied by an expanded power generation facility at the NCWRP that will provide a total of 20.4 megawatts, which includes 5 megawatts of existing capacity. A 1.6 megawatt new generation facility is planned at the MBC that is expected to expand the MBC site total generation to produce approximately 11.2 megawatts of electrical power. Refer to Section 6.2.2.2.r for a description of the North City Renewable Energy Project.

The electrical system will be designed to allow integration of a future photovoltaic solar power system. Each of these supplemental power supplies would have a positive impact on power reliability.

6.3.1.6 Failsafe Features

6.3.1.6.a Measures for Pathogen Control and Off-spec Water Monitoring

The NCPWF design will achieve pathogen LRVs in excess of the minimum log reduction required. With this design strategy, the NCPWF will have a buffer so that even if an individual process or monitor fails, the facility will not generate off-specification, or off-spec water. Off-spec water is defined as any final effluent leaving the NCPWF that does not meet the requirements for discharge to Miramar Reservoir. The critical control points and associated performance criteria are discussed in Section 10 and Section 15 of this Engineering Report.

6.3.1.6.b Use of Distributed Control System in the Critical Control Point Management Process

Using monitoring data for flow and for surrogates at all the critical control points, supervisory control and data acquisition will be used to continuously calculate and display the performance of the NCPWF in meeting its performance goals. Each surrogate for each critical control point will be separately displayed and, using colors and flashing lights, supervisory control and data acquisition will provide operational staff with a clear picture of the status of the NCPWF as a whole, as well as each critical control point. Operators will know where plant performance stands at all times. For further explanation of the reporting of critical control points and operator-friendly display system, please refer to Section 13.3.

6.3.1.6.c Facilities for Diversion of Water within the Treatment Train

Water diversions may be triggered in response to two different scenarios:

- If on-line monitors indicate non-compliance with the pre-established water quality limits established for the several critical control points located along the NCPWF treatment train; and
- If the on-line monitor at the NCPW Pump Station, which measures the final effluent leaving the NCPWF, indicates non-compliance with the NPDES permit requirements for discharge to Miramar Reservoir (i.e., production of off-spec water).

In the very unlikely event that off-spec water is produced at the NCPWF, plant operators will take all necessary steps to discontinue pumping of that water into the NCPW Pipeline and ramp down flow production; if necessary, operators will initiate a full shutdown of the NCPWF. The various options available to divert or drain any off-spec water that may have entered the NCPW Pipeline are described in Section 16.4. This section addresses the various diversion options for water that is in non-compliance with critical control point limits. The continuous monitoring of critical control points will allow for the detection of non-compliant water at the following treatment processes:

- Ozone and BAC Filters;
- MF;
- RO;
- UV/AOP; and
- Product water stabilization.

In the event of a process upset at the ozone system or BAC filters, the effluent will be intercepted at the MF feed tank. Similarly, in the event of a process upset at the MF process, the MF effluent will be intercepted at the RO feed tank. Each of the RO trains is provided with a permeate dump line to discharge water that is not in compliance with critical control point limits. The product from the UV/AOP process and product water stabilization will be intercepted at the NCPW Pump Station wet well. All the non-compliant flows listed above (ozone, BAC, MF, RO, and UV/AOP) will be redirected to the 54-inch-diameter Combined Waste Pipeline to the NCWRP as described in Section 6.3.1.3.a. The 54-inch-diameter Combined Waste Pipeline is connected to the NCWRP waste diversion structure, which can recycle the non-compliant flow back to the influent of the NCWRP via the waste backwash tank (which accepts the NCWRP tertiary filter backwash waste) and the NCWRP Tertiary Treated Pump Station. During high-flow scenarios to the NCWRP waste diversion structure, these non-compliant flows will overflow into an existing drop structure and be redirected to a 42-inch-diameter line, which will direct flow offsite to the sewer system and discharge to the PLWTP. A summary of the waste diversion facilities is presented in Table 6-66.

Critical control limits and SOPs associated with various water quality measurements along the NCWPF will further be developed in the North City Project OP.

Table 6-66: Summary of NCPWF Diversion Facilities

Process Upset Location	Diverted From	Diverted To
Ozone	MF Feed Tank	NCWRP Waste Diversion Structure via 54-inch-diameter Combined Waste Pipeline
BAC	MF Feed Tank	
MF	RO Feed Tank	
RO	RO Permeate Dump Line	
UV/AOP	NCPW Pump Station Wet Well	
Product Water Stabilization	NCPW Pump Station Wet Well	

6.3.1.6.d Facilities for Diversion of the Tertiary Treated Water

The NCPWF is designed assuming specific water quality parameters to be achieved by the NCWRP. The on-line measurement of the turbidity of the tertiary treated water produced by the NCWRP will be used as a surrogate for detecting non-compliance with pre-established water quality parameters. Critical control limits and SOPs associated with various levels of turbidity in the tertiary treated water will further be developed in the North City Project OP. If the tertiary treated water quality varies drastically from the design values, the water will be discharged to the sewer system via the 54-inch-diameter Combined Waste Return Pipeline and the NCPWF will stop operation

6.3.2 North City Pure Water Conveyance System

The following sections describe the NCPW Pump Station and NCPW Pipeline that convey purified water from the NCPWF to Miramar Reservoir, as well as the NCPW Dechlorination Facility.

6.3.2.1 North City Pure Water Pump Station

The NCPW Pump Station is designed to deliver up to a peak flow of 32.8 mgd of purified water from the NCPWF to Miramar Reservoir. While the NCPWF is designed for a peak production of purified water of 34 mgd, a portion of that production will be blended with NPR water for salinity management and for plant water uses; subtracting these demands results in a peak purified water delivery rate from the NCPW Pump Station to the reservoir of 32.8 mgd.

Daily flows may vary seasonally from approximately 23.4 mgd in the summer to 32.8 mgd in the winter. The NCPW Pump Station will deliver an average annual flow of 29.8 mgd (33,600 AFY) of purified water to Miramar Reservoir. The conveyance system spans 8 miles, and the purified water is conveyed from the NCPWF Product Water Tank/Pump Wetwell to Miramar Reservoir and distributed via a subaqueous pipeline.

6.3.2.2 System Hydraulics

The NCPW Pump Station will house three duty and one standby 1,000-hp pumps which is the most efficient pumping arrangement in terms of operational flexibility and site footprint. The design point for the three duty pumps was selected to meet the ultimate design flow rate of 32.8 mgd and the maximum total discharge head requirement at that condition. The design set point of two pumps was set at 23.4 mgd to maximize efficiency in both pumping conditions. Table 6-67 presents design criteria for the NCPW Pump Station.

Table 6-67: NCPW Pump Station Design Criteria

Parameter	Units	Value
Number of pumps	units	3 duty + 1 standby
Pump Type	--	Vertical Turbine
Station flow under normal operation: maximum	mgd	32.8 mgd
Station flow under normal operation: minimum	mgd	23.4 mgd
Station low flow limit	mgd	6.0 mgd
Static lift range	ft	313–331 ft
Friction head loss	ft	72 ft
Total discharge head range	ft	385-403
Pump max-flow design point	--	7,593 gpm (10.9 mgd) at 410 ft total discharge head
Pump motor size	hp	1,000
Drive type	--	Variable frequency

6.3.2.3 Pump Station Layout

The NCPW Pump Station is the final (most downstream) hydraulic element on the NCPWF site, which is on the north side of Eastgate Mall across from the existing NCWRP. Figure 6-28 illustrates the location of the NCPW Pump Station relative to the NCWRP and NCPWF.

The NCPW Pump Station is in the southeast corner of the NCPWF parcel. This location simplifies facility yard piping by locating the station next to Eastgate Mall, where the discharge pipeline will be installed.

(Source: *90% Design Report, North City Conveyance," HDR, dated August 18, 2017*

Figure 6-29 illustrates the yard piping layout, and Figure 6-30 illustrates the mechanical plan based on the current NCPW Pump Station 60% Design (HDR, 2017). The proposed pump arrangement is efficient in terms of operational flexibility, operational simplicity, and candidate pump availability.

The site development and civil design criteria, geotechnical investigations and design criteria, structural design criteria, architectural design criteria, general mechanical systems criteria, electrical design criteria, instrumentation, control, and monitoring system design criteria, and hydraulic transient analysis and surge control for the NCPW Pump Station are discussed in depth in the NCPW Pump Station 30% Basis of Design Report (HDR, 2016a).

Figure 6-28: Location of the NCPW Pump Station

6.3.2.4 Pump Control Strategy

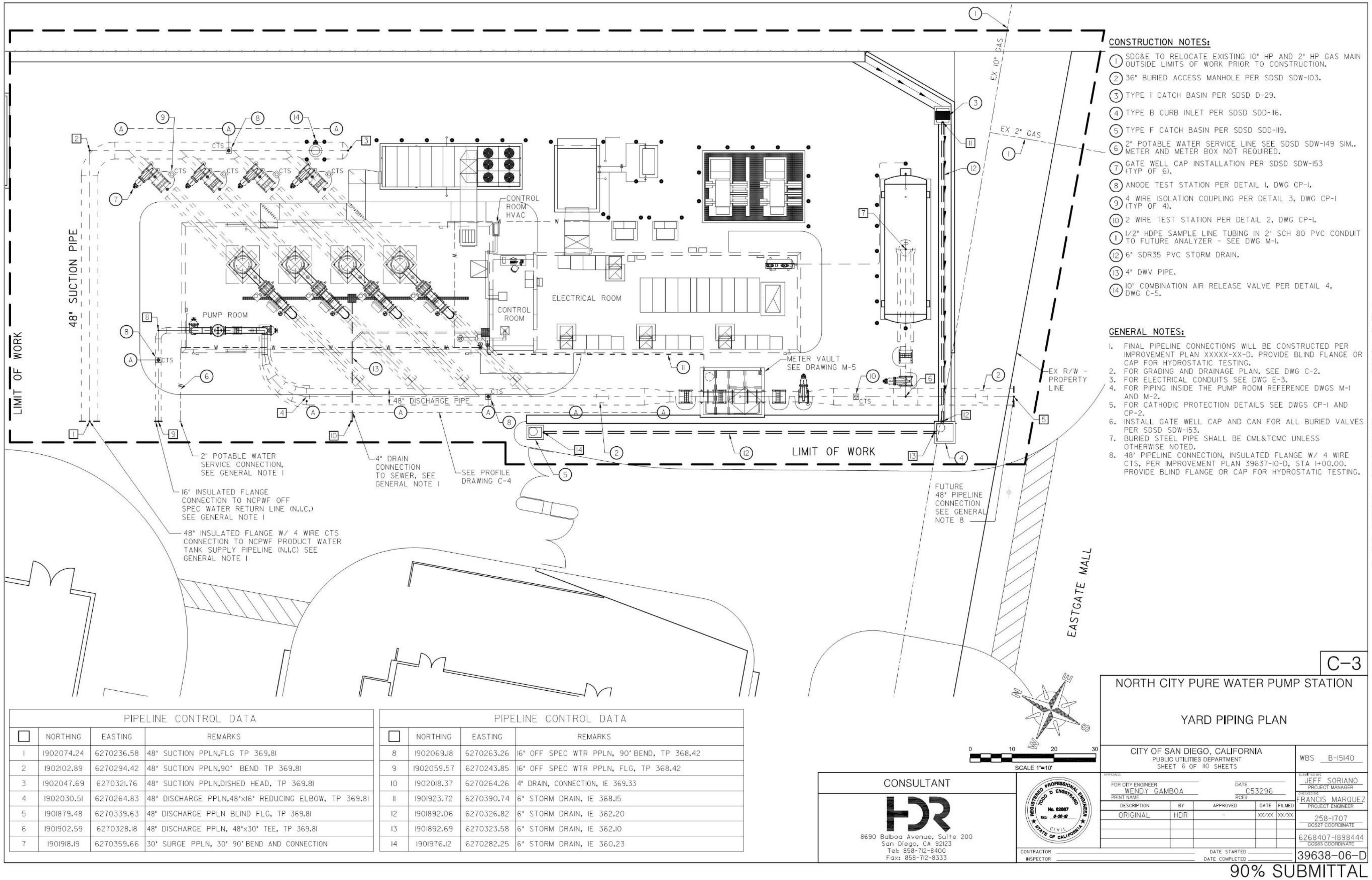
The pumps at the NCPW Pump Station (three duty and one standby) will operate off a flow diversion clearwell to meet the expected maximum and minimum purified water flows from the NCPWF. All pumps will be driven by variable frequency drives with pump speed modulated to maintain a constant clearwell level. The clearwell functions as an atmospheric tank and will flow by gravity to the NCPW Pump Station via a common suction header connected to the canned pumps. The flow diversion clearwell design will include overflow provisions that match the NCPWF production capacity. Any overflow from the clearwell will be discharged to the Combined Waste Pipeline and returned to the NCWRP waste diversion structure. Refer to Figure 6-4 presented earlier.

The NCPW Pump Station will be connected to the NCPWF control system. Communication signals can be used to coordinate start-up and shut-down procedures between the NCWRP, NCPWF, and NCPW Pump Station systems; however, primary pump functions, including pump on, pump off, and speed modulation can be controlled by locally monitored hydraulics and do not have to rely on remote signals. Operational control descriptions will be developed during the final design.

The NCPW Pump Station will use a distributed control system to monitor water levels and pump status, and to provide remote monitoring and control. The NCPW Pump Station will feature a low meter to monitor purified water flow going to Miramar Reservoir. The distributed control system will have the capability of starting and stopping pumps, ramping motor speeds up and down, recording pump runtimes, activating alarms, and trending pressures and flow rate.

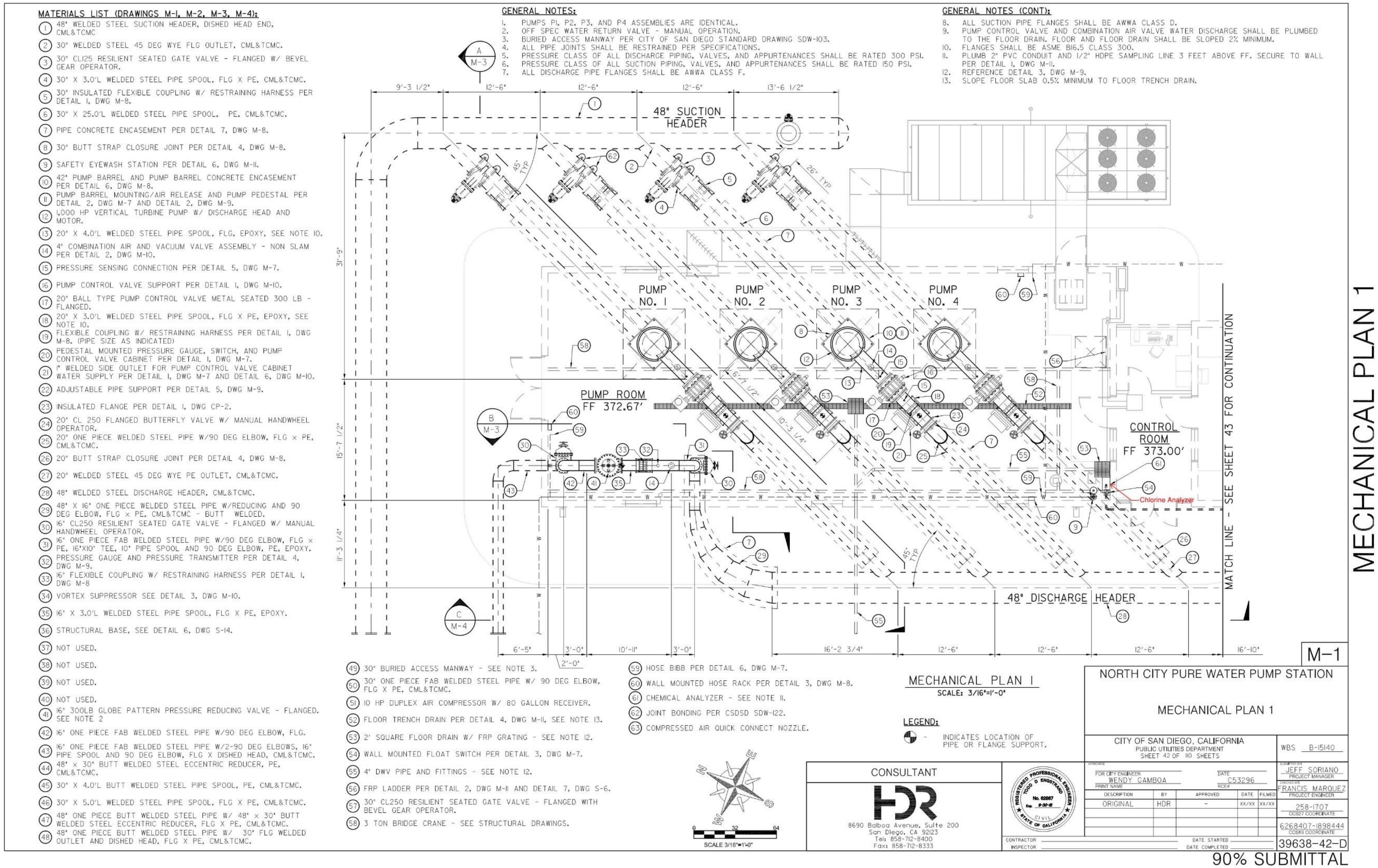
6.3.2.5 Transient Analysis

A hydraulic transient analysis was performed based on selected pump performance curves and the NCPW Pipeline Design. Results from this analysis suggest a 18,000-gallon capacity steel hydropneumatic surge tank with duplex 10-hp and 80-gallon capacity air compressor in conjunction with a dual 12-inch air vacuum valves at the high point and a 12-foot-diameter, 85-foot tall stand pipe located at the tunnel shaft to prevent water column separation transients in the NCPW Pipeline. The welded steel piping between the NCPW Pump Station discharge and the surge tank will be a minimum of 48-inch-diameter piping. The study also recommended surge protection on the suction line.



(Source: 90% Design Report, North City Conveyance," HDR, dated August 18, 2017

Figure 6-29: NCPW Pump Station Yard Piping Plan



Source: 90% Design Report, North City Conveyance," HDR, dated August 18, 2017

Figure 6-30: NCPW Pump Station Mechanical Plan

6.3.2.6 North City Pure Water Pipeline

The NCPW Pipeline consists of an approximately 8-mile pipeline that connects the NCPWF to Miramar Reservoir. The majority of the NCPW Pipeline alignment will be 48-inch-diameter pipeline. The overall alignment is illustrated on Figure 6-31. The NCPW Pipeline will be installed primarily within street and roadway rights-of-way, but the new pipeline will require the acquisition of three permanent easements. The majority of the pipeline will be constructed using conventional cut and cover methods; some crossings and portions of the pipeline will be installed using trenchless construction methods. Based on preliminary review of the pipeline alignment, the use of welded steel pipe is recommended. To prevent internal corrosion, a cement mortar lining will be installed. Soils are anticipated to be moderately corrosive to low or negligibly corrosive along the alignment. A tape coating and rock shield mortar coating will be applied to the pipeline. An impressed current cathodic protection system will also be applied.

6.3.2.7 Design Flow

The Project's 30-mgd average annual flow commitment is the basis of the NCPW Pipeline design. The Miramar Pipeline and its appurtenances have been designed for an average daily flow of 30 mgd with a minimum daily flow of 23.4 mgd and maximum daily flow of 32.8 mgd. Table 6-68 presents the design flow rates, including seasonal variation.

Table 6-68: NCPW Pipeline Design Flow Rates

Description	Maximum Daily Flow, Winter (mgd)	Minimum Daily Flow, Summer (mgd)	Average Daily Flow (mgd)	Average Travel Time (Hours)
Discharge target to Miramar Reservoir	32.8	23.4	30	3.2

The NCPWF daily purified water production will be constant to maintain process stability, and will not be subjected to diurnal variations. Upstream of the NCPW Pump Station, purified water will be diverted to the NPR water system at a flow range between 1 and 10 mgd to reduce the TDS concentration of the NPR water and provide flow augmentation for NPR water demands. NPR water flow augmentation will vary daily and seasonally, which results in the flow variations presented in Table 6-16. Additionally, Figure 6-32 illustrates the modeled flow variation to the NCPW Pump Station and, in turn, the NCPW Pipeline and Miramar Reservoir, as a result of NPR demands over the course of a year.

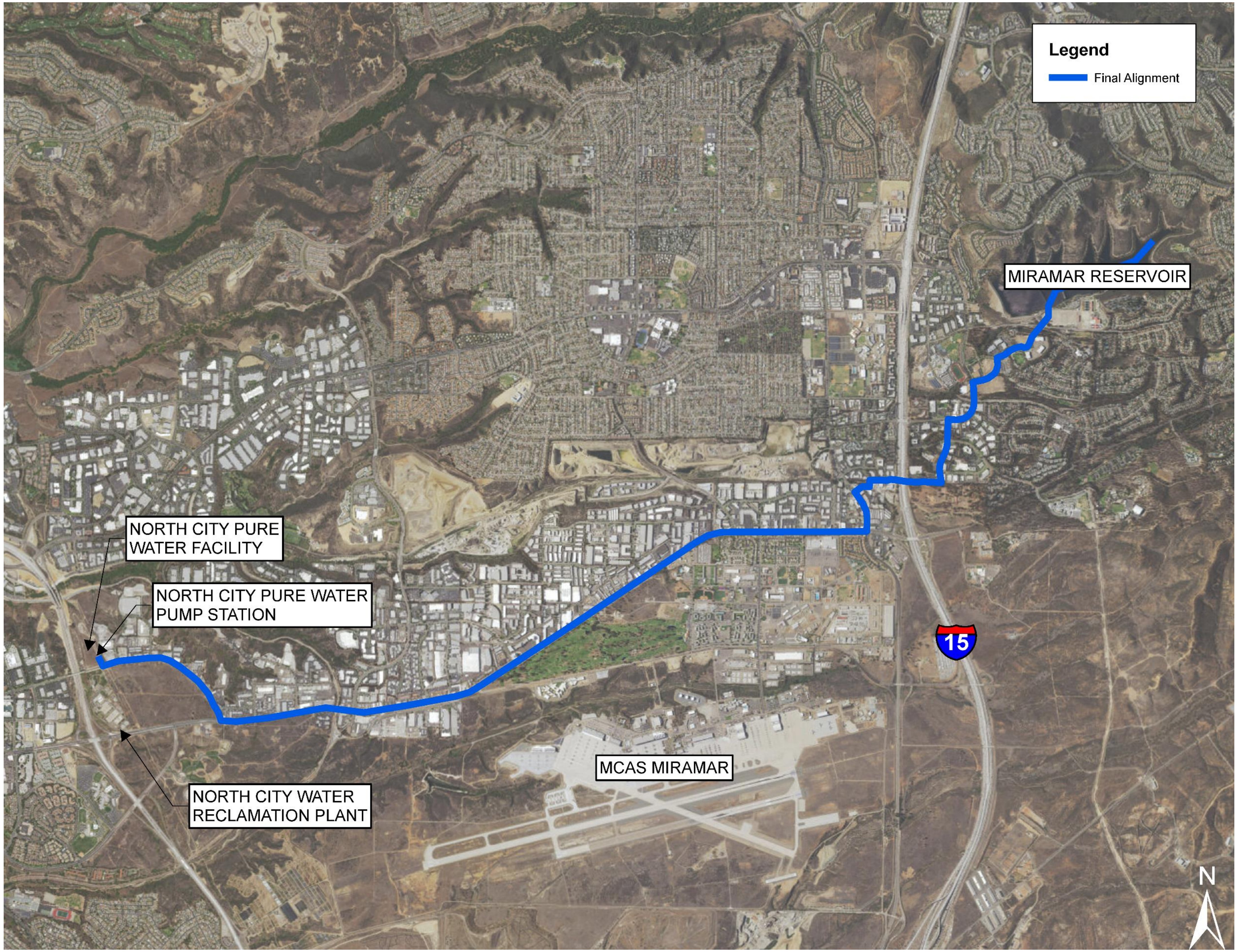


Figure 6-31: NCPW Pipeline Alignment

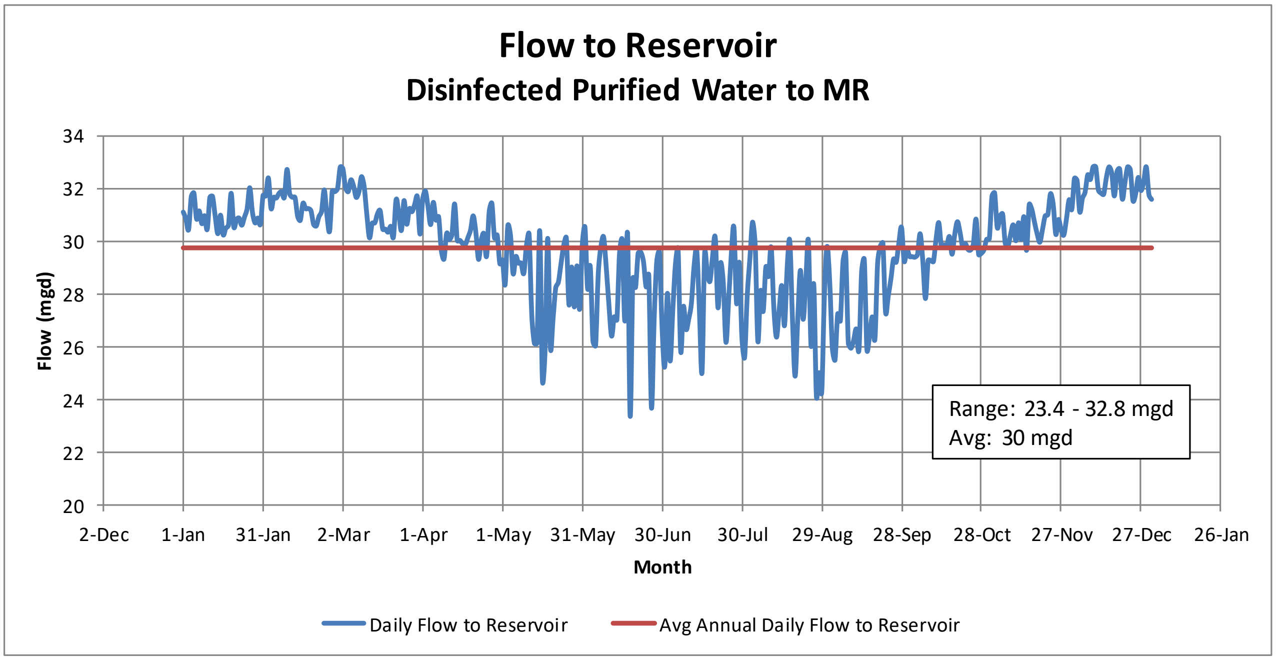


Figure 6-32: Purified Water Flow Variations to Miramar Reservoir

6.3.2.8 North City Pure Water Dechlorination Facility

Before the purified water can be discharged into Miramar Reservoir, dechlorination is required to reduce any free chlorine residual to chloride ion prior to discharge.

The NCPW Dechlorination Facility will be located at the north end of Meanley Drive at the entrance to the Miramar NPR water storage tank, which is located approximately 1,500 ft upstream of Miramar Reservoir (see Figure 6-33). The NCPW Dechlorination Facility consists of a designed concrete masonry block with a metal roof building capable of storing two 7,000-gallon dual-walled fiberglass reinforced plastic sodium bisulfite chemical storage tanks (14 days of storage), metering pumps, transfer pump, emergency shower/eyewash, and control panel. The NCPW Dechlorination Facility includes a propane powered backup generator with a 24-hour supply and an automatic transfer switch in case of loss of electrical power. Table 6-69 presents the facility's design criteria.

The introduction of the sodium bisulfite will be the method in which free chlorine residual will be reduced. The sodium bisulfite will be pumped from the storage tanks, located in the NCPW Dechlorination Facility, to an adjacent vault where the sodium bisulfite will be injected into the NCPW Pipeline via an injection quill. The sodium bisulfite will rapidly mix with the purified water in the NCPW Pipeline through a static mixer. After the static mixer, chlorine residual and oxygen reduction potential sensors will measure residual chlorine within the NCPW Pipeline.

Figure 6-33: North City Pure Water Dechlorination Facility Location

Table 6-69: North City Pure Water Dechlorination Facility Design Criteria

Parameter	Units	NCPW Dechlorination Facility
Sodium Bisulfite Storage		
Number of tanks	units	2
Volume of each tank	gallons	7,000
Total volume	gallons	14,000
Average dose	mg/L	2
Average use	pounds per day	1,988
Storage at average dose	days	14
Sodium Bisulfite Pumps		
Number of metering pumps	duty / standby	1 / 1
Capacity of metering pumps, each	gallons per hour	2.4 to 24

On a more temporary basis, the current design assumes that City-furnished temporary dechlorination systems will be provided during any pipeline dewatering activities. Blowoff valves discharging to sanitary sewers do not require dechlorination.

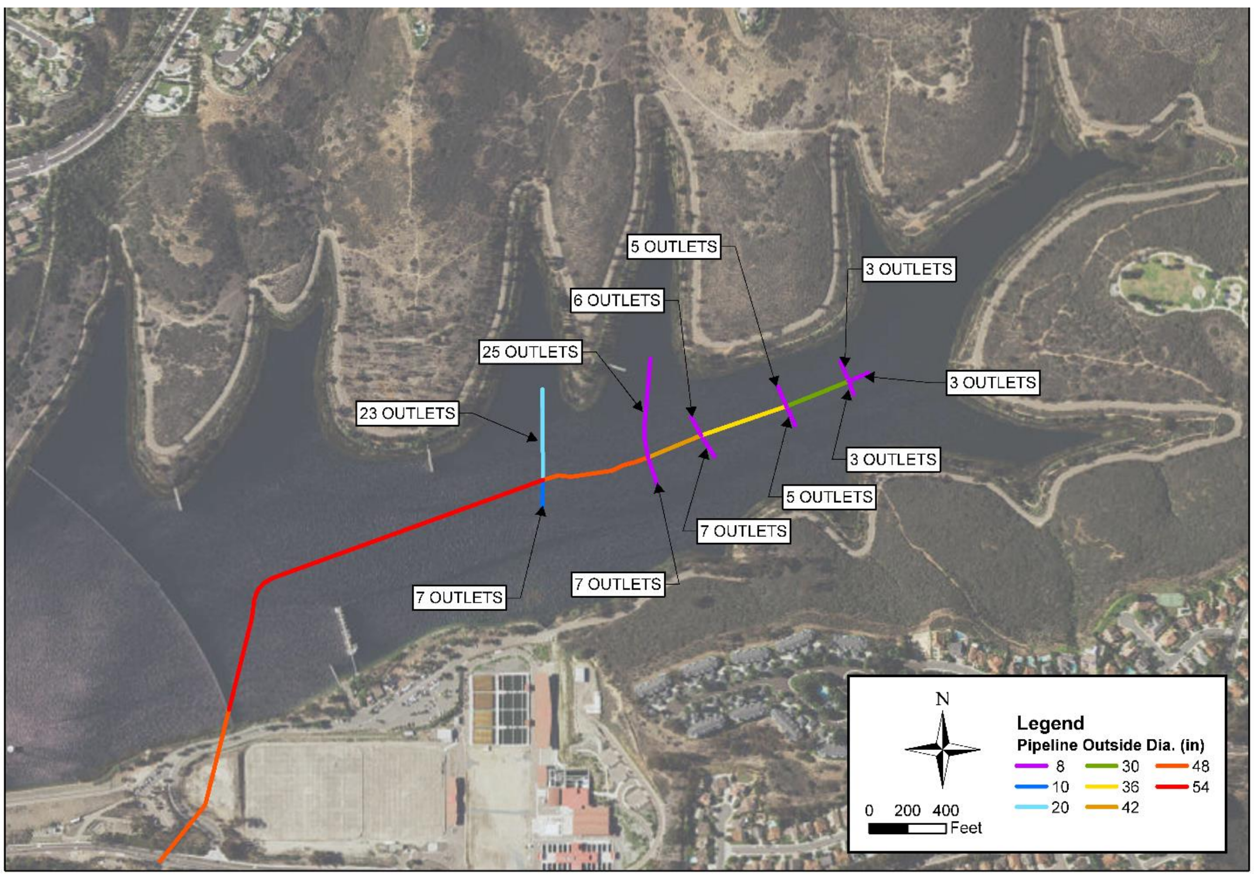
6.3.2.9 Reservoir Inlet and Subaqueous Pipeline

Most of the NCPW Pipeline will be constructed by conventional cut-and-cover or trenchless tunneling methods with the exception of the segment within Miramar Reservoir where a subaqueous pipeline will be installed.

The purified water will be introduced within Miramar Reservoir in a distributed fashion though the use of multiple ports located along the subaqueous pipeline. This method will ensure that the required minimum 10:1 dilution ratio is met before any purified water is subsequently withdrawn from Miramar Reservoir at the Miramar DWTP source water intake. The treated water pipeline will enter Miramar Reservoir by way of a tunnel to be constructed on the south shore, west of the Miramar DWTP.

By locating the pipeline in the lowest part of the reservoir, its tendency to move or slide downslope will be eliminated or minimized. This is a concern in Miramar Reservoir due to the rather steep slopes in this reservoir, and it will make the pipeline less likely to move during a seismic event.

As illustrated on Figure 6-34, the subaqueous pipeline will include multiple branches and some of the orifices will be located some distance from the main pipeline. The treated water will discharge from all of these orifices at high velocity in order to further enhance mixing in the reservoir between the newly introduced purified water and the other water in Miramar Reservoir.



(Source: Figure 2, "North City Conveyance System, Subaqueous Pipeline", HDR, dated September 30, 2016.)

Figure 6-34: Conceptual Layout of the Subaqueous Pipeline

Pipe sizing determination is still ongoing; however, some initial pipe sizing has been done for the purposes of establishing a construction cost estimate. Modeling runs were conducted for this configuration under normal lake operating conditions. Additional model runs at other operating conditions, including lower lake levels and with other water quality parameters such as varying wind conditions are currently underway.

Based on the design team's preliminary pipeline sizing efforts, it has been determined that the main pipeline will initially have a 48-inch inner diameter and, as the total flow in the main pipeline gets reduced due to water discharging into Miramar Reservoir, the pipeline diameters will be reduced in order to maintain similar pressure out of all pipe orifices.

The preliminary design calls for the subaqueous pipeline to be approximately 4,700 ft long and have an inner diameter range from 8 inches to 48 inches. High density polyethylene pipe will be used for the subaqueous portion of the NCPW Pipeline, as it is the easiest pipe material to install for this type of application, and it is corrosion resistant. The pressure class of the high density polyethylene pipe will be determined to suit the hydraulic and installation conditions.

For underwater distributed flow installations, it is recommended that the diffusers or orifices be fitted with "duckbill" valves as they provide good velocity performance over a wide range of flow rates and they have the ability to adjust the valve opening in response to flow. The "duckbill" valves will also prevent biota from entering the subaqueous pipes during periods of no or very low flow rates.

There is not an instantaneous monitor or sensor in the NCPW subaqueous pipeline that would indicate a break or leak in the system. The flow rate and pressure monitored at the NCPW Pump Station will be relatively consistent once the system is operational. A change in the performance of the NCPW Pump Station could be the result of a break in the NCPW Pipeline or NCPW subaqueous pipeline and then would be investigated.

The following are additional design and operational methods to ensure proper function:

- The subaqueous pipe system has a minimum diameter ratio of 21, which is a thicker pipe than required for the application:
    - Provides a minimum pressure rating 100 psi.
    - 54-inch diameter pipe has a minimum wall thickness of 2.571-inches, with allowable tolerance of +/- 0.243" for a 54" with DR 21 per AWWA C906-15.
    - Routine maintenance and inspections:
        - Physical Diver Inspections of the subaqueous pipe system is recommended every three years.
        - A blind flange tee has been provided near the reservoir at the access shaft for launching of video inspection equipment.

6.3.2.10 Pipeline Appurtenances

Pipeline appurtenances are necessary to properly maintain and operate the proposed pipeline. Appurtenances will include combination air vacuum air release valves, blowoff valves, access manways, isolation valves, and other miscellaneous appurtenances.

Prior to discharge into Miramar Reservoir, an isolation valve is provided downstream of the NCPW Dechlorination Facility. The isolation valve will be manually operated; however, the position of the valve (open/closed) will be connected to the distributed control system.

6.3.2.11 Pipeline Discharge Operations

The NCPW Pipeline will be directly or indirectly connected to various other facilities, including the NCPW Pump Station, NCPW Dechlorination Facility, Miramar NPR water storage tank, Miramar Reservoir, and Miramar DWTP. The design of communication and control systems will be coordinated between the NCPW Pump Station and critical points along the NCPW Pipeline, as well as with the above mentioned facilities. Some of the elements include:

- Improvements and replacement of existing modem connection at the Miramar NPR water storage tank with the new fiber-optic cable installed along with the NCPW Pipeline;
- Installation of communication and controls at the NCPW Dechlorination Facility;
- Operation controls for motorized isolation valve along the NCPW Pipeline, including one just downstream of the NCPW Dechlorination Facility, to prevent off-spec water discharge into Miramar Reservoir; and
- Operation controls such as a level sensor shutoff to relate the level in Miramar Reservoir to the NCPW Pump Station, such that the NCPW Pump Station shuts off before the spillway is activated.

To facilitate communication between facilities, fiber-optic cable will be provided in a conduit alongside the NCPW Pipeline. The conduit will be buried in the NCPW Pipeline trench and routed through casings at trenchless crossings. Conduit routing will be reviewed as the design progresses to locate pull boxes.

In addition to normal operation and maintenance activities, pumping or draining of the NCPW Pipeline may be required to purge any off-spec water from the pipeline. Handling of off-spec water is discussed in Section 16.4.

6.3.3 Miramar Reservoir

This section describes the physical features of Miramar Reservoir and associated infrastructure. Results of the water quality and limnology studies of Miramar Reservoir are presented in Section 11.

6.3.3.1 Miramar Reservoir and Existing Infrastructure

Miramar Reservoir, illustrated on Figure 6-35 is located in the Scripps Ranch community of San Diego and is owned, operated, and maintained by the City. The reservoir is adjacent to the Miramar DWTP, also illustrated on Figure 6-35. Miramar Reservoir and the Miramar DWTP serve the northern part of the City.

Miramar Reservoir is located in what was once a small, naturally dry canyon. The reservoir is formed by an earth-fill dam in the canyon. The dam was completed in 1960 in association with the Second San Diego Aqueduct project. Since its creation, the reservoir has impounded only imported water from the Colorado River Aqueduct and State Water Project conveyed to the reservoir in aqueducts owned and operated by the SDCWA. Essentially no runoff from the local watershed flows into the reservoir. The City has full control of the inflow, outflow, and storage volume of the reservoir.

Miramar Reservoir is used to store imported water as a source water for the Miramar DWTP. The reservoir was constructed and has been maintained exclusively for the purpose of municipal water supply. Limited recreational activities, such as picnicking, hiking, boating, and fishing, are ancillary to the overarching purpose of municipal water supply. The reservoir is seasonally stocked with fish. All public access and recreational uses are managed by the City.

When full, Miramar Reservoir has a maximum surface area of 162 acres, depth of 114 ft, and water storage capacity of 6,682 AF. Figure 6-36 illustrates the reservoir storage volume at varying depths and the elevations of the four sets of outlet ports.

Figure 6-37 illustrates a schematic of the sources, conveyances, and outflows associated with Miramar Reservoir. Under the existing operational scheme, water delivered through the imported water aqueduct that is in excess of treatment plant demands is diverted into the reservoir. The existing lake pumps lift stored water from the reservoir to the Miramar DWTP. The combination of diversion into the reservoir and pumping out of the reservoir allows operators to balance aqueduct flows and treatment plant demands, and to sustain storage in the reservoir at the desired level.

6.3.3.2 Miramar Reservoir Purified Water Infrastructure

With the implementation of the North City Project, the infrastructure and operation of Miramar Reservoir will remain effectively unchanged other than the purified water delivery system described in Section 6.3.2. Purified water produced by the NCPWF will be conveyed to the reservoir via the NCPW Pump Station and NCPW Pipeline. Prior to release into the reservoir, the purified water will be dechlorinated at the NCPW Dechlorination Facility. Inflowing purified water will be distributed in the reservoir through a subaqueous pipeline and an extensive diffuser system, which is discussed in Section 6.3.2.

From Miramar Reservoir, stored water will be conveyed (i.e., lifted) to the Miramar DWTP using the existing pump station (referred to later in other sections of this report as the Miramar Reservoir Pump Station) illustrated on Figure 6-38. The six pumps have a combined capacity of 100 mgd; however, the outflow from the reservoir (intake tower) is limited by the size of the outlet pipe leading from the reservoir to the pumps. At normal reservoir operating levels, the maximum outflow rate is about 70 mgd. As described below, the pump station will be refurbished as part of the Project.

Figure 6-35: Miramar Reservoir and the Miramar DWTP

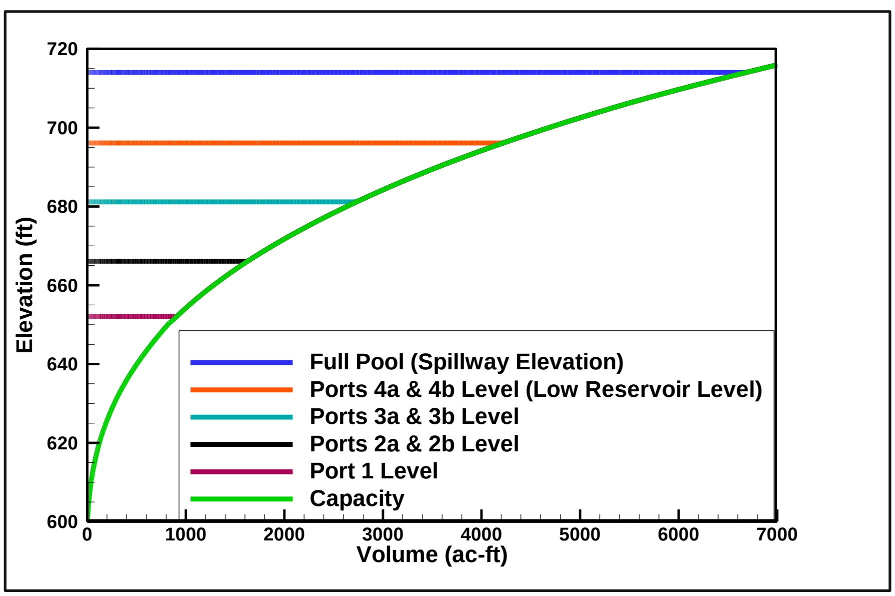


Figure 6-36: Capacity of Miramar Reservoir and Outlet Ports

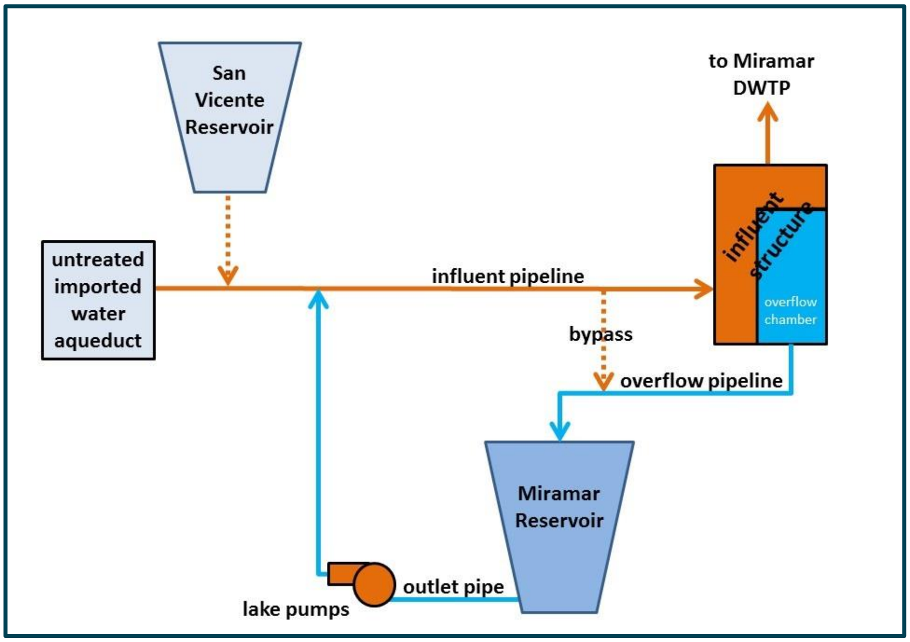


Figure 6-37: Miramar Reservoir and Miramar DWTP Existing Connections

Figure 6-38: Miramar Reservoir with Lake Pumps and the Miramar DWTP

6.3.3.3 Miramar Reservoir Pump Station Improvements

Finally, the increased use of Miramar Reservoir water will require rehabilitation of the Miramar Reservoir Pump Station, and associated pipelines, which currently have a maximum capacity of 100 mgd. Miramar Reservoir is used primarily for balancing flows and for emergency storage and supply. Currently, the Miramar Reservoir Pump Station operates under the following scenarios:

- To supplement imported SDCWA water to Miramar DWTP production demands;
- To provide reservoir storage (water surface elevation) control; and
- During SDCWA raw water shut-downs, the pump station is the sole water supply to the Miramar DWTP and operates with four to six pumps (depending on demand) continually for the shutdown duration, typically 10 to 14 or more days.

When operation of the NCPWF is initiated, it will run continuously as purified water flows into the reservoir. The Miramar Reservoir Pump Station has six pumps, two of which currently have variable frequency drives. Based on a recently conducted condition assessment, necessary upgrades to the Pump Station will include rehabilitating the existing pumps. Rehabilitation would include replacing wear rings, impellers, line shaft bearings, and seals. Furthermore, appurtenances to the pumps, pump check valves, pressure gauges, pressure switches, and small piping will require replacement to ensure reliable control of purified water influent to the Miramar DWTP.

6.3.4 Miramar Drinking Water Treatment Plant

The Miramar DWTP has been operating since 1962 and serves approximately 500,000 customers in the northern part of San Diego as illustrated on Figure 6-39. The Miramar DWTP is located in the Scripps Miramar Ranch community in San Diego, adjacent to Miramar Reservoir as illustrated on Figure 6-5 and Figure 6-38.

The Miramar DWTP treats imported raw water from the SDCWA. This water comes from the Colorado River Aqueduct and the State Water Project, which are the two sources of imported raw water for the Metropolitan Water District of Southern California and its member agencies. The raw water supply to the Miramar DWTP is typically a blend of Colorado River Aqueduct and the State Water Project water; the blend varies depending on the availability of these two sources at any given time. The Miramar DWTP can also receive source water from Hodges Reservoir, which is used by the SDCWA to store water during wet years. Under current operations, most of the water treated by the Miramar DWTP comes directly to the plant by way of the various SDCWA raw water pipelines, including the Second San Diego Aqueduct and the San Vicente Pipeline. The Miramar DWTP is adjacent to Miramar Reservoir, which is currently used for supplemental storage. Water is pumped from this reservoir to supplement the SDCWA supply when required to meet the service area demand. The raw source water supply to the Miramar DWTP is illustrated conceptually on Figure 6-40.

The existing Miramar DWTP is permitted for a maximum finished water flow rate of 144 mgd, which is based on the maximum allowable filtration rate. After the new clearwells and chlorine contact chamber are constructed, the plant will have the ability to produce up to 215 mgd; however, the permit will need to be amended to allow high rate filtration to attain this higher rated capacity. About 3 to 4 percent of the plant inflow is lost to backwash, so the maximum finished water flow rate of 215 mgd corresponds to a raw water flow rate of 225 mgd. The minimum flow rate of the Miramar DWTP is set by the turndown range of the chemical feed systems. This minimum flow rate is about 50 mgd.

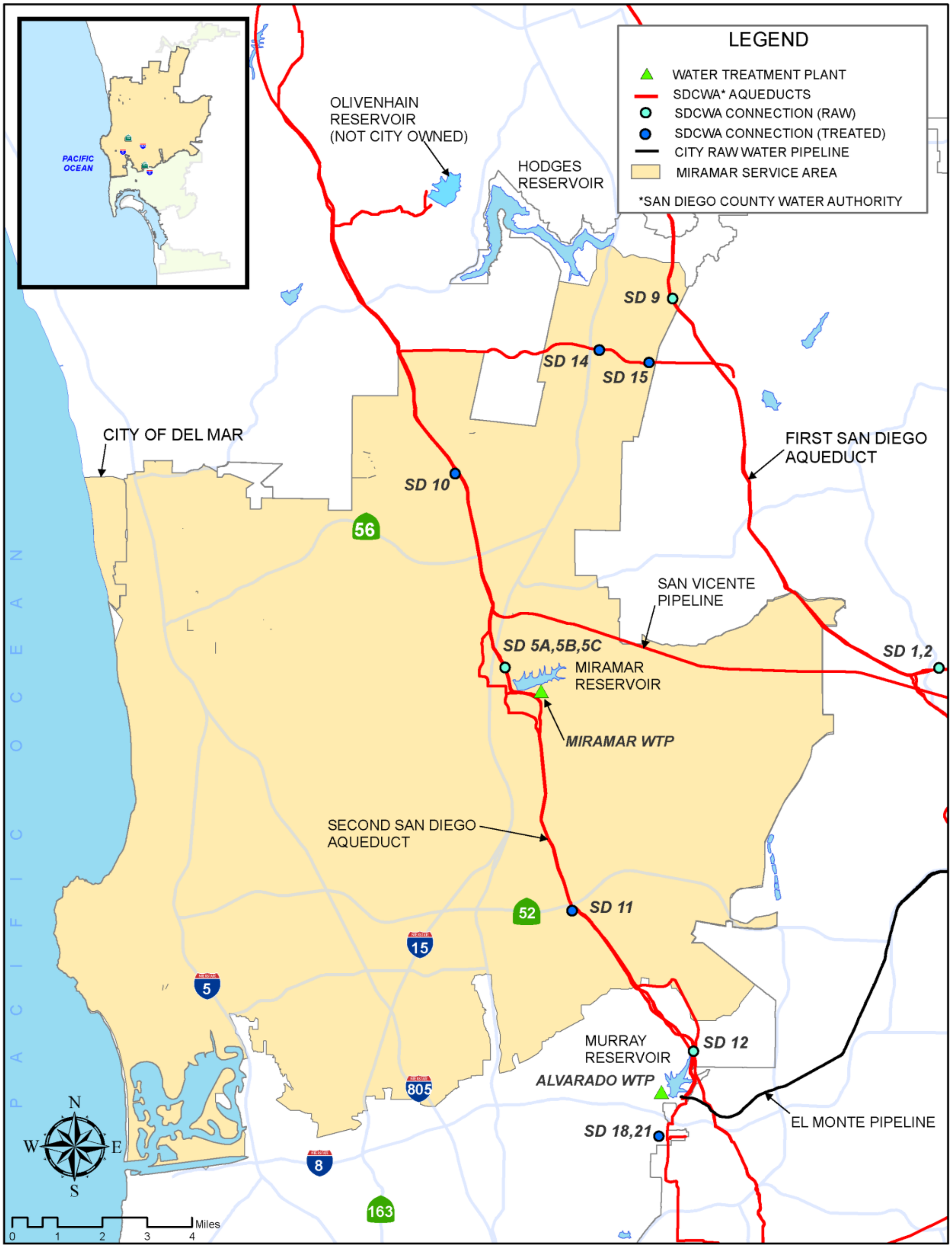


Figure 6-39: Map of Miramar DWTP Service Area

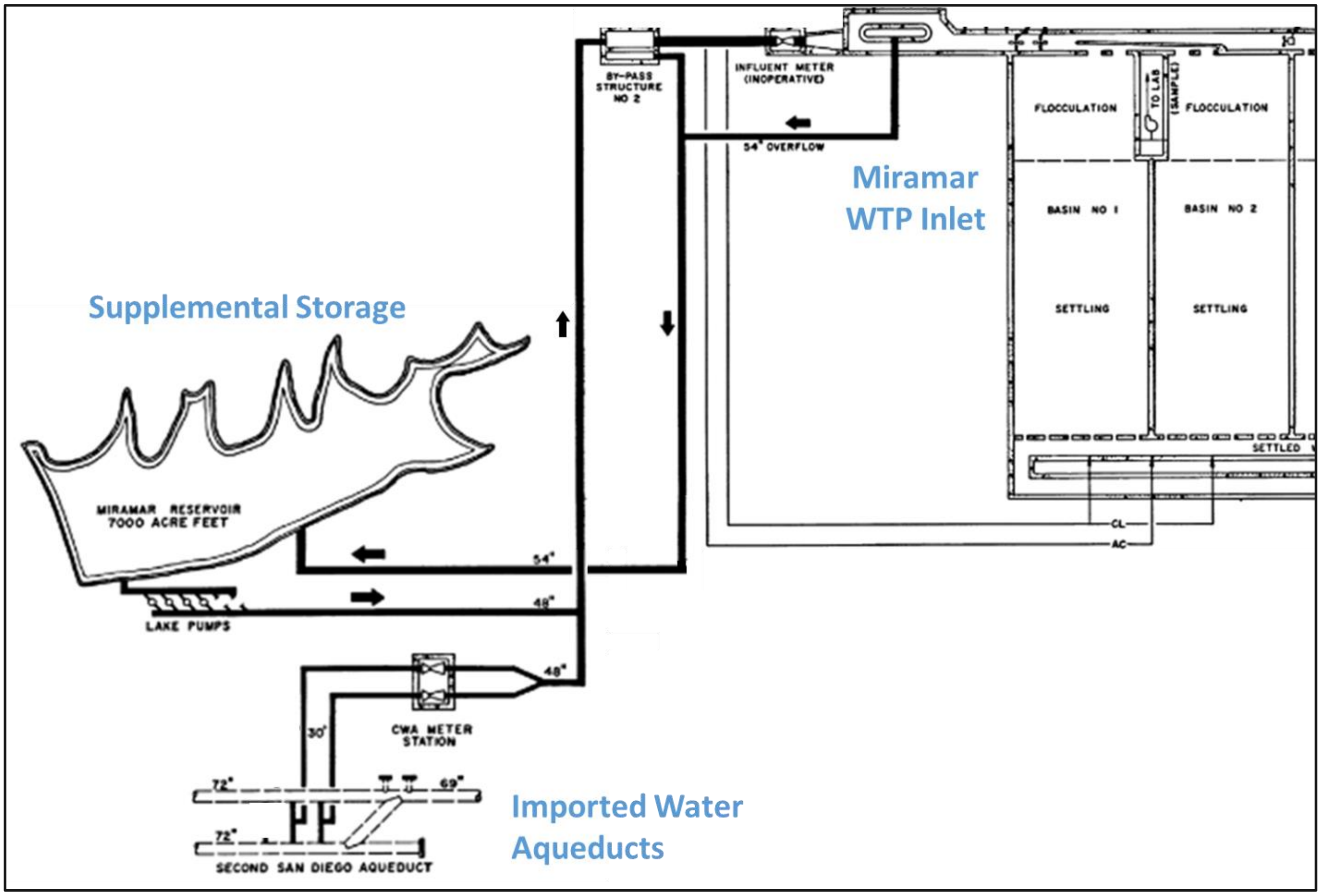


Figure 6-40: Source Water Supply Configuration at Miramar DWTP

6.3.4.1 Miramar DWTP Treatment Process Description

The Miramar DWTP utilizes conventional water treatment processes of coagulation, flocculation, sedimentation, filtration, pH adjustment, and disinfection. The Miramar DWTP also provides pre-aeration to mitigate air entrainment and two stages of ozonation to improve disinfection and the control of dissolved organic compounds. Key design criteria for these processes are presented in Table 6-70 and the Miramar DWTP site layout is illustrated on Figure 6-41.

Table 6-70: Miramar DWTP Design Criteria

Process/Parameter	Units	Value
Influent Flow (Design/Future)	mgd	225/288
Filtered Effluent Flow (Design/Future)	mgd	215/275
Raw Water Ozonation		
Configuration	-	Diffusion w/ Serpentine flow
Hydraulic Detention Time	minutes	1.6 @ 288 mgd
Ozone Dose (min/max)	mg/l	0.4/1.25
Continues on next page...		

Process/Parameter	Units	Value
Deaeration Basin		
Configuration	-	Cascade w/ Diffusion
Influent Weir Length	ft	40
Water Depth Over Weir	ft	1.3
Design Water: Gas Ratio	-	20:1
Diffused Air Flow per Basin	cubic ft per minute	700
Number of Centrifugal Blowers	-	3
Blower capacity	cubic ft per minute	1000
Rapid Mixing		
Type	-	Flash Mix
Total Number of Diffusion Pumps	-	3
Pump Capacity (maximum – each Pump)	gpm	2300 @ 28 – ft
Flocculation		
Type	-	Horizontal Paddle
Total Detention Time	minute	30-34
Mixing Energy	1 per second	20-70
Peripheral Paddle Speed	ft per second	0.5 – 3.0
Sedimentation Basins1, 2		
Type	-	Serpentine
Side Water Depth	ft	13.5
Surface Loading Rate per Total Projected Area	gpm/sf	0.54
Detention Time	ft	97
Horizontal Velocity (Bottom Deck)	ft/minute	3.55
Weir Loading Rate	gpd/LF	20000
Residual Solids Collection		Chain & Flight
Sedimentation Basins 5, 6, 7, 8		
Type	-	Horizontal Flow
Side Water Depth	ft	17
Surface Loading Rate per Total Projected Area	gpm/sf	0.4
Detention Time	ft	31
Horizontal Velocity (Bottom Deck)	ft/minute	3.55
Weir Loading Rate	gpd/LF	20000
Residual Solids Collection		Chain & Flight
Continues on next page...		

Process/Parameter	Units	Value	
Settled Water Ozonation			
Configuration	-	Diffusion w/ Serpentine Flow	
Hydraulic Detention Time	minute	10.5	
Diffuser Cells	-	Counter current – two per train & Co-current (Future)	
Length/Width Ratio	-	~35:1	
Hydraulic Efficiency, t10/T	-	0.65	
Ozone Dose (min/max)	mg/l	0.5/1.95	
Filters			
Filtration Capacity – winter minimum	mgd	47	
Filtration Capacity – summer maximum	mgd	144 existing, 215 if rerated	
Number of Filters	-	12	
Cells per filter	-	2	
Filtration Rate – winter max	gpm/sf	1.2	
Filtration Rate – summer max	gpm/sf	6 existing, 9 if rerated	
Depth of Submergence	ft	10	
Media	-	Dual media	
		Anthracite	Sand
Depth	inches	48	9
Uniformity Coefficient	-	< 1.4	< 1.4
Effective Size	-	1.2 – 1.3	0.65 – 0.75
Underdrain	-	Block w/ Porous Cap	
Backwash Water Rate	gpm/sf	5 to 25	
Air Scour Rate	Cubic ft per minute/sf	2 to 4	
Filter Conditioning	-	Polymer Filter Air and Backwash Aid	
Wash Water Supply			
Type	-	Vertical Turbine	
Backwash Flow/Cell	gpm	3800-19000	
Auxiliary Wash System			
Type	-	Air Scour	
Volume Flow/Cell	cubic ft per minute	1500-3000	

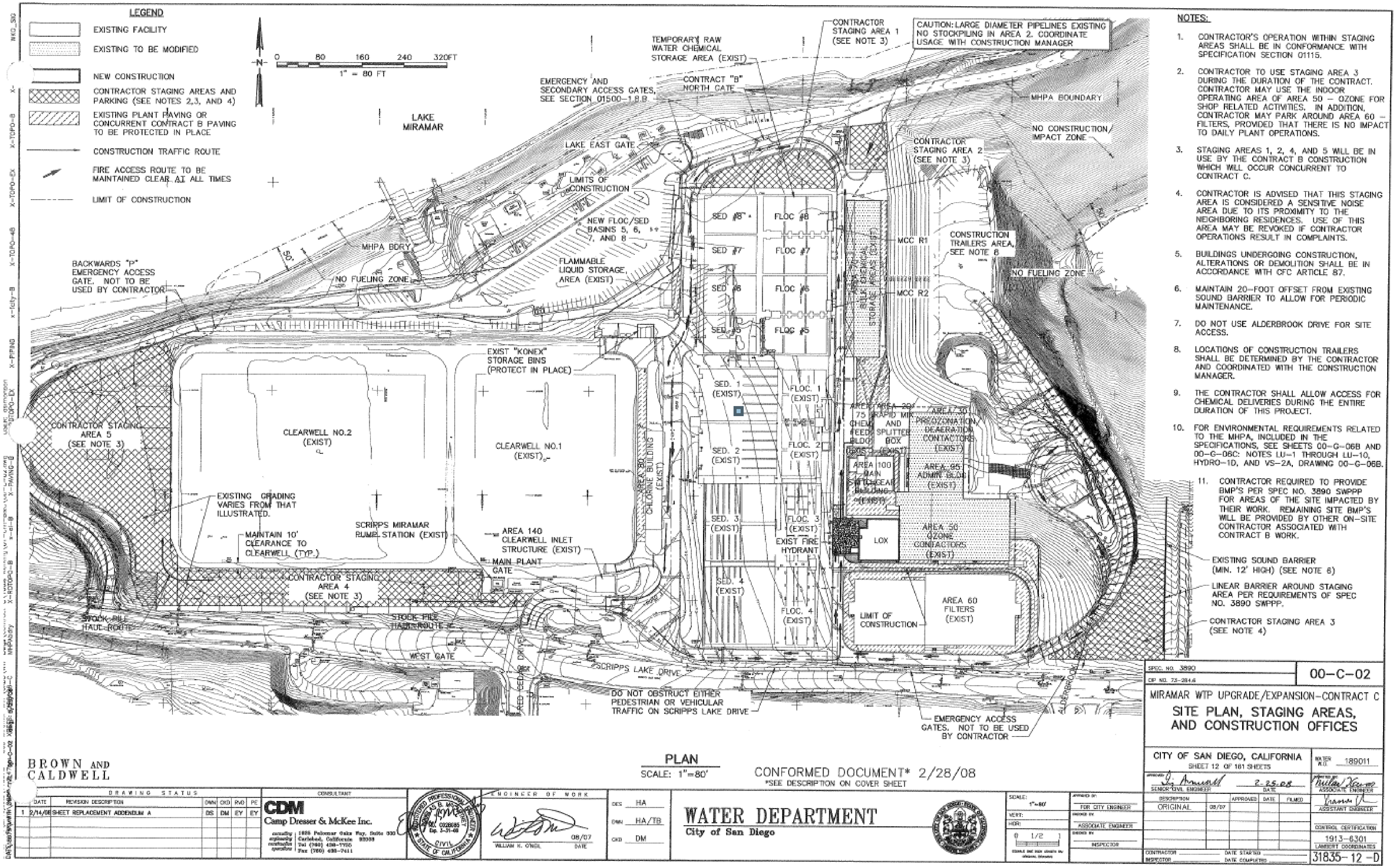


Figure 6-41: Miramar DWTP Site Layout

6.3.4.2 Monitoring and Compliance

The Miramar DWTP operation is governed by a set of compliance goals based on the Safe Drinking Water Act requirements. Like any drinking water plant, the Miramar DWTP targets the MCLs for drinking water as defined by the EPA. These include the pMCLs, which are legally enforceable, and the sMCLs, which serve as guidelines. In addition to these requirements, the Miramar DWTP participates in the Partnership for Safe Water Program, holds the President's Award from the Partnership, and is applying for the Excellence Award. Requirements for these prestigious awards are more stringent than DDW's requirements. These awards demonstrate the Miramar DWTP's ability to optimize the treatment process.

Major categories of MCLs that affect the Miramar DWTP include:

- ***Turbidity Removal.*** The pMCLs define standards for turbidity to ensure the microbiological safety of the water. In addition, there is a turbidity reduction requirement in the Miramar DWTP operating permit.
- ***Disinfection.*** The pMCLs define measurable limits on certain pathogens, and stipulate total log removal requirements for other pathogens per the SWTR.
- ***pH Control.*** The sMCLs establish a range of acceptable pH levels for drinking water.

Key water quality targets for the existing Miramar DWTP, in light of these compliance goals, are presented in Table 6-71.

Table 6-71: Water Quality Targets for Miramar DWTP

Parameter	Unit	Goal	Goal Type
Turbidity	NTU	0.3 - 95% of the time, and <1 at all times	Primary MCL
Turbidity	NTU	0.1	Miramar DWTP treatment goal
Total turbidity removal	percent	80	Miramar DWTP permit requirement
Virus inactivation	log	4	MCL / SWTR
Giardia inactivation	log	3	MCL / SWTR
Cryptosporidium inactivation	Log	2	MCL / SWTR
Total coliform samples	percent positive	< 5.0% per month	pMCL
Heterotrophic Plate Count	CFU/mL	500	MCL / SWTR
Disinfection CT	mg-min/L	Varies depending on source water quality, 28-55	Miramar DWTP treatment goal
Ozone Dose	mg/L	0.15-0.4	Miramar DWTP treatment goal
Ozone Hydraulic Detention	minutes	10.5	Miramar DWTP treatment goal
Chlorine Residual	mg/L as Total Cl_2	2-3	Miramar DWTP treatment goal
Finished water pH	pH units	6.5-8.5	sMCL
Finished water pH	pH units	8.0-8.5	Miramar DWTP treatment goal

Operational strategies at the Miramar DWTP are tailored to meet the key water quality targets, and the various processes in the plant have been optimized by operational experience to meet them. Coagulant and polymer dosing (for flocculation and settling) and filter operation achieve consistently low turbidities in the finished water, and optimizing these processes for turbidity removal also ensures that the pathogen removal goals are met. In addition, the ozone and chlorine doses required to meet the CT targets are well understood, and the Miramar DWTP includes pH and alkalinity chemical conditioning to ensure that the finished water pH is in an acceptable range. Finished drinking water quality is understood and steps are employed to ensure that the distribution system has adequate corrosion control.

The plant includes in-line instrumentation to ensure compliance with these goals. In-line monitoring includes the parameters presented in Table 6-72. This instrumentation allows for continuous monitoring of the treatment processes to verify their performance for turbidity removal, pathogen removal, and pH. In addition, the Miramar DWTP operators take and analyze grab samples every two hours, to confirm the performance of the plant and the accuracy of the in-line instruments.

Table 6-72: Key In-line Water Quality Instrumentation at Miramar DWTP

Parameter	Instrument	Monitoring Locations
Turbidity	Nephelometer	Raw water; settled water; each filter; finished water
Ozone Dose	Electrochemical probe	Pre-ozonation dosing point and pre-filter dosing point
Chlorine Residual	Colorimetric analyzer	Duty/standby analyzers on finished water
pH	Electrochemical probe	Raw water; finished water

The Miramar DWTP is intended to operate continuously to meet the demand in its service area. In recent experience, the plant has periodically shut down in response to low demand for water. This is both a seasonal phenomenon (as water use varies throughout the year) and a result of conservation (as per capita water trends downward, particularly in arid regions like Southern California). The available Miramar DWTP capacity allows the plant to meet variable system demands (50 – 144 mgd). The ability to take the plant off-line is currently based on system demand, clearwell storage, distribution system tank storage, and availability of treated water from SDCWA.

7. Filter Loading Rate Evaluation

The filter loading rate evaluation conducted at the NCWRP is described in this section. Following discussion of the purpose of the filter loading rate evaluation, results from similar studies conducted at other plants in 2007 are summarized, and results of the 2017 NCWRP filter loading rate evaluation are presented.

7.1 Background

The City conducted a filter loading rate evaluation in order to increase the capacity of the existing NCWRP tertiary filters from 32.1 to 48.1 mgd through an increase in the filtration rate to 7.5 gpm/sf[1]. The filter loading rate evaluation began in January 2017 and concluded in March 2017.

The City conducted a filter loading rate evaluation in order to increase the capacity of the existing NCWRP tertiary filters from 32.1 to 48.1 mgd through an increase in the filtration rate to 7.5 gpm/sf[2]. The filter loading rate evaluation began in January 2017 and concluded in March 2017.

DDW allows full-scale testing, on a plant-by-plant basis, to demonstrate equivalency of treatment at filtration rates up to 7.5 gpm/sf.

Based on the FLEWR Study, DDW approved a set of criteria for determining equivalent filter performance at a filtration rate of 7.5 gpm/sf. The DDW Equivalency Criteria are:

- No significant* increase in mean turbidity of filter effluent;
- No significant* increase in mean concentration of 2 to 5 and 5 to 15 micrometer (µm) sized particles in filter effluent; and
- No significant decrease in the ability to disinfect filter effluent.

* Where significant increase = $\frac{0.2\ NTU}{NTU\ produced\ at\ 5.0\ gpm/sf}$ (reported as percent)

For the NCWRP, a significant increase is 69 percent determined using the mean 5 gpm/sf turbidity of 0.29 NTU during the filter loading rate testing.

7.2 Summary of the FLEWR Study

This section provides a summary of the 2007 FLEWR Study that was performed to evaluate the effects of loading rates on tertiary wastewater filtration that led to DDW's development of the Equivalency Criteria.

7.2.1 Pilot-Scale Phase of the FLEWR Study

Five pilot-scale filters were constructed to simulate the full-scale filters at the Monterey Regional Water Pollution Control Agency tertiary treatment plant. The results of the pilot-scale study are presented in Table 7-1. The comparison of key water quality parameters between the 5 and 7.5 gpm/sf loading rates indicates either equivalent or better quality for the higher rate.

[1] Assuming operation in an n+2 configuration
[2] Assuming operation in an n+2 configuration

Table 7-1: Summary of Results from the Pilot-Scale Phase of the FLEWR Study at Monterey Regional Water Pollution Control Agency

Parameter	5 gpm/sf	7.5 gpm/sf	% Change to 7.5
Average Run Time (hour)	24	22.7	-5%
Coagulant Dose (mg/L)	3.5	5.6	62%
Effluent Turbidity (NTU)	1.9	1.86	-2%
Effluent Particle Count 2-5 µm (#/milliliter)	4,600	3,900	-15%
Effluent Particle Count 5-15 µm (#/milliliter)	830	790	-5%
Log MS2 Phage Removal	0.29	1.48	407%

7.2.2 Full-Scale Phase of the FLEWR Study

Full-scale testing was conducted at five water-recycling facilities in California. Each facility has a unique treatment process for producing recycled water, and those processes are presented in Table 7-2. During full-scale testing, similar parameters to those measured during pilot-scale testing were monitored, including the filter influent and effluent turbidity and particle counts, flow, and coagulant dose.

Table 7-2: Recycled Water Production Treatment Trains for the Full-Scale Phase of the FLEWR Study

Water Recycling Plant	Secondary	Pretreatment	Filtration	Disinfection
San Jose-Santa Clara Regional Wastewater Facility	Step-feed activated sludge process with biological nutrient removal	No pretreatment (can add alum)	Dual-media	Chloramines
Monterey Regional Water Pollution Control Agency Salinas Valley Reclamation Plant	Trickling filters / solids contact	Aluminum chlorohydrate /polymer addition and flocculation	Dual-media	Chloramines
Delta Diablo Sanitation District Recycled Water Facility	Trickling filters and activated sludge with mechanical aeration	Alum/polymer addition and tertiary clarifiers (with ballasted flocculation)	Mono-media (silica sand): continuous backwash	Chloramines
Santa Rosa Subregional Water Reuse System Laguna Wastewater Treatment Plant	Activated sludge with nitrification	Alum addition to aeration basin effluent (and optional filter influent addition)	Mono-media (anthracite)	UV disinfection
Los Angeles County Sanitation District San Jose Creek East WRP	Step-feed activated sludge process with biological nitrogen removal	Alum/cationic polymer addition to aeration basin effluent	Dual media	Sequential chlorination

To achieve equivalent filter effluent water quality, the Monterey Regional Water Pollution Control Agency and Del Diablo Sanitation District Recycled Water Facility increased their coagulant dose, while the San Jose-Santa Clara Regional Wastewater Facility, City of Santa Rosa, and Los Angeles County Sanitation District San Jose Creek East WRP required no change in their coagulant dose. Table 7-3 presents the change in coagulant doses required, as well as the change in effluent water quality at higher filter loading rates. All full-scale facilities demonstrated equivalency of treatment at the higher filter-loading rate. No facility showed a significant increase, as defined by DDW, in any of the parameters while operating at a higher filter loading rate.

Table 7-3: Summary of Results from the Full-Scale Phase of the FLEWR Study[a]

Parameter	San Jose-Santa Clara Regional Wastewater Facility	Monterey Regional Water Pollution Control Agency	Del Diablo Sanitation District Recycled Water Facility	Santa Rosa Subregional Water Reuse System Laguna Wastewater Treatment Plant	Los Angeles County Sanitation District San Jose Creek East WRP
Coagulant dose	none added (no change)	+51%	+6%	none added (no change)	No change
Turbidity (NTU)	+0.04 (5%)	-0.4 (-22%)	+0.03 (4%)	+0.03 (5%)	+0.01 (2%)
2-5 µm particles (per milliliter)	+58 (3%)	-221 (-19%)	-265 (-9%)	+174 (12%)	+8 (3%)
5-15 µm particles (per milliliter)	+44 (11%)	0 (0%)	-12 (-6%)	+82 (23%)	+4 (10%)
DDW definition of significant	27.7%	11.3%	24.7%	39.2%	31.3%

[a] Values in table present the amount each parameter increased or decreased and the percent increased or decreased in parentheses when operating at the higher filter loading rate.

7.3 Filter Loading Rate Evaluation at the North City Water Reclamation Plant

This section provides a summary of the testing protocol for the filter loading rate evaluation at the NCWRP and the results of the testing.

7.3.1 Testing Protocol, Operations Plan, Engineering Report, and Waiver

The testing protocol for the filter loading rate evaluation along with an interim operations plan and an updated Engineering Report was submitted to DDW and the RWQCB in August 2016 and approved in December 2016 (Trussell, 2016b; Trussell, 2016c). A waiver to produce and distribute recycled water during testing was issued following approval of the test protocol, interim operations plan, and the updated Engineering Report which included a condition that the filter effluent turbidity not exceed 2.0 NTU during testing (Barnard, 2016).

The approach for the filter loading rate evaluation was as follows:

- Collect sufficient data to statistically determine whether an equal degree of treatment can be provided by the NCWRP tertiary filters while operating at filtration rates of 5 and 7.5 gpm/sf; and
- Evaluate the operational feasibility of operating the filters at such rates.

The evaluation entailed conducting several filter runs at alternating filtration rates of 5.0 or 7.5 gpm/sf and comparing the effluent water quality between the two rates to determine if the higher filtration rate produces a water quality that is significantly different. A sufficient number of runs was conducted to determine if the effluent water quality at the higher loading rates was significantly different from the water quality at the lower loading rate. One filter was designated the “test filter” and was included in all filter runs. The effluent water quality of the test filter was evaluated for the study. The NCWRP cannot run the filters at different filter loading rates (i.e., they all run at the same loading rate); thus, the filtration rate was alternated to compare the two filtration rates. The secondary effluent water quality was measured to ensure that the secondary effluent water quality was not statistically different while testing at the two filtration rates.

7.3.2 Results of the Filter Loading Rate Evaluation

The filter loading rate evaluation concluded in March 2017. The following sections present and discuss the filter performance during the filter loading rate evaluation conducted at the NCWRP in terms of the following:

- Operational performance;
- Ability to remove particulates; and
- Ability to disinfect tertiary effluent.

7.3.2.1 Operational Results

A summary of the operational performance is presented in Table 7-4. The only differences between the two loading rates that were statistically significant were the filter loading rate and the clean filter head loss, as expected. Furthermore, the average filter run times were very similar for the two loading rates, but slightly shorter for 7.5 gpm/sf target loading rate runs (not a statistically significant difference). That said, the unit filter run volumes (volume produced for a filter before terminal headloss) increased approximately 45 percent indicating higher filter productivity at a filtration rate of 7.5 gpm/sf.

Table 7-4: Summary of Operational Data from NCWRP Filter Loading Rate Evaluation (mean ± 95th percentile confidence intervals)

Loading Rate (gpm/sf)	Number of Filter Runs	Filter Run Time (hour)	Filter Effluent Flow Control Valve Starting Position[a] (%)	Terminal Head Loss (ft)
4.96 ± 0.03	15	17.9 ± 3.0	55 ± 1	13.0 ± 0.22
7.48 ± 0.01	15	17.1 ± 1.8	67 ± 0	13.1 ± 0.18
% Change	--	-4.7	+22	+0.7

[a] The filter effluent flow control valve starting position represents the steady-state position at the beginning of the filter run. It relates to the clean filter head loss which was estimated to be 2.3 and 5 feet for 5 gpm/sf and 7.5 gpm/sf, respectively, from the filter to the downstream weir.

The City currently adds polymer to the NCWRP aeration basin effluent channel when the secondary effluent turbidity exceeds 4.8 NTU for 20 minutes. The secondary effluent turbidity did not exceed 4.8 NTU for 20 minutes during the filter loading rate testing; accordingly, polymer/coagulant was not added during testing. None of the filter runs were terminated due to particle breakthrough. There was no apparent impact of the filtration rate on the ability to backwash the filters, which is consistent with what was observed at other facilities during the FLEWR Study.

7.3.2.2 Turbidity and Particle Counts

A summary of the ability of the filters to remove particulates at a loading rate of 5 gpm/sf and 7.5 gpm/sf is presented in Table 7-5. No statistical difference (α = 0.05) in effluent turbidity or particle counts was detected between the two flow rates. Additionally, the average influent turbidity and particle counts were similar and not statistically different between loading rates.

Similar to what was observed during the FLEWR Study, the water quality parameter that showed the greatest (though not statistically significant) difference between loading rates was the effluent concentrations for the larger particle size range (5-15 μm). The increase was not statistically significant, and the percent increase of 4.7% fell well below the significance threshold defined by the DDW Equivalency Criteria (69%). Recall, the level of significance is a function of the filter effluent turbidity observed at 5 gpm/sf during the filter loading rate tests. Thus, the level of significance for the NCWRP is higher than some facilities evaluated during the FLEWR Study because its filter effluent turbidity is low compared to the other facilities tested. This method of determining significance was intentionally designed to not penalize facilities, like the NCWRP, that produce an effluent that has a turbidity significantly less than 2 NTU.

A comparison of the overall filter performance at the two loading rates and an evaluation of the DDW Equivalency Criteria are illustrated on Figure 7-1. Filter performance at the two loading rates was similar for turbidity and particle counts; average effluent turbidity and particle counts were slightly higher at the 7.5 gpm/sf loading rate but these small differences were not statistically significant (α = 0.05). For all equivalency parameters, the difference between filter loading rates were less than the 69% increase allowed by the Equivalency Criteria. As discussed with DDW (Yamamoto, 2007), a sufficient number of filter runs must be completed so that the variability is low enough to detect the defined level of significance. For the two loading rates at the NCWRP, it was possible to detect differences of 4.2%, 16.6%, and 5.5% for turbidity, 2-5 μm particles, and 5- 15 μm particles, respectively, which are less than the 69% allowable increase as presented in Table 7-6. Thus, the turbidity and particle data from the NCWRP testing met DDW Equivalency Criteria.

Table 7-5: Summary of Ability of Filters to Remove Particulates during the NCWRP Filter Loading Rate Evaluation

Loading Rate (gpm/sf)	Turbidity (NTU) [a]		2-5 µm Particle (per milliliter)[a]		5-15 µm Particles (per milliliter)[a]	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
5	2.71 ± 0.28	0.29 ± 0.05	2425 ± 679	796 ±332	653 ± 124	145 ±32
7.5	2.43 ± 0.31	0.29 ± 0.05	2323 ± 593	812 ± 296	650 ± 109	152 ± 31
% Change[b]	-10.5	3.1	-4.2	2.0	-0.5	4.7

[a] mean ± 95[th] percentile confidence intervals
[b] Percent change calculated using unrounded data.

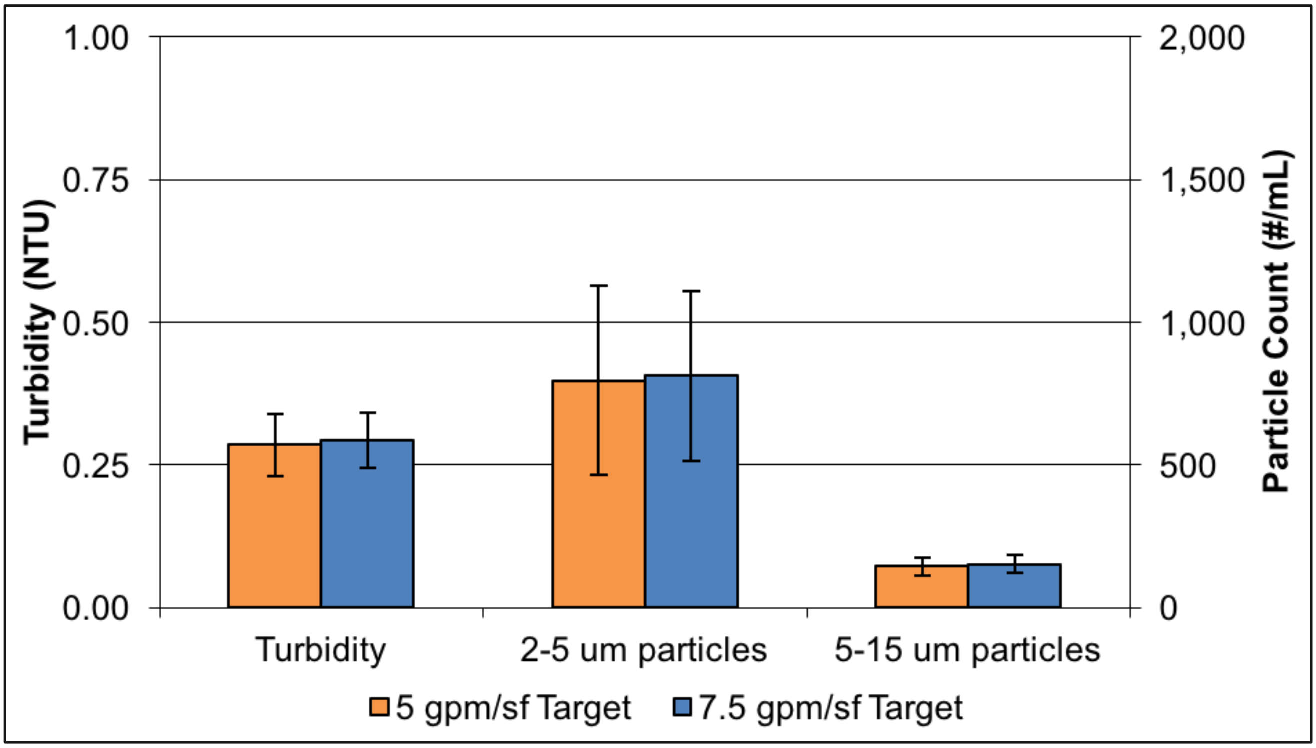


Figure 7-1: Comparison of Turbidity and Particle Concentrations in Filter Effluent

Table 7-6: Evaluation of DDW Filter Loading Rate Evaluation Equivalency Criteria for Turbidity and Particle Counts

Comparative Statistics	Turbidity (NTU)	Particles per Milliliter	
		2-5 µm	5-15 µm
Filter Effluent at 5 gpm/sf	0.29 ± 0.05	796 ± 332	145 ± 32
Filter Effluent at 7.5 gpm/sf	0.29 ± 0.05	812 ± 296	152 ± 31
Equivalency criteria defined significant increase[a]	0.20	558	102
Actual difference between rate (average)	0.01	16	7
Percent change from 5 to 7.5 gpm/sf	3.1%	2.0%	4.7%
Significance detection ability	4.2%	16.6%	5.5%
Do data meet the minimum ability to detect significant increase (as defined by DDW Equivalency Criteria)?	Yes	Yes	Yes
Is performance at 7.5 gpm/sf worse than performance at 5 gpm/sf?	No	No	No
Does this meet DDW Equivalency Criteria?	Yes	Yes	Yes

[a] Defined as a 69 percent increase compared to the performance at 5 gpm/sf.

7.3.2.3 Ability to Disinfect Tertiary Effluent

The ability to disinfect the filter effluent was assessed by comparing total coliform concentrations in daily grab samples from the chlorine contact tank effluent of tests run at the two filter loading rates. All water produced at the NCWRP is disinfected in accordance with Title-22 Water Recycling Criteria for disinfected tertiary recycled water (i.e., a minimum of CT of 450 mg-min/L); thus, disinfection practices were the same for both filter loading rates.

The results of the total coliform sample analyses at both filter loading rates are presented in Table 7-7. The majority of samples at both filter loading rates had concentrations of total coliforms below the detection limit of the analysis method (1.8 MPN/100 mL). Only two samples at a target loading rate of 5 gpm/sf and one sample at 7.5 gpm/sf had detectable concentrations of total coliforms, and these were all close to the detection limit at 2 MPN/100 mL. These results suggest that the disinfection of water from loading rates of 7.5 gpm/sf was just as effective as that of water from loading rates of 5 gpm/sf.

Table 7-7: Summary of Total Coliform Data from NCWRP Filter Loading Rate Evaluation

Loading Rate (gpm/sf)	Number of Samples	Average Total Coliform (MPN/100mL)	Number of Coliform Detections	Maximum Total Coliform (MPN/100mL
5	10	< 1.8	2	2
7.5	11	< 1.8	1	2

Note: Multiple tube fermentation method (Standard Methods 9221); method detection limit of 1.8 MPN/100mL

7.4 Conclusions

The City successfully completed an evaluation of operating its NCWRP tertiary granular media filters at a loading rate of 7.5 gpm/sf. A full comparison of the plant's filter performance at 5 and 7.5 gpm/sf was conducted following the protocols established and approved by DDW and the RWQCB. The NCWRP tertiary filters successfully met all of the equivalency criteria established by DDW and demonstrated that there was no significant increase in the filter effluent turbidity, 2-5 µm particles, or 5-15 µm particles. Furthermore, there was no significant decrease in the ability to disinfect the filter effluent.

Based on the results of the filter loading rate evaluation at the NCWRP, the City is seeking approval from DDW to permanently allow the NCWRP to operate its tertiary filters at loading rates of up to 7.5 gpm/sf. At a rate of 7.5 gpm/sf, the capacity of the existing tertiary filter capacity will increase from 32.1 to 48.1 mgd (assuming operation in an n+2 configuration). This increased capacity and the addition of one new tertiary filter allows the NCWRP to produce sufficient feed water for both the production of purified water at the NCPWF and NPR water using the existing CCT (as discussed in Section 6).

8. North City Water Reclamation Plant Water Quality

The NCWRP provides flow to satisfy NPR demands. Currently, the plant consists of the following:

- Preliminary treatment;
- Primary sedimentation;
- Primary effluent flow equalization;
- Secondary aeration with full nitrification and partial denitrification;
- Secondary clarification;
- Deep-bed anthracite filtration; and
- Chlorine disinfection.

The NCWRP will be upgraded to produce an increased and relatively constant flow to continue production of NPR water and to provide a new tertiary filtered effluent stream for advanced treatment at the NCPWF to produce purified water. Details for the NCWRP expansion are provided in Section 6.2.2. Section 6.1 includes a description of the overall North City Project facilities process flow (Figure 6-3) and a schematic of the proposed expanded NCWRP (Figure 6-4).

Overall, the expanded NCWRP facilities will be capable of treating 52 mgd average annual flow and will include an additional bar screen, grit pumps, primary sedimentation tanks, aeration basins, secondary clarifiers, tertiary filters, and ancillary and support systems. Additionally, the NCWRP expansion will incorporate CEPT, an expanded biological treatment process employing the 4-stage Bardenpho process, and higher loading rates for tertiary filters. The details of the tertiary filter loading rate evaluation are provided in Section 7.

The following sections describe the historical tertiary treated water and NPR water quality from the NCWRP, as well as projected water quality based on the anticipated changes to the wastewater quality (with expanded watershed) and the process changes that will be made as part of the NCWRP expansion.

8.1 North City Water Reclamation Plant Historic Water Quality

Historical secondary effluent quality (BOD, TSS, ammonia, nitrate, phosphate, and turbidity) are illustrated on Figure 8-1 through Figure 8-6. ND concentrations are shown as zero. Currently, complete nitrification is typically achieved; however, there are occasions when ammonia concentrations in the secondary effluent can be 1 mg/L or higher. A cause for the occasional ammonia spikes was not determined based on historical data and is attributed to limitations in dissolved oxygen control. Results from full-scale stress testing (MWH/BC et al., 2015a) showed that the activated sludge at the NCWRP is susceptible to lower nitrification rates at low dissolved oxygen concentrations.

Historical tertiary filter performance with respect to turbidity measurements is illustrated on Figure 8-7. Table 8-1 presents a summary of historical filter loading rates and filtration yields by year.

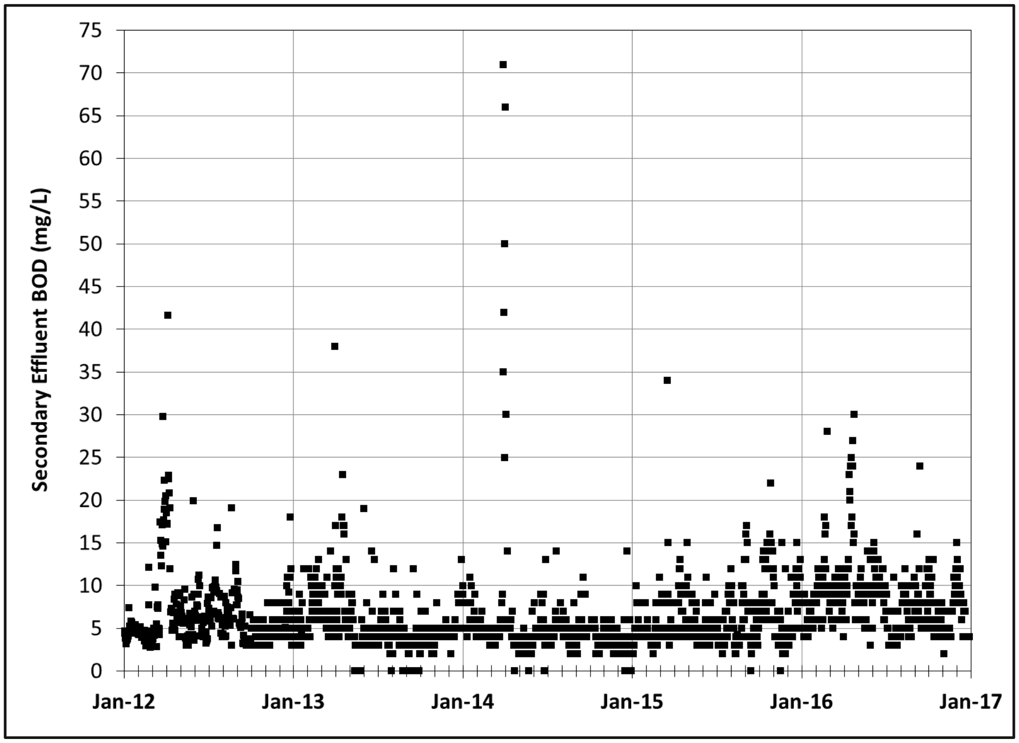


Figure 8-1: Historical Secondary Effluent Biochemical Oxygen Demand Concentration

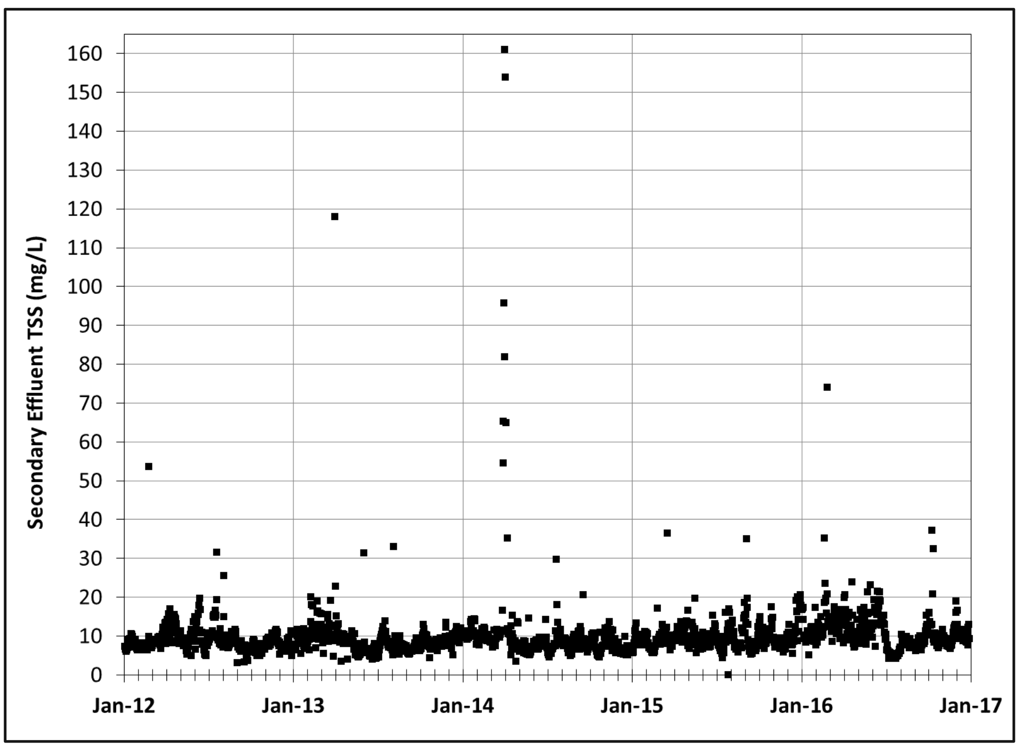


Figure 8-2: Historical Secondary Effluent Total Suspended Solids Concentration

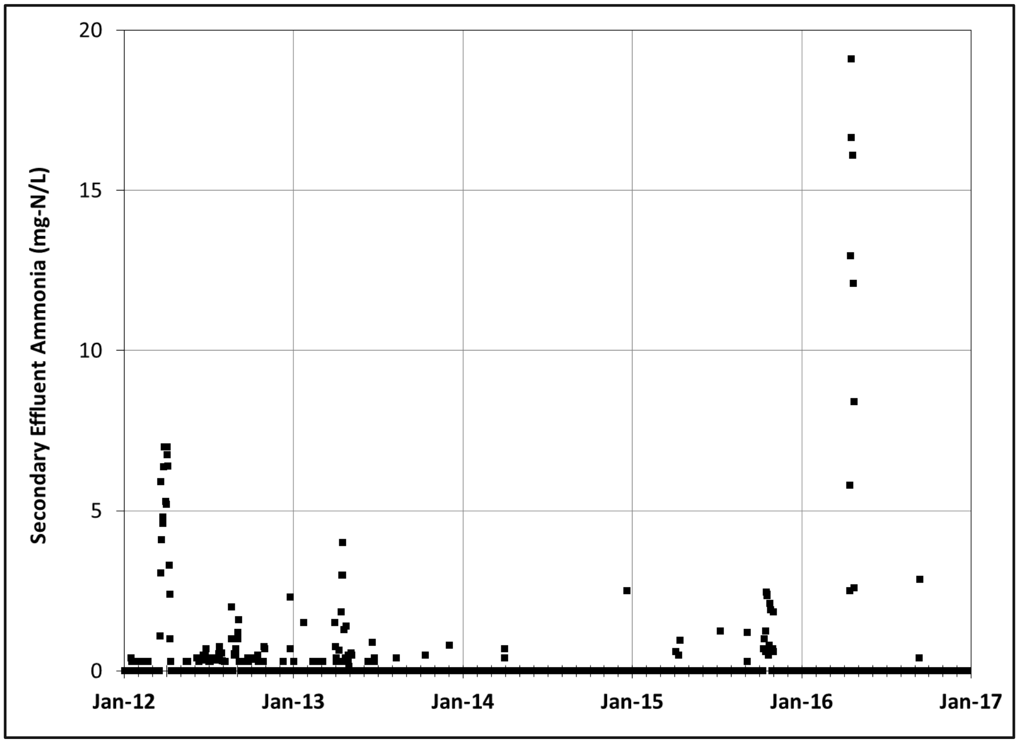


Figure 8-3: Historical Secondary Effluent Ammonia Concentration

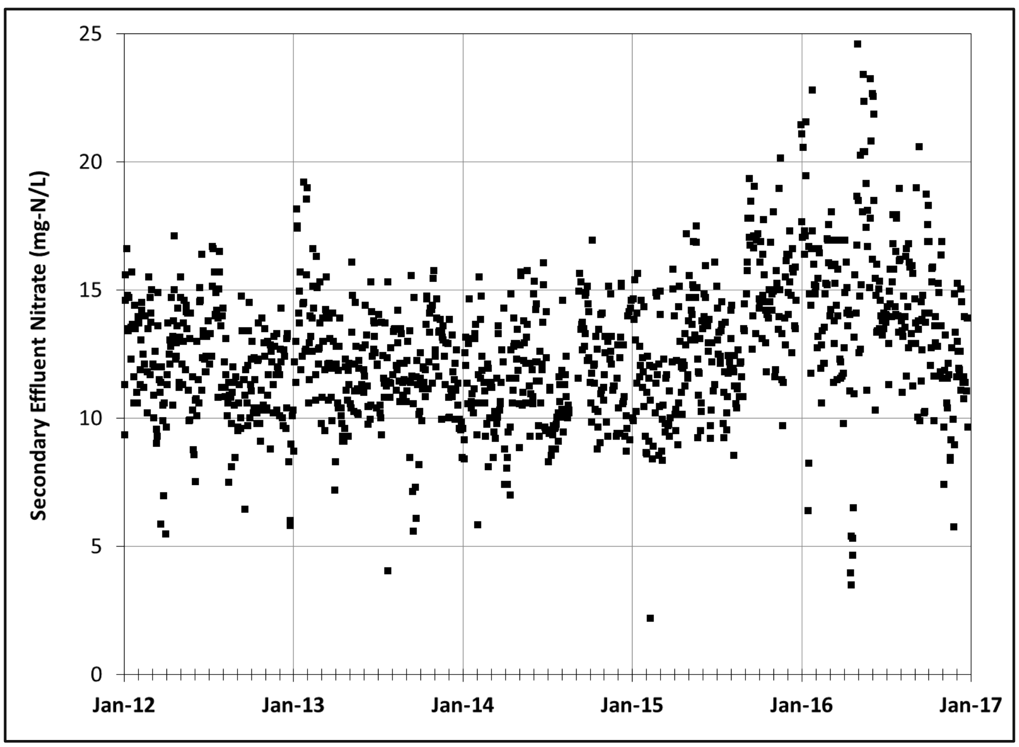


Figure 8-4: Historical Secondary Effluent Nitrate Concentration

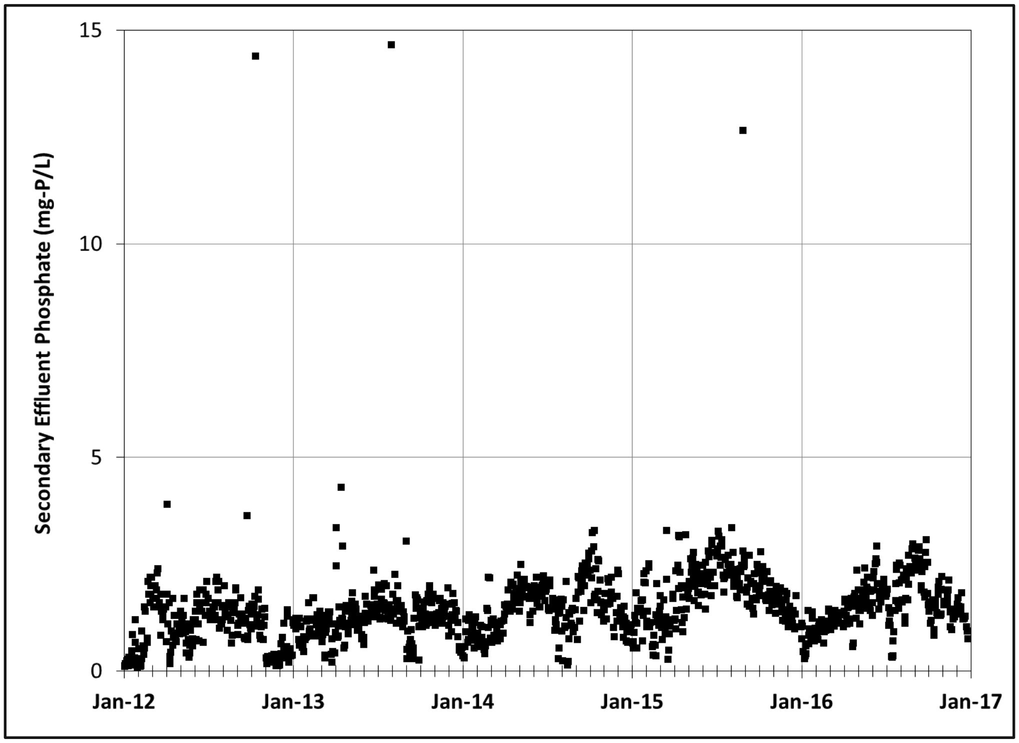


Figure 8-5: Historical Secondary Effluent Phosphate Concentration

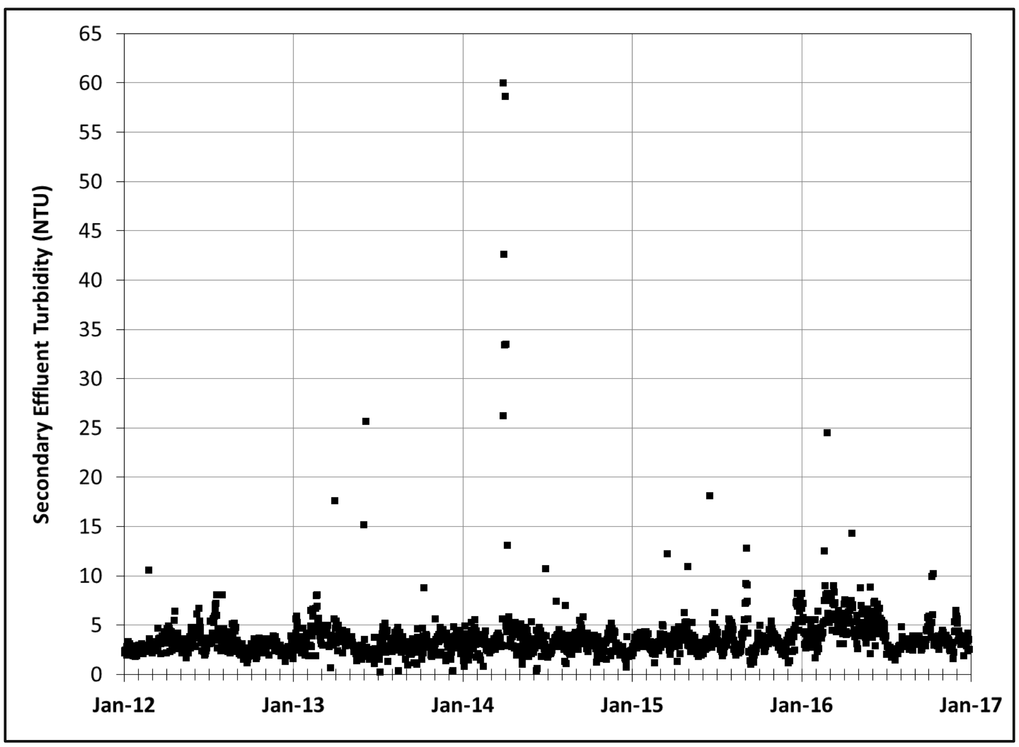


Figure 8-6: Historical Secondary Effluent Turbidity

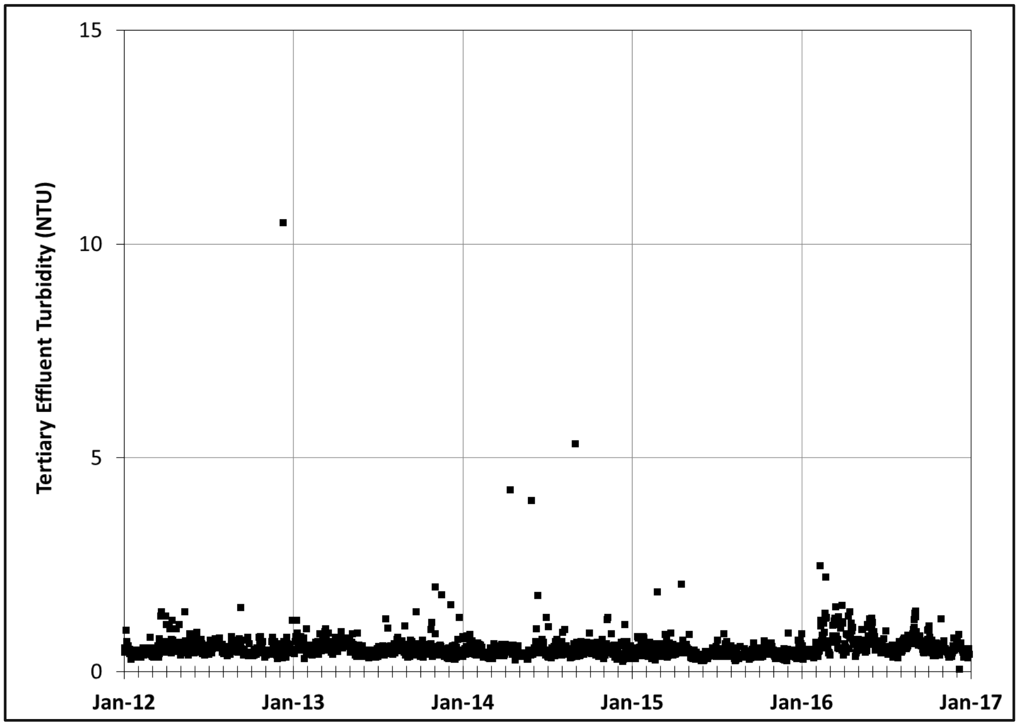


Figure 8-7: Historical Tertiary Treated Water Turbidity

Table 8-1: Historical Filtration Rate and Yield

Year	Filtration Rate (gpm/sf)	Filtration Yield
2012	2.00	0.96
2013	1.96	0.96
2014	2.06	0.96
2015	2.72	0.95
2016	2.19	0.95
Average (2012-2016)	2.19	0.96

8.1.1 Historic Non-Potable Reuse Water Quality

Table 8-2 presents a summary of the historical NPR water quality produced by the existing NCWRP. Historical CT and chlorine residual values are presented in Table 8-2, and illustrated on Figure 8-8, and Figure 8-9.

Table 8-2: Historic Non-Potable Reuse Water Quality

Parameter	Units	Minimum (2012-16)	Maximum (2012-16)	Average By Calendar Year				
				2012	2013	2014	2015	2016
Alkalinity, total	mg/L as $CaCO_3$	68.0	167.5	89.3	95.1	98.8	91.5	87.7
Aluminum	µg/L	0.0	348	75.7	45.4	4.3	10.7	1.3
Barium	µg/L	8.7	40.7	15.7	18.4	21.3	23.3	23.7
Boron	µg/L	228	571	330	314	307	322	302
Bromide	mg/L	0.00	0.34	0.03	0.00	0.00	0.00	0.00
Calcium	mg/L	47.4	74.6	55.0	61.7	65.8	64.2	65.4
Chloride	mg/L	203	272	245	238	239	233	238
Chlorine CT	mg-min/L	545	11681	2796	2708	2252	2198	2109
Chlorine Residual	mg/L	0.77	18.61	5.30	5.61	5.21	4.78	4.52
Conductivity	µmhos/cm	1150	1720	1401	1425	1461	1492	1464
Fluoride	mg/L	0.390	0.832	0.648	0.615	0.559	0.482	0.484
Hardness, total	mg/L as $CaCO_3$	228	322	NA	NA	279	272	282
Iron	µg/L	0	415	97.0	66.3	54.5	63.2	120.3
Magnesium	mg/L	22.5	33.0	26.3	27.3	27.8	27.1	27.8
Manganese	µg/L	23.2	134	81.1	77.6	62.0	74.9	63.5
Nitrate-N	mg/L as M	6.8	17.3	12.0	12.3	11.9	12.2	12.4
N, total	mg/L	8.2	25.2	13.7	14.0	13.7	13.2	16.4
Orthophosphate	mg/L as P	0.29	2.09	0.83	0.90	1.09	1.27	1.10
pH	pH	6.19	8.61	6.88	6.96	6.97	6.97	7.02
Potassium	mg/L	13.6	20.0	16.7	16.4	16.4	16.6	17.1
Sodium	mg/L	148	225	166	167	176	181	186
Sulfate	mg/L	106	233	144	176	192	201	204
TDS	mg/L	560	1145	805	828	865	864	877
Total coliform	MPN/100 milliliter	<1.8	540	1.0	1.0	1.0	1.1	4.4[a]
Turbidity	NTU	0.06	10.5	0.57	0.56	0.54	0.46	0.65

[a] Total coliform violations in 2016 are thought to be due to septic debris or other discharges from local breweries entering the NCWRP following a plant shutdown. The plant shutdown occurred due to maintenance in the 84-inch diameter influent pipe that conveys flow to the NCWRP. As a result of this shutdown, the plant experienced unreliable nitrification (high ammonia concentrations) and increased the design SRT to ten days to ensure a more robust biological process after the expansion.

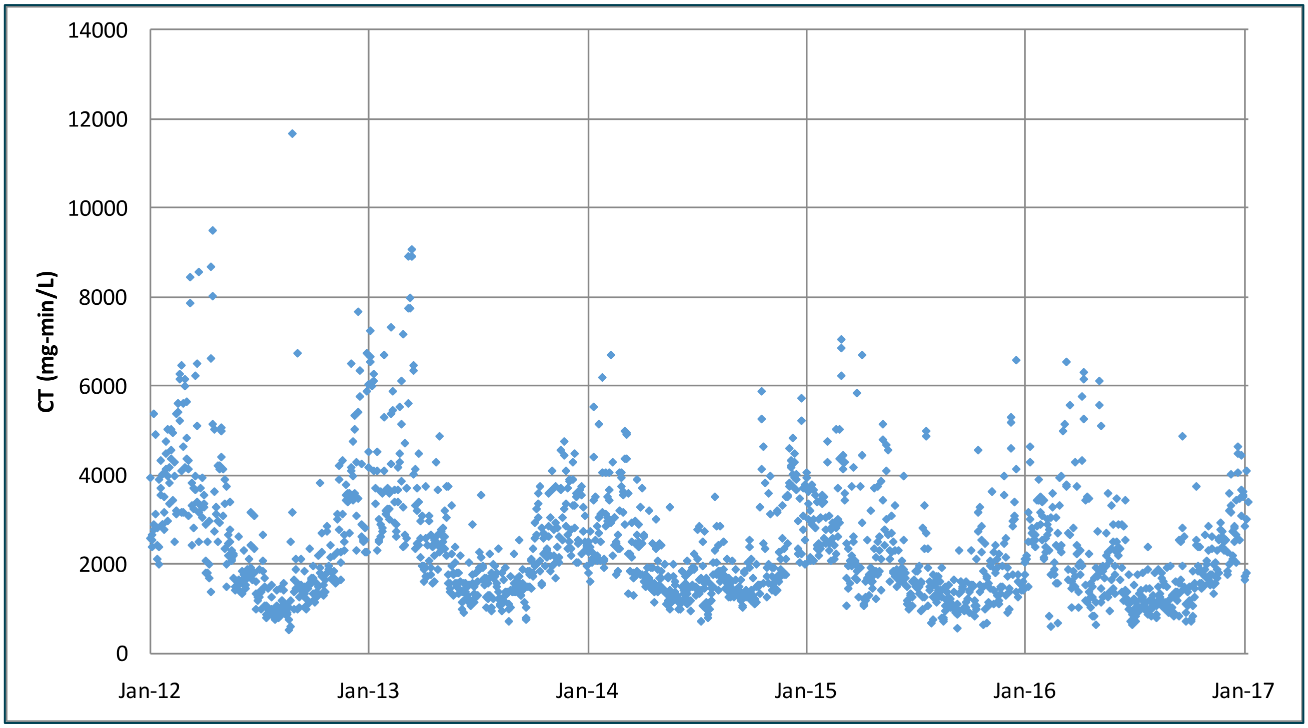


Figure 8-8: Historical Chlorine CT

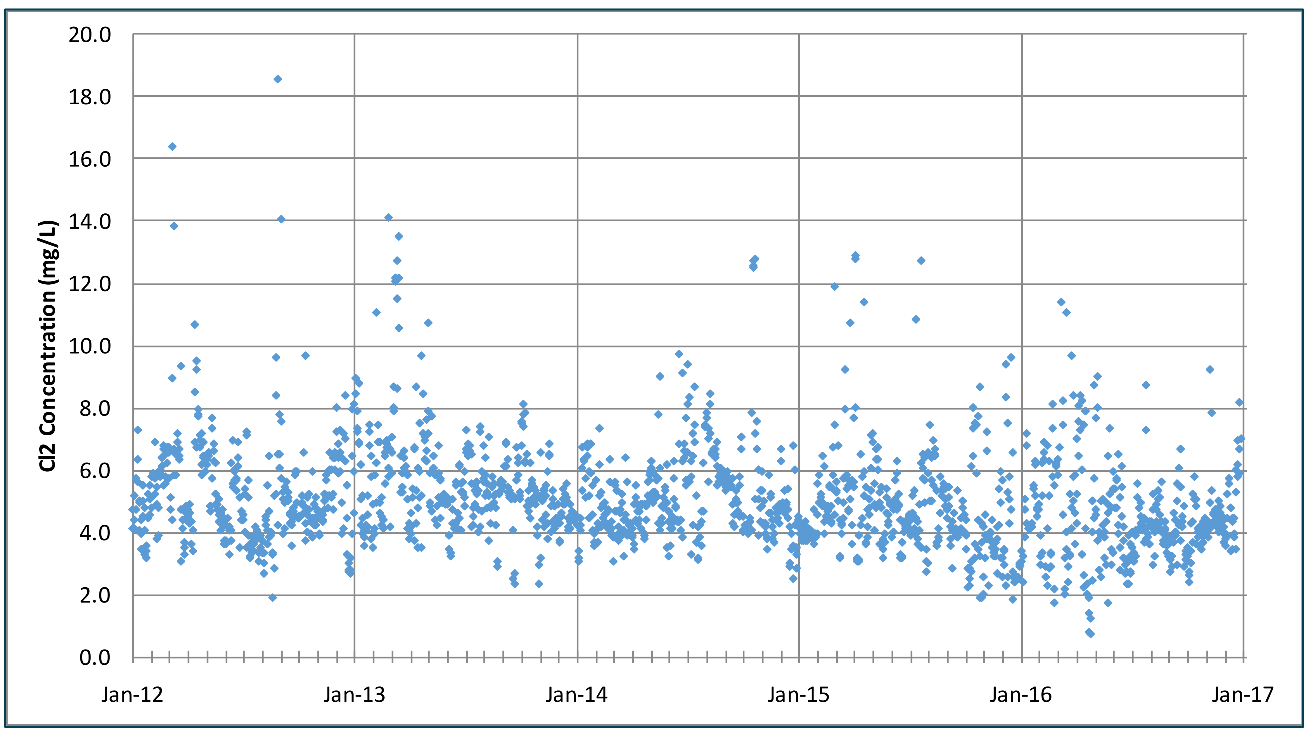


Figure 8-9: Historical Chlorine Residual

8.2 North City Water Reclamation Plant Projected Water Quality

8.2.1 Projected Tertiary Treated Water Quality

As part of the pre-design efforts for the NCWRP expansion, a water quality development study was conducted June 2015 (Trussell, 2016a). The 2015 investigation included raw wastewater sampling of key inorganic constituents and nutrient modeling of expected NCWRP tertiary effluent water quality. The collection of predicted feed water quality concentrations resulting from the 2015 investigation is presented in Table 8-3 and represents the estimate of the future NCPWF feed water.

The sampling efforts were conducted on the four new wastewater sources that will be contributed by the Morena Pump Station (North Mission Valley Interceptor, Morena Boulevard Trunk Sewer, Morena Boulevard Interceptor and East Mission Bay Trunk Sewer). High priority was placed on mineral concentrations in the new wastewater sources due to concerns about seawater intrusion in these collection systems and the consequences on RO design and performance. An inspection of available tertiary filtered effluent concentrations against the original sewer sources (Penasquitos Pump Station and Pump Station 64) was carried out as the first step of the assessment. A number of constituents (barium, aluminum, iron, and manganese) showed discrepancy suggesting partial removal across the NCWRP. For these constituents, corresponding removal rates were estimated using the difference between original sewage sources and tertiary filtered effluent concentrations. This approach was only possible for barium and aluminum, as Penasquitos Pump Station and Pump Station 64 sewage data were not available at the time for iron and manganese.

With respect to barium and aluminum, the tertiary filtered effluent and corresponding sewage sources were used to estimate a removal rate across the NCWRP. The estimated removal rates were 98.6 percent and 74.2 percent for aluminum and barium, respectively. The same estimated removal rates were applied to the four new raw sewage influents to calculate a projected flow-weighted tertiary effluent concentration for both barium and aluminum. The applied removal rates were compared to individual barium and aluminum datasets containing actual removal rates.

For iron and manganese, it was necessary to refer to a literature source for a typical removal rate of these constituents across a wastewater treatment plant (Petrasek and Kugelman, 1983). The literature source investigated a pilot-plant with similar characteristics to those from the NCWRP. An average removal rate of 77 percent and 39 percent was reported for iron and manganese, respectively. Using these average removal rates and available tertiary effluent data, a projected concentration for the Penasquitos Pump Station and Pump Station 64 was back-calculated. The same removal rate was applied to the four new sewer sources to project tertiary filtered effluent concentrations.

The new wastewater sources were not sampled for their contributions to CECs and disinfection byproducts; however, these additional sewer collection systems have a similar residential and industrial makeup to the existing sources and are not expected to significantly change the existing water quality with respect to these constituents. Detection of CECs and disinfection byproducts is generally based on drinking water laboratory methods that are sensitive to low concentrations of these constituents; their detection is difficult due to the nature of the raw wastewater matrix. Raw wastewater has been monitored for targeted constituents discussed in Section 5.3.2.2.c. CECs and disinfection byproducts are typically monitored in the purified water and, if found at significant concentrations, trigger investigations into the potential source(s). CECs and disinfection byproducts will be monitored at the NCWRP tertiary effluent and the NCPWF.

BioWin wastewater modeling software was used to project tertiary filtered effluent concentrations for those parameters affected by biological processes (ammonia, nitrite, nitrate, pH, alkalinity, ortho-phosphate, total phosphorus, and total nitrogen). The modeling considered CEPT and a ten-day SRT, which reflects the

NCWRP expansion design. For parameters unaffected across the wastewater treatment processes, the projected tertiary filtered effluent concentrations were based on raw sewage data unless otherwise noted. Lastly, a water conservation factor was applied to all parameters.

The NCPWF feed water estimate was based on the following data sources:

- Water quality measurements made at the NCDPWF from September 2013 to mid-June 2014;
- Tertiary filtered effluent samples collected in November and December 2014;
- Data generated during the past City of San Diego North City Project, "Implementation of Advanced Water Purification Facility Extended Testing," special studies between February 2015 and May 2015;
- Tertiary filtered effluent data collected at the NCDPWF from August 2011 to May 2012;
- NCWRP current raw influent data (Penasquitos Pump Station and Pump Station 64) from January 2014 to June 2015;
- Water quality measurements from the expected four new sewer sources taken daily for two weeks in June 2015;
- BioWin wastewater treatment process modeling for nitrogen species, phosphorus species, pH and alkalinity; assuming CEPT and a ten-day SRT;
- Literature source (Petrasek and Kugelman, 1983) on iron and manganese removal across a typical wastewater treatment plant;
- BAC influent (ozonated) samples collected between August 2014 and September 2015, for turbidity;
- NCDPWF operating data collected from June 2011 to May 2015, for temperature;
- Tertiary filtered effluent samples collected between 2014 and 2016, for NDMA, total trihalomethanes (TTHM), and total haloacetic acids; and
- Tertiary filtered effluent samples collected between 2013 and 2016, for bromide.

Table 8-3: Projected Tertiary Treated Water Quality

Parameter	Units	Average	Data Sources[a]	Comments
Alkalinity, total	mg/L as $CaCO_3$	173	7	BioWin modeling
Aluminum	µg/L	11	2, 4, 5, 6	Estimated removal across NCWRP using data from tertiary (1,2,4) and current sewage sources (5). Applied same removal to (6) to project feed water
Barium	µg/L	31	1, 2, 4, 5, 6	Refer to Aluminum
Boron	mg/L	0.401	1, 6	Not affected by WWTP. Considered tertiary filtered effluent instead of original sewer sources because it increased projected concentrations (conservatism)
Bromide	mg/L	0.334	5, 6, 12	Not affected by WWTP. Considered tertiary filtered effluent data instead of raw wastewater data due to similarity between concentrations and strength of dataset
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Parameter	Units	Average	Data Sources[a]	Comments
Calcium	mg/L	100	1, 6	Refer to Boron
Chloride	mg/L	313	5, 6	Not affected by WWTP
Conductivity	µmhos/cm	1958	1, 6	Refer to Boron
Fluoride	mg/L	1.3	1, 6	Refer to Boron
HAA5	µg/L	< 2	11	Tertiary filtered effluent data only
Hardness, total	mg/L as $CaCO_3$	145	7	BioWin modeling
Iron	mg/L	0.52	2, 4, 6, 8	Back calculated current sewer sources using NCWRP data from tertiary (2, 4) and cited removal rate from (8). Applied cited removal to (6) and calculated original sewer source to project feed water
Magnesium	mg/L	45	1, 6	Refer to Boron
Manganese	mg/L	0.08	2, 4, 6, 8	Refer to Iron
NDMA	ng/L	3.75	11	Tertiary filtered effluent data only
Ammonia-N	mg/L as N	0.15	7	BioWin modeling
N, total	mg/L	10.4	7	BioWin modeling
Nitrite-N	mg/L as N	0.02	7	BioWin modeling
Nitrate-N	mg/L as N	7.7	7	BioWin modeling
Orthophosphate	mg/L as P	0.78	7	BioWin modeling
pH	pH	7.2	7	BioWin modeling
Phosphorus, total	mg/L	0.78	7	BioWin modeling
Potassium	mg/L	24	1, 6	Refer to Boron
Silica	mg/L	9.3	1, 6	Refer to Boron
Sodium	mg/L	215	1, 6	Refer to Boron
Strontium	mg/L	1.07	1, 6	Refer to Boron
Sulfate	mg/L	256	1, 6	Refer to Boron
Temperature	°C	25.0	10	From daily readings of on-line meter on microfiltration/UF feed
TDS	mg/L	1169	5, 6	Not affected by Wastewater Treatment Plant
TOC	mg/L	7.24	2	Tertiary filtered effluent data only
TTHM	µg/L	2.7	11	Tertiary filtered effluent data only
Tertiary Effluent Turbidity at the NCWRP	NTU	0.2	9	From 5-minute interval readings of an on-line turbidimeter
1,4-dioxane	µg/L	< 1	2	Tertiary filtered effluent data only

[a] Refer to the data source descriptions immediately preceding the table.

8.2.2 Projected Non-Potable Reuse Water Quality

The NPR water quality is projected to be similar to the tertiary treated water quality presented in Table 8-3 with the added benefit of disinfection via chlorination. In addition, TTHM and haloacetic acids formation is assumed to be similar to the quality described in the table, because the plant will operate in a similar manner in the future (ten-day SRT, complete nitrification) and there will be little to no ammonia present in the chlorine, which will reduce disinfection byproduct formation. Because sodium hypochlorite is added as the disinfectant, the concentrations of sodium, chloride, and conductivity will be increased above the concentrations in the tertiary treated water; salinity management will be provided by blending tertiary disinfected effluent with purified water. NPR water will have a lower concentration of TDS (conductivity, sodium, chloride, and other dissolved minerals) than the tertiary treated water in order to comply with the salinity requirements in the RWQCB permit.

Levels of total coliform bacteria will conform to the requirements of CCR Title 22 Section 60301.230 for disinfected tertiary recycled water for use in the NPR water system. Table 8-4 presents a summary of the anticipated water quality of NPR water that will be produced by the expanded NCWRP.

Table 8-4: Projected NPR Water Quality

Parameter	Units	Average	Comments
Alkalinity, total	mg/L as $CaCO_3$	173	Same as tertiary treated water. See Table 8-3.
Aluminum	µg/L	11	Same as tertiary treated water. See Table 8-3.
Barium	µg/L	31	Same as tertiary treated water. See Table 8-3.
Boron	mg/L	0.401	Same as tertiary treated water. See Table 8-3.
Bromide	mg/L	0.334	Same as tertiary treated water. See Table 8-3.
Calcium	mg/L	100	Same as tertiary treated water. See Table 8-3
Chloride	mg/L	238	Depends on volume of purified water blended with NPR water for salinity management. 2016 average shown. See Table 8-2.
Conductivity	µmhos/cm	1464	Depends on volume of purified water blended with NPR water for salinity management. 2016 average shown. See Table 8-2.
Fluoride	mg/L	1.3	Same as tertiary treated water. See Table 8-3.
Hardness, total	mg/L as $CaCO_3$	145	Same as tertiary treated water. See Table 8-3.
Iron	mg/L	0.52	Same as tertiary treated water. See Table 8-3.
Magnesium	mg/L	45	Same as tertiary treated water. See Table 8-3.
Manganese	mg/L	0.08	Same as tertiary treated water. See Table 8-3.
N, total	mg/L	10.4	Same as tertiary treated water. See Table 8-3.
Nitrate-N	mg/L as N	7.7	Same as tertiary treated water. See Table 8-3.
Orthophosphate	mg/L as P	0.78	Same as tertiary treated water. See Table 8-3.
pH	pH	7.2	Same as tertiary treated water. See Table 8-3.
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Parameter	Units	Average	Comments
Potassium	mg/L	24	Same as tertiary treated water. See Table 8-3.
Sodium	mg/L	186	Depends on volume of purified water blended with NPR water for salinity management. 2016 average shown. See Table 8-2.
Sulfate	mg/L	256	Same as tertiary treated water. See Table 8-3.
TDS	mg/L	877	Depends on volume of purified water blended with NPR water for salinity management. 2016 average shown. See Table 8-2.
Total coliform	MPN/100 milliliter	<2	2012-16 average shown. See Table 8.2.
Turbidity	NTU	0.2	Same as tertiary treated water. See Table 8-3.

9. Purified Water Quality

This section provides discussions on anticipated purified water quality and compliance with DDW and the RWQCB requirements.

9.1 Anticipated Purified Water Quality

The concentrations of key water quality parameters were assessed during the NCPWF 30% Design in a Technical Memorandum entitled, “Concentration of Key Water Quality Parameters in the NCPWF (MR) Process Streams” (hereinafter referred to in this section as the “Water Quality Technical Memorandum”) (Trussell, 2016a). The Water Quality Technical Memorandum was integrated into the 30% NCPWF Engineering Design Report (MWH/BC et al., 2016). Water quality of the NCPWF feed (tertiary treated water from the expanded NCWRP) and individual process streams were predicted using supporting data from the NCDPWF, modeling, and applicable assumptions. The feed water quality includes predicted changes from the existing NCWRP conditions and serves as the basis of design for the NCPWF. The NCPWF purified water quality accounts for expected changes by applying estimated feed water quality (detailed discussion provided in Section 8).

The inorganics that were sampled from the new wastewater sources during a June 2015 sampling event (MWH/BC et al., 2015b) study were assumed to remain constant through the majority of processes at the NCPWF until RO, and were used to model RO performance with manufacturer-specific computer software. Various age and temperature conditions were considered in this modeling. Other constituents, including the Bio-Win modeled species (which take into account the expected NCWRP conditions of CEPT and a ten-day SRT), were estimated through the NCPWF by applying observed removal efficiencies from the NCDPWF at each process or estimating removals based on literature and other pilot studies. Chemical additions that were not present at the NCDPWF, are included in the 30% NCPWF Engineering Design Report (MWH/BC et al., 2016). For more details on how select water quality parameters were predicted through the NCPWF, please refer to the Water Quality and Treatability Study Technical Memo included as Appendix D.

Broadly, the projected water qualities were based on the following:

- Water quality data from the demonstration testing conducted at the NCDPWF;
- Historical data from the NCWRP;
- NCWRP feed water quality changes based on water quality data from the four new wastewater sources (Trussell Technologies, 2016a) (detailed discussion provided in Section 5.2.2);
- NCPWF feed water quality based on BioWin wastewater treatment plant modeling to predict impact of new sewer sources (detailed discussion is provided in Section 8.2);
- Computer modeling of the RO system; and
- Various literature sources and other relevant studies such as disinfection-by-product formation based on UV and hypochlorous bench-scale testing (LABOS, 2014) and finished water turbidity based on product stabilization bench-scale testing (LADWP, 2011).

Based on five years of NCDPWF piloting, source water investigations, literature sources, and modeling, the City has a high degree of confidence that full-scale water quality will be as presented in Table 9-1, and well within all drinking water MCL and notification levels. Table 9-1 is the resulting engineering estimate of water quality after considering all of the supporting sources. The basis for the assumptions, modeling, and supporting data used to generate Table 9-1 are provided in Section 6.3 and the Water Quality Technical Memorandum (Trussell, 2016a).

The remainder of this subsection details anticipated feed water quality changes and City-sponsored research initiatives at the NCDPWF, which informed the expected purified water quality at the full-scale NCPWF.

Table 9-1: Concentration of Key Parameters in Purified Water

Parameter	Units	UV/AOP Effluent		Finished Water[a]		
		Range	Median	Post-Conditioning	Post-Chlorination	Post-Dechlorination
pH[b]	-	4.1 – 5.0	4.3	7.5 - 8.5	7.5 - 8.5	7.5 - 8.5
Alkalinity[c]	mg/L as $CaCO_3$	2 – 15	8	>100	>100	>100
Turbidity[d]	NTU	0.01 - 0.08	0.03	5	< 5	< 5
Calcium[b]	mg/L as $CaCO_3$	4 – 4.4	4.2	92 - 146	92 - 146	92 - 146
Sodium[b]	mg/L	7 – 22	11	11	12 - 13	13 - 14
TOC[e]	mg/L	0.02 – 0.07	0.03	0.03	0.03	0.03
TDS[f]	mg/L	14 – 69	36	50 - 195	50 - 195	50 - 195
LSI[g]	-	-5.5 – -3.5	-4.7	0 – 0.5	0 – 0.5	0 – 0.5
Free Chlorine[h]	mg/L as Cl_2	1.0	1.0	1.0	1.5 – 4.0	ND (0.03)
Chloramines[h]	mg/L as Cl_2	0.7 – 1.5	1.0	1.0	1.0	ND (0.03)
Total Chlorine[h]	mg/L as Cl_2	1.7 – 2.5	2.0	2.0	2.5 – 5.0 [n]	ND (0.03)[n]
Bromide[i]	mg/L	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Bromate[j]	µg/L	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)
HAA5[k]	µg/L	1.5 - 5.3	3.3	3.3	3.3	3.3
TTHM[k]	µg/L	2 – 5	3.8	3.8	3.8	3.8
NDMA[l]	ng/L	2 – 12	ND (2)	ND (2)	ND (2)	ND (2)
1,4-dioxane[m]	µg/L	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)
Nitrate[c]	mg/L as N	0.52 – 1.12	0.75	0.75	0.75	0.75
Ammonia	mg/L as N	0.27 – 0.62	0.31	0.31	0.31	ND (0.03)
Total Nitrogen[c]	mg/L	0.8 – 1.7	1.1	1.1	1.1	0.8
Total Phosphorus[c]	mg/L	0.01	0.01	0.01	0.01	0.01

Note: Method reporting limit shown in parenthesis next to ND.

[a] Values shown for Finished Water represent expected median water quality. In cases where there is a design range of chemical addition to the finished water (e.g., the impact of lime on calcium concentrations), a range is shown instead of a single median value.

[b] Ranges and medians provided for pH, calcium, and sodium were set by feed water values at the NCDPWF from September 2013 to June 2014 and daily samples of new sewer sources for two weeks in June 2015. Calculations were made through each treatment process to estimate water quality changes on these ranges and medians. RO modeling in high and low rejection scenarios and three element manufacturers was conducted to estimate RO permeate water quality and corrections were made for sodium hypochlorite (pH, sodium), carbon dioxide (pH), lime (pH, calcium), and sodium bisulfite addition (sodium).

[c] Ranges and medians provided for alkalinity, nitrate, ammonia, total N, and total P were set by BioWin wastewater treatment plant modeling predictions of feed water quality. Subsequent ranges result from calculations after each treatment process, including RO modeling projections (all parameters), UV/AOP destruction (nitrate), chemical addition (alkalinity), and breakpoint reactions (ammonia, total N) to estimate UV/AOP effluent and finished water values.

[d] The turbidity range and median in UV/AOP effluent is set by MF filtrate turbidity, which was taken from 500 samples in 2014 and 2015. Lime addition will contribute to an increase in turbidity which was estimated using bench-scale test results from similar facilities. Settling and dissolution will result in a subsequent decrease in turbidity upon conveyance to Miramar Reservoir. Turbidity is not of regulatory concern upon discharge to Miramar Reservoir.

[e] Ranges and medians provided for TOC were set by RO permeate measurements taken at the NCDPWF from October 2014 to November 2015. TOC concentrations are not expected to change after RO.

[f] The ranges and median provided for TDS were set by the NCWRP raw influent data from January to June 2015 and daily samples of new sewer sources for two weeks in June 2015. RO modeling was used to estimate TDS range in RO permeate and lime addition calculations were used to estimate the finished water TDS concentration range.

[g] Ranges and medians provided for LSI represent calculations using Standard Method 2330 B with a modification for errors at high pH (Kenny et al., 2015).

[h] Ranges provided for chlorine species represent calculations made along each step of the treatment process, including expected NaOCl design doses (UV/AOP oxidant addition and chlorination for pipeline residual) and reactions in the UV/AOP and finished water (UV photolysis, chloramine oxidation, and chlorine quenching).

[i] Bromide concentrations in the UV/AOP effluent are set by RO permeate data, which included five of five NDs from November to December of 2015 and is further supported to be reduced to ND levels in the literature (von Gunten, 2003). Bromide levels are not expected to change after RO.

[j] Bromate concentrations in the UV/AOP effluent are set by RO permeate data, which included 11 of 11 NDs from November 2014 to September 2015, and is further supported to be reduced to ND levels in the literature (von Gunten, 2003). Bromate levels are not expected to change after RO.

[k] UV/AOP effluent ranges and medians of HAA5 and TTHM resulted from data at the NCDPWF throughout 2014 to 2015 from 19 and 20 samples, respectively. HAA5 and TTHM levels are not expected to change after UV/AOP (negligible disinfection-by-product formation potential during chlorination to maintain pipeline residual).

[l] The UV/AOP effluent range and medians of NDMA are from 20 NCDPWF samples taken from 2014 to 2015. The range and median value of NDMA concentrations are not expected to change in the finished water.

[m] The UV/AOP effluent range and median of 1,4-dioxane was taken from six of six NDs in November and December of 2014 at the NCDPWF. The range and median value of 1,4-dioxane concentrations are not expected to change in the finished water.

[n] Total chlorine residual (present as free chlorine) is expected to be around 2.5 mg/L as chlorine (Cl_2) just prior to the dechlorination facility after complete chloramine breakpoint and chlorine decay through the NCPW Pipeline to Miramar Reservoir.

9.1.1 Research Initiatives

These following four research initiatives provide valuable information on anticipated characteristics of the purified water after advanced treatment:

- Advanced Water Purification Facility Study involved the design, installation, operation (2009 – 2013), and testing (2011 – 2013) of the initial NCDPWF;
  - This NCDPWF consisted of MF/ultrafiltration, RO, and UV/AOP (City, 2013c) – hereinafter referred to in this section as the "2013 NCDPWF Study."
- Advanced Water Purification Facility Extended Testing (2013 – 2015) involved the design and installation of Ozone/BAC filters as pretreatment to the NCDPWF, and testing of the NCDPWF with and without Ozone/BAC pretreatment (Trussell et al., 2015) – hereinafter referred to in this section as the "Extended Testing;"
- WateReuse Research Foundation (WRRF, 2017 in publication) Demonstrating Redundancy and Monitoring to Achieve Reliable Potable Reuse Study (2015 – 2016) involved the implementation of new failsafe measures at the NCDPWF, such as enhanced monitoring and testing of UV/AOP with free chlorine as the oxidant and additional pathogen barrier to test potable reuse without an environmental buffer – hereinafter referred to in this section as the "WRRF 14-12 Study;" and
- Design Pilot Optimization (2016 – 2017) involves additional studies at the NCDPWF to test potential solutions to key design challenges and provide the correct process water for the pre-selection of MF equipment, pre-qualification of RO elements, and pre-selection of UV equipment to assure lower operating costs and optimized functioning of the future NCPWF – hereinafter referred to in this section as the "Design Pilot Studies."

Data collected as part of the four NCDPWF research initiatives listed above represent five years of variable operating conditions. Some operating conditions have an effect on the measured final water quality. The four operating conditions during each of the four NCDPWF research initiatives are presented in Table 9-2. The differences in operating conditions, which may impact the final effluent water quality, and the implications for translating these NCDPWF studies to the full-scale water quality projections include:

- Ozone/BAC operations were implemented at the NCDPWF in July 2014;
  - The first three years of data were from a process train without Ozone/BAC.
  - The majority of the data collected after July 2014 included Ozone/BAC in the process train.
  - The biggest difference in final product water was approximately 40 percent lower TOC when ozone and BAC were included in the process train.
- The RO elements deteriorated over the test period, as expected, but accelerated deterioration was observed after occasional free chlorine exposure;
  - The RO elements were installed in June 2011 and replaced in May 2016. Average conductivity and nitrate rejection in the first year of operation was 98.6 percent and 96.4 percent, respectively.
  - Average conductivity and nitrate rejection during the last year of operation was 95.0 percent and 81.4 percent, respectively.
  - At the NCPWF, each RO train must maintain minimum conductivity and nitrate rejections of 90 percent.
  - Because the four research initiatives collected data throughout the lifecycle of the RO membranes, it is reflective of the expected range of removal at the future NCPWF.
  - RO modeling was used to supplement the NCDPWF data in water quality predictions.
- Typically, the RO was operated with a 75 percent recovery, with several periods of 85 percent recovery; and
  - Sulfuric acid was not added for RO pre-treatment at the NCDPWF until the summer of 2016.
  - The RO at the NCPWF is designed to operate at 85 percent recovery, with sulfuric acid pre-treatment.
  - Increasing RO recovery to 85 percent with sulfuric acid addition has shown to decrease rejection of dissolved salts by about 10 percent.
  - Testing for the optimization of sulfuric acid and antiscalant dosing is currently in progress at the NCDPWF.
  - Preliminary results show that the changes in TDS from the existing NCDPWF conditions should not be as large as the initial 10 percent decrease that was observed because that encompassed an extreme pH drop of one unit that was not representative of future NCPWF conditions.
  - The full-scale conditions will likely result in minor discrepancies in TDS rejection from historical NCDPWF data.
  - RO modeling was used to supplement the NCDPWF data in water quality predictions.
- Up until June 2016, the oxidant used for the AOP was hydrogen peroxide. After June 2016, the oxidant was changed to sodium hypochlorite.

- The oxidant for the NCPWF will be sodium hypochlorite.
- The UV and hypochlorous testing done for the 30% NCPWF design (City, 2016e), and Terminal Island UV and hypochlorous bench-scale testing (LABOS, 2014), were used to supplement the NCDPWF data.

Table 9-2: Operating Conditions Explored during Piloting at the NCDPWF

Pilot Studies at the NCDPWF	Testing Period	Treatment Train Tested
2013 NCPWF Study	Jun 2011 – Dec 2012	MF-RO-UV/H_2O_2
Interim Operations	Dec 2012 – Apr 2013	MF-RO-UV/H_2O_2
Extended Testing	April 2013 – Jun 2014 July 2014 – Jan 2015	MF-RO-UV/H_2O_2 Ozone-BAC-MF-RO-UV/H_2O_2
Interim Operations	Feb 2015-Mar 2015	MF-RO-UV/H_2O_2
WRRF14-12 Study	Apr 2015 – Mar 2016	Ozone-BAC-MF-RO-UV/H_2O_2
Design Pilot Studies	Apr 2016 – Jul 2017	Ozone-BAC-MF-RO-UV/HOCl

These past and current studies provide the basis for the necessary treatment to satisfy applicable regulations to ensure protection of public health and the environment. Some discrepancies exist between the operating conditions present in the NCDPWF studies and the design conditions for the full-scale NCPWF. There are also unknowns as to how the addition of new wastewater sources will impact treatment efficacies; however in aggregate, the data from the four research initiatives are representative of the range of probable water quality to be produced by the NCPWF.

Purified water quality statistics after advanced treatment were computed for each of the above-mentioned efforts used to project purified water quality for the full-scale facility. For each constituent discussed, the following is provided in the form of tables: number of samples, median, and regulatory targets, where applicable. When computing the median for datasets containing measurements below the method reporting limit, the ND values were assigned the method reporting limit. Also, statistics that are equal to the method reporting limit are reported as less than their respective method reporting limit. For unique cases where there were multiple method reporting limits (either as a result of matrix effects or different analysis methods for a given analyte), the various method reporting limits are used for statistical computations, but the method reporting limit with the highest value is reported, thus providing a conservative approach.

Overall, the results show treated water is of high quality and concentrations of target constituents are below levels of concern. Purified water quality data are summarized in this subsection for the following groups of constituents:

- Section 9.1.1.1: Constituents with pMCLs
- Section 9.1.1.2: Constituents with sMCLs
- Section 9.1.1.3: Constituents with Notification Levels
- Section 9.1.1.4: Priority Pollutants
- Section 9.1.1.5: Basin Plan Objectives
- Section 9.1.1.6: Other Relevant Constituents

Please note that the following parameters appear in multiple categories:

- Aluminum: pMCL and sMCL

- Boron: Basin Plan and Notification Level
- Chloride: sMCL and Basin Plan
- Color: sMCL and Basin Plan
- Copper: pMCL, sMCL, and Notification Level
- Fluoride: pMCL and Basin Plan
- Disinfection byproducts haloacetic acids: pMCL and UCMR
- Iron: sMCL and Basin Plan
- Manganese: sMCL, Basin Plan, Notification Level, and UCMR4
- Foaming Agents/Methylene blue active substances: sMCL and Basin Plan
- Methyl-tert-butyl ether: pMCL and sMCL
- Quinoline: UCMR4 and CEC
- Sulfate: sMCL and Basin Plan
- Thiobencarb: pMCL and sMCL
- TDS: sMCL and Basin Plan

9.1.1.1 Constituents with Primary Maximum Contaminant Levels

The 2013 NCDPWF Study completed the most comprehensive monitoring of the Title 22 regulated constituents, with measurements for the entire suite of constituents with pMCLs. The 2013 NCDPWF Study showed that purified water consistently met all established pMCLs. All of the studies and their overarching conclusions based on measured concentrations are presented in summary in Table 9-3. Statistics of the results are presented in

Table 9-4, Table 9-5, Table 9-6, Table 9-7, and Table 9-8.

Table 9-3: Summary of Findings from Current and Past Efforts for Constituents with pMCL

Data Source	pMCL Inorganics	pMCL Organics	pMCL Disinfection Byproducts	pMCL Radionuclides	Action Level
2013 NCDPWF Study	All pMCLs monitored. All measurements below regulated values – statistics provided in Table 9-4 and Table 9-5 for detected constituents.				
Extended Testing	Select pMCLs monitored. All measurements below regulated values – statistics provided in Table 9-6 for detected constituents.		All pMCLs monitored. All measurements below regulated values – statistics provided in Table 9-6 for detected constituents.		Not monitored
WRRF 14-12 Study	Select pMCLs monitored. All measurements below regulated values – statistics provided in Table 9-7 for detected constituents.		All pMCLs monitored. All measurements below regulated values – statistics provided in Table 9-7 for detected constituents.		Not monitored
Design Pilot Studies	Select pMCLs monitored. All measurements below regulated values – statistics provided in Table 9-8 for detected constituents.		All pMCLs monitored. All measurements below regulated values – statistics provided in Table 9-8 for detected constituents.		Not monitored

Table 9-4: Statistics for Constituents with pMCLs for 2013 NCDPWF Study

Analyte	Units	pMCL	N	Range	Median
All inorganics with pMCLs were not detected except the following:					
Hexavalent chromium	mg/L	0.010	4	0.00004 - 0.00016	0.000087
Nitrate	mg/L as N	10	96	0.47 – 1.40	0.67
All organics with pMCLs were not detected.					
All disinfection byproducts with pMCLs were not detected except the following:					
TTHM	mg/L	0.08	12	<0.0006 – <0.002	<0.0006
Uranium was not detected, but all other radionuclides with pMCLs were detected and are summarized in Table 9-5.					
Lead and copper were not detected.					

Table 9-5: Statistics for Radionuclides with pMCLs for 2013 NCDPWF Study

Analyte	Units	pMCL	Quarter 1: 08/24/2011	Quarter 2: 11/08/2011	Quarter 3: 2/1/2012	Quarter 4: 5/1/2012
Radium-226	pCi/L	5 (combined)	0.118+/-0.172 (MDA=0.439)	0.000+/-0.21 (MDA=0.439)	0.048+/-0.282 (MDA=0.439)	0.22+/-0.259 (MDA=0.354)
Radium-228	pCi/L		0.207+/-0.707 (MDA=0.277)	0.000+/-0.484 (MDA=0.204)	0.00+/-0.418 (MDA=0.203)	0.2+/-0.495 (MDA=0.2)
Gross Alpha Particle Activity	pCi/L	15	0.94+/-0.404 (MDA=0.601)	-2.0+/-0.582 (MDA=0.886)	-0.30+/-0.47 (MDA=0.801)	0.16+/-0.529 (MDA=0.927)
Beta/photon Emitters	pCi/L	50	-0.59+/-0.578 (MDA=0.968)	-1.4+/-0.575 (MDA=0.922)	0.28+/-0.532 (MDA=0.902)	0.62+/-0.531 (MDA=0.884)
Strontium-90	pCi/L	8	0.00+/-0.411 (MDA=0.675)	0.152+/-0.215 (MDA=0.675)	0.062+/-0.287 (MDA=0.636)	0.636+/-0.546 (MDA=0.636)
Tritium	pCi/L	20000	0.00+/-242 (MDA=423)	0.00+/-421 (MDA=714)	0+/-267 (MDA=437)	25.7+/-305 (MDA=505)

Table 9-6: Statistics for the Select Constituents Monitored with pMCLs for Extended Testing

Analyte	Units	pMCL	N	Range	Median
Only select Inorganics were monitored, of which aluminum, barium, fluoride, hexavalent chromium, and perchlorate were not detected and the following were detected:					
Fluoride	mg/L	2	11	<0.02 – 0.025	<0.02
Nitrate	mg/L as N	10	20	1.28 – 2.17	1.6
Nitrate + Nitrite	mg/L as N	10	9	1.3 – 2.0	1.6
Nitrite	mg/L as N	1	20	<0.05 – 0.077	<0.05
Only three organics were monitored, of which atrazine, 2,4-D, and simazine were not detected.					
Radionuclides were not monitored.					
Only select disinfection byproducts were monitored, of which HAA5 and Bromate were not detected, and TTMH was detected:					

TTHM	mg/L	0.08	9	0.0005 – 0.0024	0.00068
Lead and copper were not monitored.					

Table 9-7: Statistics for Constituents with pMCLs for WRRF 14-12 Study Project

Analyte	Units	pMCL	N	Range	Median
Only select Inorganics were monitored, of which aluminum, fluoride, and perchlorate were not detected and the following were detected:					
Fluoride	mg/L	2.0	11	<0.02 - 0.0477	0.0218
Nitrate	mg/L as N	10	12	1.17 - 4.98	2.51
Nitrite	mg/L as N	1	12	<0.0049 - 0.106	<0.0049
Perchlorate	mg/L	0.006	8	0.00028 - 0.001	0.000515
Only three organics were monitored, of which atrazine, 2,4-D, and simazine were not detected					
Radionuclides were not monitored.					
Only select disinfection byproducts were monitored, of which HAA5 was not detected, and the following were detected:					
TTHM	mg/L	0.08	15	0.0013 – 0.0031	0.0024
Bromate[a]	mg/L	0.01	11	0.001 – 0.0033	0.0016
Lead and copper were not monitored.					

[a] Bromate was elevated due to age of RO membrane and operation at a constant ozone dose to achieve a minimum of 2-log (or greater) at all times. The Project anticipates NDs, as discussed in the 30% NCPWF Engineering Design Report (MWH/BC et al., 2016), which is when ozone is operated with proper controls and targeting 1-log inactivation of *Cryptosporidium.*

Table 9-8: Statistics for Constituents with pMCLs for Design Pilot Studies

Analyte	Units	pMCL	N	Range	Median
Only select Inorganics were monitored, of which nitrite, and perchlorate were not detected and the following were detected:					
Aluminum	mg/L	1	6	<0.00085 – 0.011	<0.00085
Fluoride	mg/L	2.0	6	<0.02 – 0.0665	0.035
Nitrate	mg/L as N	10	6	0.402 – 5.99	0.6155
Only atrazine, 2,4-D, and simazine were monitored and were not detected					
Radionuclides were not monitored.					
Only select disinfection byproducts were monitored, of which HAA5 and Bromate were not detected, and the following were detected:					
TTHM	mg/L	0.08	5	0.0011 – 0.0018	0.0012
Lead and copper were not monitored.					

9.1.1.2 Constituents with Secondary Maximum Contaminant Levels

The 2013 NCDPWF Study completed the most comprehensive study of the Title 22 Engineering Report sMCL constituents, with measurements for the entire suite of constituents with sMCLs. The 2013 NCDPWF Study showed that purified water consistently met all established sMCLs. Statistics for constituents with sMCLs from all data sources are presented in Table 9-9.

Table 9-9: Statistics for Chemicals with sMCLs

Chemicals with sMCLs	Units	sMCL or Upper Limit	2013 NCDPWF Study Median (Range)	Extended Testing Median (Range)	WRRF 14-12 Study Median (Range)	Design Pilot Studies Median (Range)
MCLs						
Aluminum	mg/L	0.2	<0.005	<0.02	<0.00085	<0.00085 (<0.00085 - 0.0111)
Color	Units	15	<3	---	---	---
Copper	mg/L	1	<0.0005	---	---	---
Foaming Agents - MBAS	mg/L	0.5	<0.05	---	---	---
Iron[a]	mg/L	0.3	<0.01	<0.05	<0.05 (<0.05 - 0.052)	<0.05
Manganese[a]	mg/L	0.05	<0.0002 (<0.0002 - 0.00037)	<0.00004 (<0.00004 - 0.00022)	0.000169 (<0.00004 - 0.00096)	<0.00004 (<0.00004 - 0.000068)
MTBE	mg/L	0.005	<0.002	---	---	---
Odor Threshold	Units	3	<1	---	---	---
Silver	mg/L	0.1	<0.0002	---	---	---
Thiobencarb	mg/L	0.001	<0.0001	---	---	---
Turbidity	NTU	5	<0.1	---	---	---
Zinc	mg/L	5	<0.005	---	---	---
Upper Limits						
TDS	mg/L	1000	14.5 (11 - 16)	<28 (<28 - 33)	34 (<28 - 54)	<28 (<28 - 94)
Specific Conductance	µS/cm	1600	21 (16 - 26)	83.2 (63.45 - 94)	93.95 (64.7 - 157)	47.15 (28.3 - 157.5)
Chloride	mg/L	500	2.8 (2.5 – 3.9)	8.56 (6.7 - 10.5)	13.35 (7.16 - 25.6)	6.045 (3.86 - 21.3)
Sulfate	mg/L	500	<0.5	<0.5 (<0.5 - 1.2)	0.642 (<0.5 - 1.12)	<0.5 (<0.5 - 1.5)

[a] Iron and Manganese reported values are near the detection limit and are likely suspect and outliers.

9.1.1.3 Constituents with Notification Levels

The 2013 NCDPWF Study completed the most comprehensive study of constituents with Notification Levels, with measurements for the entire suite of such constituents. The 2013 NCDPWF Study showed that purified water was consistently below all the Notification Levels. Statistics for constituents with Notification Levels are presented from all data sources in Table 9-10.

Table 9-10: Statistics for Chemicals with Notification Levels

Chemicals with Notification Levels	Units	Notification Levels	2013 NCDPWF Study Median (Range)	Extended Testing Median (Range)	WRRF 14-12 Study Median (Range)	Design Pilot Studies Median (Range)
Boron	mg/L	1	0.225 (0.2 - 0.29)	0.259 (0.225 - 0.277)	0.275 (0.241 - 0.31)	0.203 (0.168 - 0.259)
Carbon disulfide	mg/L	0.16	<0.0005	---	---	---
Chlorate	mg/L	0.8	<0.01	<0.02 (<0.02 - 0.0289)	0.175 (0.17 - 0.18)	0.095 (0.068 - 0.17)
Copper	mg/L	1.3	<0.0005	---	---	---
Diazinon	mg/L	0.0012	<0.0001	---	---	---
Freon 12	mg/L	1	<0.0005	---	---	---
Ethylene glycol	mg/L	14	<1	---	---	---
Formaldehyde	mg/L	0.1	0.0061 (0.002 - 0.0089)	0.013 (0.0082 - 0.031)	---	---
HMX	mg/L	0.35	<0.01	---	---	---
Isopropylbenzene	mg/L	0.77	<0.0005	---	---	---
Manganese[a]	µg/L[b]	500	<0.2 (<0.2 - 0.37)	<0.04 (<0.04 - 0.22)	0.17 (<0.04 - 0.96)	<0.04 (<0.04 - 0.068)
MIBK	mg/L	0.12	<0.005	---	---	---
NDPA	ng/L	10	<2	---	---	---
NDEA	ng/L	10	<2 (<2 – 4.9)	---	---	---
NDMA	ng/L	10	<2 (<2 - 5.5)	<2	<2 (<2 - 6)	<2
Naphthalene	mg/L	0.017	<0.0005	---	---	---
Propachlor	mg/L	0.09	<0.00005	---	---	---
RDX	mg/L	0.0003	<0.002	---	---	---
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Chemicals with Notification Levels	Units	Notification Levels	2013 NCDPWF Study Median (Range)	Extended Testing Median (Range)	WRRF 14-12 Study Median (Range)	Design Pilot Studies Median (Range)
TBA	mg/L	0.012	<0.002	---	---	---
Vanadium	mg/L	0.05	<0.0005	---	---	---
n-Butylbenzene	mg/L	0.26	<0.0005	---	---	---
n-Propylbenzene	mg/L	0.26	<0.0005	---	---	---
sec-Butylbenzene	mg/L	0.26	<0.0005	---	---	---
tert-Butylbenzene	mg/L	0.26	<0.0005	---	---	---
1,2,3-TCP	mg/L	0.000005	<0.000005	---	---	---
1,2,4-Trimethylbenzene	mg/L	0.33	<0.0005	---	---	---
1,3,5-Trimethylbenzene	mg/L	0.33	<0.0005	---	---	---
1,4-Dioxane	mg/L	0.001	<0.0005	<0.001	<0.001	<0.001
TNT	mg/L	0.001	<0.002	---	---	---
2-Chlorotoluene	mg/L	0.14	<0.0005	---	---	---
4-Chlorotoluene	mg/L	0.14	<0.0005	---	---	---

[a] Iron and Manganese values are near the detection limit and are likely suspect and outliers.
[b] Note that units are µg/L compared to mg/L when reported as a sMCL.

9.1.1.4 Priority Pollutants

Most of the priority pollutants were monitored during the 2013 NCDPWF Study, and some of the priority pollutants were monitored in later studies. Most UV/AOP product water samples from the 2013 NCDPWF Study had priority pollutant concentrations less than their reporting and detection limits. Based on quarterly and routine monitoring, three constituents were detected at levels above the CTR criterion. Bromodichloromethane exceeded the CTR criterion of 0.56 µg/L three times with values of 0.78, 0.71, and 0.85 µg/L. Dibromochloromethane exceeded the CTR criterion of 0.401 µg/L one time with a value of 0.6 µg/L. N-Nitrosodimethylamine exceeded the CTR criterion of 0.00069 µg/L one time with a value of 0.0055 µg/L. It was also observed that the di-n-butyl phthalate and chloroform results were below the reporting limits of 1 µg/L and 0.5 µg/L, respectively, for all testing periods, with the exception of the first quarterly monitoring period with results of 2.2. µg/L and 1.4 µg/L, respectively.

9.1.1.5 Basin Plan Objectives

Statistics for constituents with Basin Plan objectives are presented from all data sources in Table 9-11. Minerals with Basin Plan objectives consistently met the requirements in the purified water produced at the NCDPWF. Constituents with pMCLs and sMCLs are discussed in Sections 9.1.1.1 and 9.1.1.2 and the purified water has been shown to comply with all established pMCLs.

Additionally, using data from piloting efforts and data from the 30% NCPWF Engineering Design Report (MWH/BC et al., 2016), the percent sodium is significantly lower than the required 60 percent limit. At the point of discharge to Miramar Reservoir, the percent sodium is expected to be 20 percent.

The constituents assigned to ensure that biostimulation effects do not adversely impact beneficial uses are numeric concentration objectives for total phosphorus and provisions that natural ratios of N:P are to be identified and upheld. The total phosphorus concentrations were typically below detectable levels, thus consistently measuring below the anticipated compliance value of 0.05 mg/L as phosphorus. Using a “limited nutrient” approach, the City will be able to control biostimulation by maintaining Miramar Reservoir phosphorus concentrations at near-zero levels. Through this management approach, the City will be able to ensure that Miramar Reservoir N:P ratios are sustained at high levels (two orders of magnitude or more).

It is anticipated that the RWQCB will establish a long-term average purified water effluent nitrogen concentration standard for Miramar Reservoir that is on the order of 2 mg/L as total nitrogen. The median of measured levels during piloting was less than 2 mg/L during the 2013 NCDPWF Study and Extended Testing. During Extended Testing, the RO membranes were inadvertently oxidized when problems occurred with the ammonia feed pump, resulting in free chlorine exposure. Chlorine exposure can significantly damage RO membranes, which impacts salt rejection and, in particular, nitrate rejection. The membranes were replaced in July 2016 after completing the WRRF 14-12 Study and special precautions are being taken with the full-scale design to protect RO membranes. During the recent Design Pilot Studies, the total nitrogen concentrations have been on average 0.6 mg/L. Additionally, as noted, the full-scale system will include a control strategy to protect the RO membranes from exposure to free chlorine. Most importantly, the treatment train is designed to maintain a total nitrogen concentration of 0.8 mg/L after dechlorination. The 0.8 mg/L value was based on expected water qualities after expansion of the NCWRP using the BioWin model (Trussell, 2016a).

Table 9-11: Statistics for Basin Plan Objective

Basin Plan Objective Chemicals	Units	Basin Plan Objective	2013 NCDPWF Study Median (Range)	Extended Testing Median (Range)	WRRF 14-12 Study Median (Range)	Design Pilot Studies Median (Range)
TDS	mg/L	500	13 (<10 - 19)	<28 (<28 - 30)	34 (<28 - 54)	<28 (<28 - 94)
Chloride	mg/L	250	2.9 (2.6 - 4.3)	8.68 (<1 - 10.5)	13.35 (7.16 - 25.6)	6.045 (3.86 - 21.3)
Sulfate	mg/L	250	<0.5 (<0.1 - 1.1)	0.528 (<0.5 - 1.2)	0.752 (<0.5 - 1.12)	<0.5 (<0.5 - 1.5)
Iron[a]	mg/L	0.3	<1.1 (<0.01 - <10)	<0.01 (<0.00201 - <0.02)	<0.05 (<0.05 - 0.052)	<0.05
Manganese[a]	µg/L[b]	50	<2.6 (<2.6 - <5)	<0.04 (<0.04 - 0.22)	0.17 (<0.04 - 0.96)	<0.04 (<0.04 - 0.068)
Foaming Agents – MBAS	mg/L	0.5	<0.019	---	---	
Boron	mg/L	0.75	0.220 (0.180 - 0.290)	0.259 (0.225 - 0.277)	0.275 (0.241 - 0.31)	0.2025 (0.168 - 0.259)
Odor	TON	0	<1	---	---	
Turbidity	NTU	20	<0.024	---	---	
Color	Color Units	20	<3	---	---	
Fluoride	mg/L	1	<0.1	0.02 (<0.02 – 0.025)	0.0218 (<0.02 - 0.0477)	0.035 (<0.02 - 0.0665)
Phosphorus	mg/L as P	0.05	<0.010 (<0.010 – 0.94)	<0.02 (<0.02 - <0.078)	<0.078	0.0252 (<0.0125 - 0.0516)
Nitrogen	mg/L as N	2	0.865 (0.53 - 2.2)	1.9 (1.6 - 2.4)	3.16 (1.42 -5.15)	0.57 (0.46 - 0.784)

[a] Iron and Manganese reported values are near the detection limit and are likely suspect and outliers.

[b] Note that units are µg/L compared to mg/L when reported as a sMCL.

9.1.1.6 Other Relevant Constituents

This section provides a discussion of observed concentrations of microbial constituents, UCMR constituents, and a suite of CECs, such as pharmaceuticals, and personal care products.

9.1.1.6.a Microbial

Microbial monitoring conducted in the purified water showed measured microbial parameters (total coliform, fecal coliform, male specific and somatic coliphage) were either not-detected or absent in samples collected during the 2013 NCDPWF Study. During the Extended Testing, microbial analysis was only completed up through MF. All measured microbial parameters (total coliform, fecal coliform, male specific and somatic coliphage) in the MF filtrate were below the detection limit. Measures of microbes were not completed during the WRRF 14-12 Study. There is a special pathogen study planned in mid-2017 at the NCWRP as part of the Design Pilot Studies to develop treatment train removal profiles. These results are discussed in Section 10.

9.1.1.6.b UCMR

The EPA proposed the fourth UCMR (UCMR4) list in December 2015, with a proposed sampling time frame between March 2018 and November 2020. Due to its recent release, the data sources available do not provide a full list of UCMR4 constituents. The 2013 NCDPWF Study was completed when the third UCMR list (UCMR3) was still in place. Results from this testing period showed that 27 of the 30 compounds included in the UCMR3 were consistently below quantifiably detectable levels in the purified water. Three constituents, bromochloromethane, hexavalent chromium, and strontium, were quantifiably detected in the purified water. The limited data available for chemicals on the UCMR4 list is presented from all data sources in Table 9-12 for the UV/AOP effluent.

Table 9-12: Statistics for Chemicals related to UCMR4

Chemicals Related to UCMR4	Units	2013 NCDPWF Study Median (Range)	Extended Testing Median (Range)	WRRF 14-12 Study Median (Range)	Design Pilot Studies Median (Range)
No Cyanotoxins were monitored.					
Metals - Germanium not monitored, but Manganese was monitored					
Manganese[a]	µg/L[b]	<2.6	<0.04 (<0.04 - 0.22)	0.17 (<0.04 - 0.96)	<0.04 (<0.04 - 0.068)
No Pesticides or Pesticide Manufacturing Byproduct were monitored.					
Brominated Haloacetic Acid - HAA6Br and HAA9 not monitored, but HAA5 was monitored					
HAA5	mg/L	<0.001	<0.002	<0.002	<0.002
No Alcohols were monitored.					
Semivolatile Chemicals - butylated hydroxyanisole and o-toluidine not monitored, but quinoline was monitored					
Quinoline	mg/L	<0.000005	<0.000005	<0.000005	---
Indicators - Temperature were not monitored, but TOC, bromide, and pH were monitored					
TOC	mg/L	<0.3 (<0.3 - 1.4)	<0.3 (<0.3 - 0.382)	<0.3 (<0.3 - 1.44)	0.107 (0.059 - 0.733)
Bromide	mg/L	---	<0.1	---	---
pH	pH Units	5.86 (5.75 - 5.99)	7.5 (6.88 - 7.7)	6.09 (5.84 - 7.22)	5.835 (5.66 - 7.15)

[a] Iron and Manganese values are near the detection limit and are likely suspect and outliers.
[b] Note that units are µg/L compared to mg/L when reported as a sMCL.

9.1.1.6.c Constituents of Emerging Concern

CECs were measured during all four testing periods. A summary of the statistics for the detected CECs are presented from all data sources in Table 9-13. Of the 92 CECs monitored during the 2013 NCDPWF Study, three CECs were detected at quantifiable concentrations in the purified water. Of the 139 CECs monitored during Extended Testing, 20 CECs were detected at quantifiable concentrations in the purified water. Of the 121 CECs monitored during the WRRF 14-12 Study, two CECs were detected at quantifiable concentrations in the purified water (Table 9-13). No CECs are being quantified as a part of the Design Pilot Studies.

Table 9-13: Statistics for CECs

Constituents of Emerging Concern	Units	2013 NCDPWF Study Median (Range)	Extended Testing Median (Range)	WRRF 14-12 Study Median (Range)
1,7-Dimethylxanthine	ng/L	<5	<10	<10
17 alpha-ethynylestradiol	ng/L	---	---	<0.0009
17-beta-Estradiol	ng/L	---	---	<0.0004
4-androstene-3,17-dione	ng/L	---	---	<0.0003
4-nonylphenol - semi quantitative	ng/L	<100	<100	<100
4-tert-Octylphenol	ng/L	<50	<50 (<50 - 62)	<50
Acesulfame-Potassium	ng/L	<20 (<20 - 50)	<20	<20
Acetaldehyde	µg/L	---	<1 (<1 - 1.7)	---
Acetaminophen	ng/L	<5	<5	<5
Acetate-Glycolate	µg/L	---	<5	---
Albuterol	ng/L	<5	<5	<5
Amoxicillin (semi-quantitative)	ng/L	<20	<20	<20
Andorostenedione	ng/L	<5	<5	<5
Assimilable Organic Carbon	µg/L	---	<10 (<10 - 600)	---
Atenolol	ng/L	<5	<5	<5
Azithromycin	ng/L	---	<20	<20
Bisphenol A	ng/L	<10	<10	<10
Bendroflumethiazide	ng/L	<5	<5	<5
Bezafibrate	ng/L	<5	<5	<5
Bromacil	ng/L	<5	<5	<5
Bromochloroacetic acid	µg/L	---	<1	<1
Bromodichloromethane	µg/L	<0.5 (<0.5 - 0.85)	<0.5 (<0.5 - 0.85)	0.84 (<0.5 - 1.1)
Bromoform	µg/L	<0.5	<0.5	<0.5 (<0.5 - 1.7)
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Constituents of Emerging Concern	Units	2013 NCDPWF Study Median (Range)	Extended Testing Median (Range)	WRRF 14-12 Study Median (Range)
Butalbital	ng/L	<5	<5	<5
Butylparaben	ng/L	<5	<5	<5
Caffeine	ng/L	<5	<5	<5
Carbadox	ng/L	<5	<5	<5
Carbamazepine	ng/L	<5	<5	<5
Carisoprodol	ng/L	<5	<5	<5
Chloramphenicol	ng/L	<10	<10	<10
Chloridazon	ng/L	<5	<5	<5
Chloroform	µg/L	<0.5 (<0.5 - 1.1)	1.5 (1.3 - 1.7)	1.5 (0.83 - 2.1)
Chlorotoluron	ng/L	<5	<5	<5
Cimetidine	ng/L	<5	<5	<5
Clofibric Acid	ng/L	<5	<5	<5
Cotinine	ng/L	<10	<10	<10
Cyanazine	ng/L	<5	<5	<5
Diaminochlorotriazine	ng/L	<5	<5	<5
Deethylatrazine	ng/L	<5	<5	<5
DEET	ng/L	<10	<10	<10
Deisopropylatrazine	ng/L	<5	<5	<5
Dehydronifedipine	ng/L	<5	<5	<5
Diazepam	ng/L	<5	<5	<5
Dibromoacetic acid	µg/L	<1	<1	<1
Dibromochloromethane	µg/L	<0.2 (<0.2 - 0.6)	<0.5	<0.5 (<0.5 - 1.2)
Dichloroacetic acid	µg/L	<1	<1	<1
Diclofenac	ng/L	<5	<5 (<5 - 1600)	<5
Dilantin	ng/L	<20	<20	<20
Diltiazem	ng/L	---	<5	<5
Diuron	ng/L	<5	<5	<5
Equilin	ng/L	---	---	<0.004
Erythromycin	ng/L	<10	<10	<10
Estradiol	ng/L	<5	<5	<5
Estriol	ng/L	---	---	<0.8

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Constituents of Emerging Concern	Units	2013 NCDPWF Study Median (Range)	Extended Testing Median (Range)	WRRF 14-12 Study Median (Range)
Estrone	ng/L	<5	<5	<2
Ethinyl Estradiol - 17 alpha	ng/L	<5	<5	<5
Ethylparaben	ng/L	<20	<20	<20
Flumeqine	ng/L	<10	<10	<10
Fluoxetine	ng/L	<10	<10	<10
Formate-Isobutyrate	µg/L	---	<5 (<5 - 17)	---
Gemfibrozil	ng/L	<5	<5	<5
Glyoxal	µg/L	---	<10	---
Hydrazine	ng/L	<5	---	---
Ibuprofen	ng/L	<15	<10	<10
Iohexal	ng/L	<10 (<10 - 19)	<10	<100
Iopromide	ng/L	<5	<5 (<5 - 11)	<5
Isobutylparaben	ng/L	<5	<5	<5
Isoproturon	ng/L	<100	<100	<100
Ketoprofen	ng/L	<5	<5	<5
Ketorolac	ng/L	<5	<5	<5
Lidocaine	ng/L	<5	<5	<5
Lincomycin	ng/L	<10	<10	<10
Linuron	ng/L	<5	<5	<5
Lopressor	ng/L	<20	<20	<20
Meclofenamic Acid	ng/L	<5	<5	<5
Meprobamate	ng/L	<5	<5	<5
Metazachlor	ng/L	<5	<5	<5
Methyl glyoxal	µg/L	---	<10	---
Methylparaben	ng/L	<20	<20	<20
Metolachlor	ng/L	---	<5	<5
Monobromoacetic acid	µg/L	<1	<1	<1
Monochloroacetic acid	µg/L	<2	<2	<2
Naproxen	ng/L	<10	<10	<10
Nifedipine	ng/L	<20	<20	<20
Norethisterone	ng/L	<5	<5	<5
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Constituents of Emerging Concern	Units	2013 NCDPWF Study Median (Range)	Extended Testing Median (Range)	WRRF 14-12 Study Median (Range)
OUST (Sulfameturon,methyl)	ng/L	---	---	<5
Oxalate	µg/L	---	<5	---
Oxolinic acid	ng/L	<10	<10	<10
Pentoxifylline	ng/L	<5	<5	<5
Perfluorobutanesulfonic acid	µg/L	---	---	<0.003
Perfluorodecanoic acid	µg/L	---	---	<0.003
Perfluorododecanoic acid	µg/L	---	---	<0.003
Perfluoroheptanoic acid	µg/L	---	---	<0.003
Perfluorohexanesulfonic acid	µg/L	---	---	<0.003
Perfluorohexanoic acid	µg/L	---	---	<0.025
Perfluorononanoic acid	µg/L	---	---	<0.003
Perfluorooctanesulfonic acid	µg/L	---	---	<0.003
Perfluorooctanoic acid	µg/L	---	---	<0.025
Perfluorotetradecanoic acid	µg/L	---	---	<0.003
Perfluorotridecanoic acid	µg/L	---	---	<0.003
Perfluoroundecanoic acid	µg/L	---	---	<0.003
Phenazone	ng/L	<5	<5	<5
Primidone	ng/L	<5	<5	<5
Progesterone	ng/L	<5	<5	<5
Propazine	ng/L	<5	<5	<5
Propylparaben	ng/L	<5	<5 (<5 - 7)	<5
Pyruvate	µg/L	---	<5	---
Quinoline	ng/L	<5	<5	<5
Salicylic Acid	ng/L	---	---	<100
Simazine	ng/L	<5	<5 (<5 - 9.7)	<5
Sucralose	ng/L	<100	<100	<1000
Sulfachloropyridazine	ng/L	<5	<5	<5
Sulfadiazine	ng/L	<5	<5	<5
Sulfadimethoxine	ng/L	<5	<5	<5
Sulfamerazine	ng/L	<5	<5	<5
Sulfamethazine	ng/L	<5	<5	<5
Continues on next page...				

Constituents of Emerging Concern	Units	2013 NCDPWF Study Median (Range)	Extended Testing Median (Range)	WRRF 14-12 Study Median (Range)
Sulfamethizole	ng/L	<5	<5	<5
Sulfamethoxazole	ng/L	<5	<5 (<5 - 11)	<5
Sulfathiazole	ng/L	<5	<5	<5
TCEP	ng/L	<10	<10	<10
TCPP	ng/L	---	<100	<1000
TDCPP	ng/L	<100	<100	<100
Testosterone	ng/L	<5	<5	<0.1
Theobromine	ng/L	<10	<10	<10
Theophylline	ng/L	<10	<20	<20
Thiabendazole	ng/L	---	<5	<5
Trichloroacetic acid	µg/L	<1	<1	<1
Triclocarban	ng/L	---	<5	<5
Triclosan	ng/L	<10 (<10 - 19)	<10	<10
Trimethoprim	ng/L	<5	<5	<5
Warfarin	ng/L	<5	<5	<5

9.2 Compliance with Anticipated Title 22 Water Recycling Criteria

As discussed in Section 4, the purified water must be monitored to determine compliance with the established water quality standards contained in the Title 22 Water Recycling Criteria for the following groups of constituents:

- Constituents with pMCLs and Action Levels (60320.302(h) and 60320.312(a))
- Constituents with Notification Levels (60320.302(h))
- Constituents with sMCLs (60320.312(b))
- Priority Toxic Pollutants (60320.320(a))
- SWRCB-specified chemicals based on its review of the Title 22 Engineering Report, the augmented reservoir, and the results of the source control program (60320.320(a))
- RWQCB and SWRCB-specified indicator compounds (60320.320(d))

The NPDES permit for the Project will include requirements and water quality standards that implement Title 22 Water Recycling Criteria for purified water used for SWA.

9.2.1 Constituents with Primary Maximum Contaminant Levels and Action Levels

In accordance with Section 60320.302(h), the purified water will be subject to effluent concentration limits established for constituents with pMCLs and Action Levels. Based on the available water quality data presented in Section 9.1.1.1, the purified water will satisfy all corresponding pMCLs and Action Levels. All of the samples taken of the purified water for the analysis of constitutes with pMCLs and Action Levels were consistently below their regulated levels. Additionally, all but five constituents had median concentrations that measured below the method detection limit. A summary of statistics may be reviewed in Table 9-3 through Table 9-8. The majority of the constituents are mitigated by the NCWRP treatment processes. As presented in the Table 9-3 through Table 9-8, none of the constituents are above the pMCLs, and are well addressed by the multi-barrier treatment train. All of the constituents are effectively controlled by the RO process. Several volatile and semi-volatile organic constituents are also mitigated by the Ozone/BAC, RO, and UV/AOP processes.

9.2.2 Constituents with Secondary Maximum Contaminant Levels

In accordance with Section 60320.312(d), the purified water will be subject to effluent concentration limits established for constituents with sMCLs and upper limits. Based on the available water quality data presented in Section 9.1.1.2, the purified water will satisfy all corresponding sMCLs and upper limits. All of the samples taken of the purified water for the analysis of constituents with sMCL and upper limits were consistently below their regulated levels. Additionally, all but three constituents had median concentrations that measured below the method detection limit. A summary of statistics may be reviewed in Table 9-9. Several constituents, including bulk parameter such as color, odor, and turbidity are mitigated by Ozone/BAC. Iron and manganese are also removed by the BAC. Additional removal of all constituents is achieved by the RO membranes.

9.2.3 Constituents with Notification Levels

In accordance with Sections 60320.302(h) and 60320.320(b), the purified water will be subject to effluent concentration limits established for constituents with Notification Levels. Based on the available water quality data presented in Section 9.1.1.3, the purified water will satisfy the entire suite of constituents with Notification Levels. All of the samples taken of the purified water were consistently below the Notification Levels. Additionally, all but three constituents had median concentrations that measured below the method detection limit. A summary of statistics may be reviewed in Table 9-10. The majority of organic constituents will be mitigated by the Ozone/BAC processes. All inorganics and organic constituents are affectively controlled by the RO, with the exception of partial rejection of boron, NDMA, and 1,4-dioxane. Both NDMA and 1,4-dioxane are effectively removed upstream of the RO (by Ozone/BAC) and downstream (by the UV/AOP processes).

9.2.4 Priority Toxic Pollutants

In accordance with CCR Title 22, Division 4, Chapter 15, Article 4, 60320.320(a)(1), the purified water will be subject to effluent concentration limits established for priority toxic pollutants. Based on the available water quality data presented in Section 9.1.1.4, most of the samples of purified water had priority pollutant concentrations less than their reporting and detection limits. As indicated by the past and on-going testing, the priority toxic pollutants are well addressed by the multi-barrier treatment train approach, which provides several barriers of protection against organic and inorganic pollutants.

9.3 Compliance with Basin Plan Requirements

As discussed in Section 4, the release of the NCPWF product water into Miramar Reservoir will be regulated by the RWQCB through the issuance of an NPDES permit. The NPDES permit will include requirements and water quality standards that implement the Basin Plan policies and objectives, water quality standards established within the CTR, and applicable state and federal water quality plans and policies.

9.3.1 Basin Plan Objectives

9.3.1.1 Mineral Constituents

The NCPWF RO treatment will be highly effective in removing dissolved minerals. TDS concentrations in the NCPWF product water are projected to be less than 100 mg/L, significantly below the Basin Plan TDS objective of 500 mg/L. As presented in Table 9-11, the NCPWF product water concentrations of chloride, sulfate, sodium, iron, manganese, methylene blue-activated substances, boron, and fluoride are projected to be significantly below Basin Plan objectives established by the RWQCB for Miramar Reservoir. In addition to achieving compliance with Basin Plan water quality objectives for mineral constituents, the NCPWF product water will result in lower concentrations of dissolved minerals in Miramar Reservoir than historic reservoir conditions.

9.3.1.2 Drinking Water Standards

The Basin Plan applies pMCLs and sMCLs to waters stored in Miramar Reservoir. The NPDES effluent concentration limits will likely be established to implement pMCLs and sMCLs for any constituent the RWQCB deems as having a "reasonable potential" to be in the NCPWF product water. RO treatment at the NCPWF will be highly effective in removing toxic organic and inorganic compounds, and additional organics removal will be achieved through the UV/AOP process. As a result, the NCPWF purified water will comply with all established pMCLs and sMCLs, and thus will comply with the MCL-based NPDES effluent concentrations standards imposed by the RWQCB. Demonstrating this, Table 9-3 through Table 9-9 present a comparison of the range of projected purified water quality with corresponding pMCLs and sMCLs. As shown in the tables, compliance is projected for each constituent with an established MCL.

9.3.1.3 Nutrients

As discussed in Section 4.3, it is anticipated that the RWQCB will impose a total phosphorus effluent concentration limit on the NCPWF effluent of 0.025 mg/L, and a long-term average total nitrogen concentration limit of approximately 2 mg/L. Phosphorus and nitrogen will be readily removed through treatment at the NCWRP and the NCPWF. As presented in Table 9-1, total phosphorus concentrations in the NCPWF product water are projected at 0.01 mg/L or less, and total nitrogen concentrations in the NCPWF product water are projected to range from 0.8 to 1.7 mg/L.

In addition to the NPDES numerical concentration limits for nutrients, the NPDES permit will implement the narrative Basin Plan requirement that concentrations of nutrients in Miramar Reservoir must be maintained below levels that stimulate algae and emergent plant growth. Compliance with this Basin Plan narrative biostimulation objective will be achieved through maintaining phosphorus-limited conditions in Miramar Reservoir. The NCPWF discharge will contain near-zero concentrations of phosphorus, and the purified water supply will comprise virtually all of the water stored in Miramar Reservoir. As a result, phosphorus-limiting conditions will be sustained within the reservoir, which will reduce the potential for biostimulation in Miramar Reservoir to below that what has been historically achieved.

9.3.2 California Toxics Rule

The RWQCB NPDES permit will implement effluent standards for the CTR-regulated constituents to ensure compliance with statewide CTR receiving water standards. In establishing effluent standards to implement the CTR receiving water standards, the RWQCB can consider and designate receiving water mixing zones, within which the CTR standards do not apply. CTR receiving water standards are established for the protection of aquatic habitat and for the protection of public health. CTR standards for the protection of aquatic habitat include standards for dissolved metals, cyanide, pentachlorophenol, and chlorinated pesticides. Because RO treatment is highly efficient in removing metals and these organic compounds, the NCPWF product water will comply with all applicable CTR standards for the protection of aquatic habitat.

The NCPWF product water will also comply with the CTR standards for the protection of human health (consumption of organisms plus water), which include standards for inorganic compounds, volatile organic compounds, chlorinated pesticides, acid-extractable compounds, and base/neutral compounds. One potential constituent that warrants attention, however, is NDMA. The CTR receiving water standard for NDMA is 0.00069 µg/L (0.69 ng/L), a standard that is below the currently achievable NDMA detection limit. As a result, if trace quantities of NDMA are present in the NCPWF influent, the NCPWF processes may not be capable of achieving sufficient reduction in NDMA concentrations to achieve compliance with the CTR standard. In this event, it will be necessary to:

- Request that the RWQCB designate a mixing zone within Miramar Reservoir; and
- Demonstrate to the RWQCB that NDMA is not persistent in the environment and that receiving water concentrations beyond the designated mixing zone will comply with the CTR receiving water standard for NDMA.

9.3.3 Chlorine Residual

As presented within Section 4.3, it is anticipated that the NPDES permit will establish effluent concentration requirements for chlorine residual that implement EPA-recommended criteria of 11 µg/L (four-day average) and 19 µg/L (instantaneous maximum limit). As presented in Table 9-1, the purified water will be dechlorinated prior to discharge to Miramar Reservoir, and the chlorine residual in the discharge to Miramar Reservoir will be below detection limits.

10. Pathogenic Microorganism Control

The Project will meet the necessary LRVs required in the SWA regulations using multiple treatment processes. The SWA regulations include a number of microorganism control requirements. The baseline level of treatment required prior to discharge to the reservoir is 8-log, 7-log, and 8-log (8/7/8) for V/G/C, respectively. If the dilution achieved in the reservoir is less than 100:1, the regulations require an additional 1/1/1 of treatment for V/G/C. If the mean theoretical hydraulic retention time is greater than 60 days and less than 120 days, the regulations require additional treatment for V/G/C. Miramar Reservoir provides between 100:1 and 10:1 dilution of recycled water and has a minimum mean theoretical hydraulic retention time of 60 days, thus the pathogen reduction requirements are 10/9/10 for V/G/C. The treatment train used to achieve the required LRVs must consist of at least three separate treatment processes for each pathogen, and at least three treatment processes must provide at least 1-log reduction, but no treatment process will be credited for any more than 6-log reduction.

The required LRVs will be achieved through the treatment processes at the NCWRP, NCPWF, and NCPW Pipeline (i.e., prior to discharge to the reservoir). The proposed pathogen removal credits for each treatment process and the surrogate performance limits to confirm pathogen removal credits are discussed within this section. For additional design criteria for each unit process, refer to Section 6. Each of the barriers discussed in this section represents a critical control point. A critical control point is a point in the treatment train (i.e., a unit treatment process) that is designed specifically to reduce, prevent, or eliminate a human health hazard and a point for which controls exist to ensure the proper performance of that process. The critical control points are monitored using surrogate parameters to assess performance and ensure LRV credits are achieved. The monitoring framework for each critical control point will be discussed in the following sections.

Multiple parameters may be measured for a given unit process, not all of which are used to assess contaminant removal performance. For this reason, it is important to distinguish critical control point monitoring from the monitoring of operational metrics. For example, some parameters may be measured to determine when maintenance or cleaning is required, but are not specifically tied to the contaminant removal performance of the system. In the case of MF and RO systems, it is important to carry a chloramine residual to limit fouling of the membranes and extend the period between cleaning events. The absence of a chloramine residual, however, will not affect the ability of the MF or RO system to provide pathogen control and protect public health; therefore, chloramine residual is measured to ensure that the other aspects of operations, beyond pathogen removal, are also optimized. These parameters are considered operational metrics and will also be monitored. Operational metrics will be determined and detailed in the North City Project’s OP.

10.1 North City Water Reclamation Plant

The NCWRP consists of primary, secondary, and tertiary treatment processes. Tertiary filtered water is conveyed to the NCPWF for further treatment for potable reuse; tertiary filtered water is also disinfected and partially desalted at the NCWRP for the NPR water stream. The pathogen removal at the NCWRP are discussed in the following sections, as they relate to potable reuse.

The primary and secondary treatment processes at the NCWRP include bar screens, grit removal, primary sedimentation, flow equalization, aeration, and secondary clarification as illustrated on Figure 10-1. The NCWRP utilizes six gravity-fed, deep bed anthracite filters to comply with the Title 22 regulations for non-potable recycled water. The filters are designed to remove turbidity and particulates from the secondary effluent.

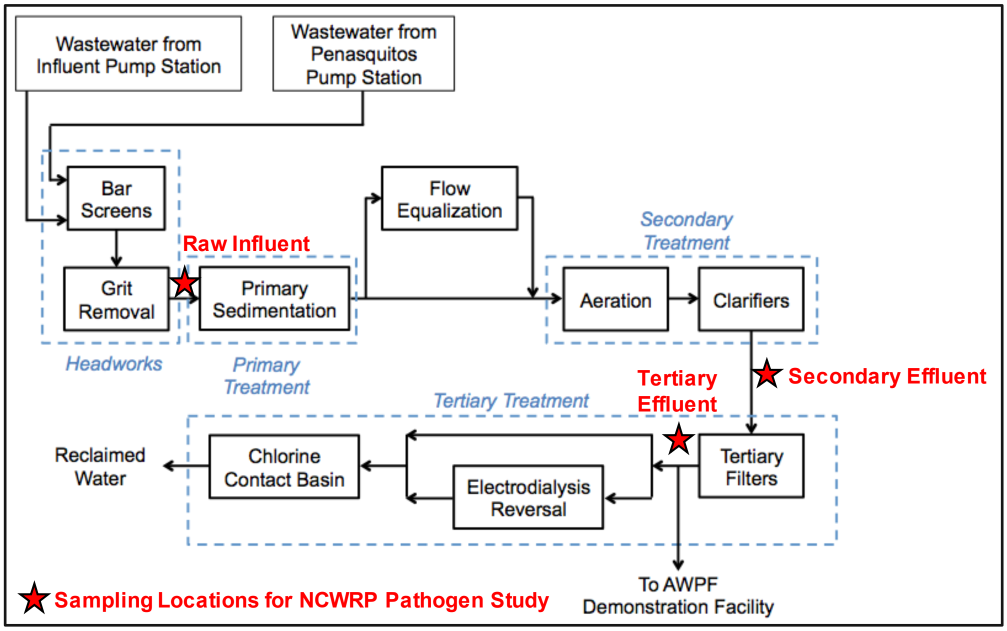


Figure 10-1: NCWRP Primary, Secondary, and Tertiary Treatment Schematic

A yearlong pathogen study was conducted at the NCWRP to determine pathogen reduction through the NCWRP (Trussell Technologies Inc. 2016a). The study was conducted following procedures described in the DDW-reviewed protocol (Trussell Technologies Inc. 2016a). The study included the collection of over 300 samples for pathogen and pathogen indicators at various locations within the NCWRP, illustrated on Figure 10-1. Sampling began in June 2016 and concluded in May 2017. The final results have been submitted to DDW and join other specific studies supporting this Title 22 Engineering Report.

The City's IAP was consulted for a recommended approach to assigning pathogen LRV credits based on the results of the NCWRP Pathogen Study. The four steps for assigning pathogen LRV credits are summarized in the steps below:

1. Fit the pathogen datasets to a lognormal distribution using the maximum likelihood estimate method to obtain the two parameters that define the distribution, namely, the mean (μ) and standard deviation (σ) of the distribution;

2. Use a Monte Carlo simulation to randomly sample one influent concentration from the influent lognormal distribution model and one effluent concentration from the effluent lognormal distribution model and calculate the resulting LRV. This was repeated 10,000 times, such that the Monte Carlo simulation includes 10,000 random pairing of influent and effluent concentrations;

3. Plot the 10,000 LRVs on a normal probability plot and parameterize the distribution with a best-fit line; and

4. Use the equation of the best-fit line to calculate the 5^{th} percentile LRV.

The results of the analysis approach recommended by the City's IAP for the NCWRP Pathogen Study for enteric virus, *Giardia* cysts, and *Cryptosporidium* oocysts are illustrated on Figure 10-2, Figure 10-3, and Figure 10-4, respectively. The enteric virus concentrations were obtained using the EPA Method 1615 infectivity assay and the protozoa concentrations were obtained using the EPA Method 1623/1693 fluorescent microscopy assay. These results are based on the current pathogen dataset collected during the 2016-2017 sampling year, but are subject to change if additional monitoring efforts occur.

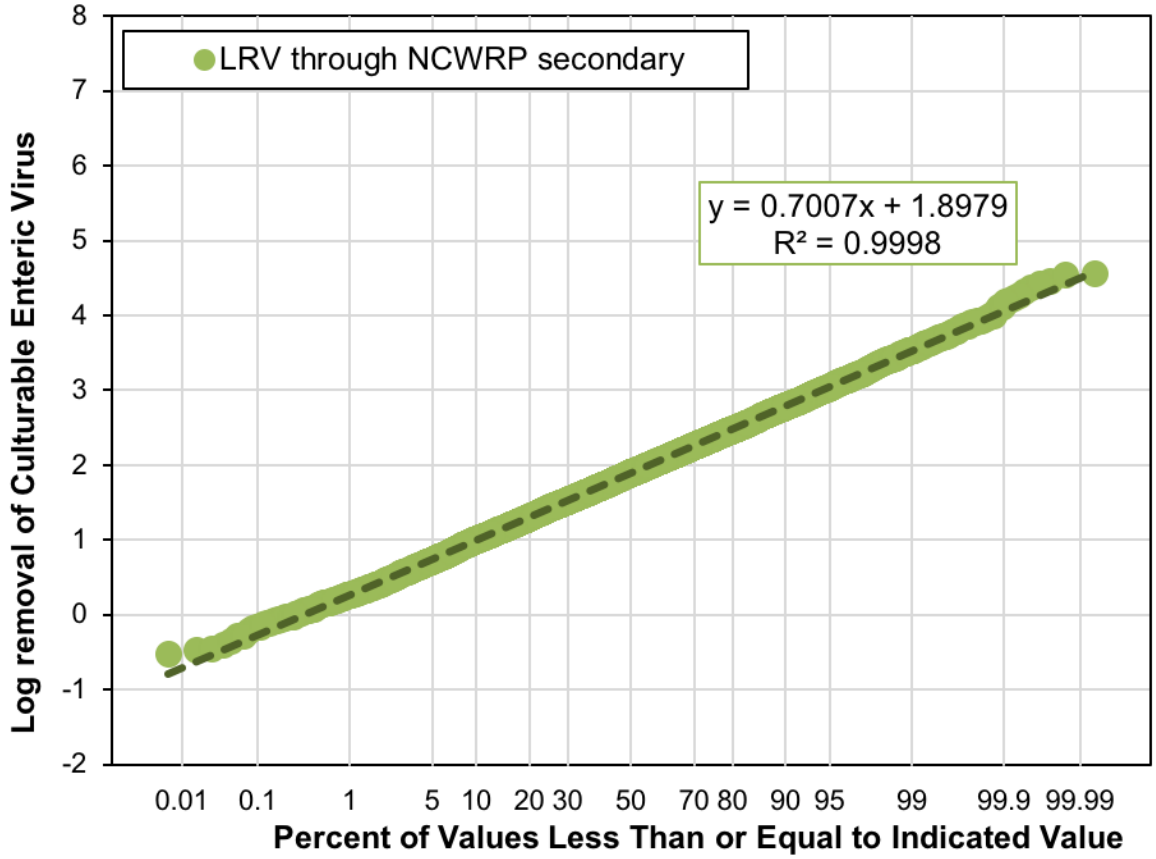


Figure 10-2: Monte Carlo LRV Distributions for Total Cultivable Enteric Virus through Secondary Treatment at NCWRP

The probability distribution of the 10,000 randomly paired LRVs from the Monte Carlo simulation are illustrated on Figure 10-2. The 5th percentile LRV, calculated from the best-fit to the probability distribution on Figure 10-2, is presented in Table 10-1. After rounding down to the nearest tenths place, the proposed LRV credit for cultivable enteric virus is 0.7.

Table 10-1: Total Culturable Enteric Virus LRV through NCWRP

Total Cultivable Enteric Virus	5th Percentile LRV
Raw through secondary treatment	0.75
Proposed Credit for NCWRP	0.7

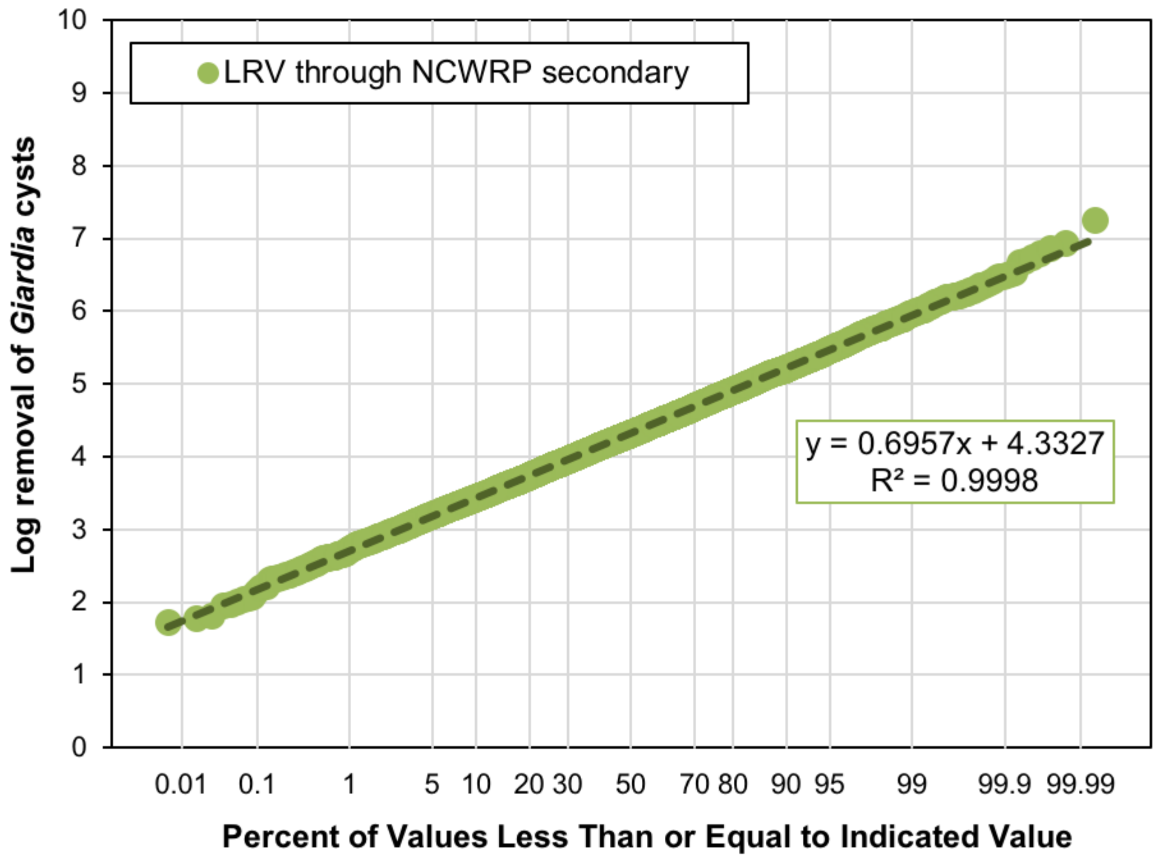


Figure 10-3: Monte Carlo LRV distributions for *Giardia* Cysts through Secondary Treatment at NCWRP

Although tertiary effluent *Giardia* samples were collected during this study, LRV credit through the tertiary treatment process is not being pursued at this time. The probability plot for log removal of *Giardia* cysts through secondary treatment at the NCWRP and the resulting 5th percentile LRV credit are illustrated on Figure 10-3 and presented in Table 10-2. The proposed LRV credit for *Giardia* cysts through the NCWRP is 3.2.

Table 10-2: *Giardia* cyst LRV through NCWRP

Giardia Cysts	5th Percentile LRV
Raw through secondary treatment	3.2
Proposed Credit for NCWRP	3.2

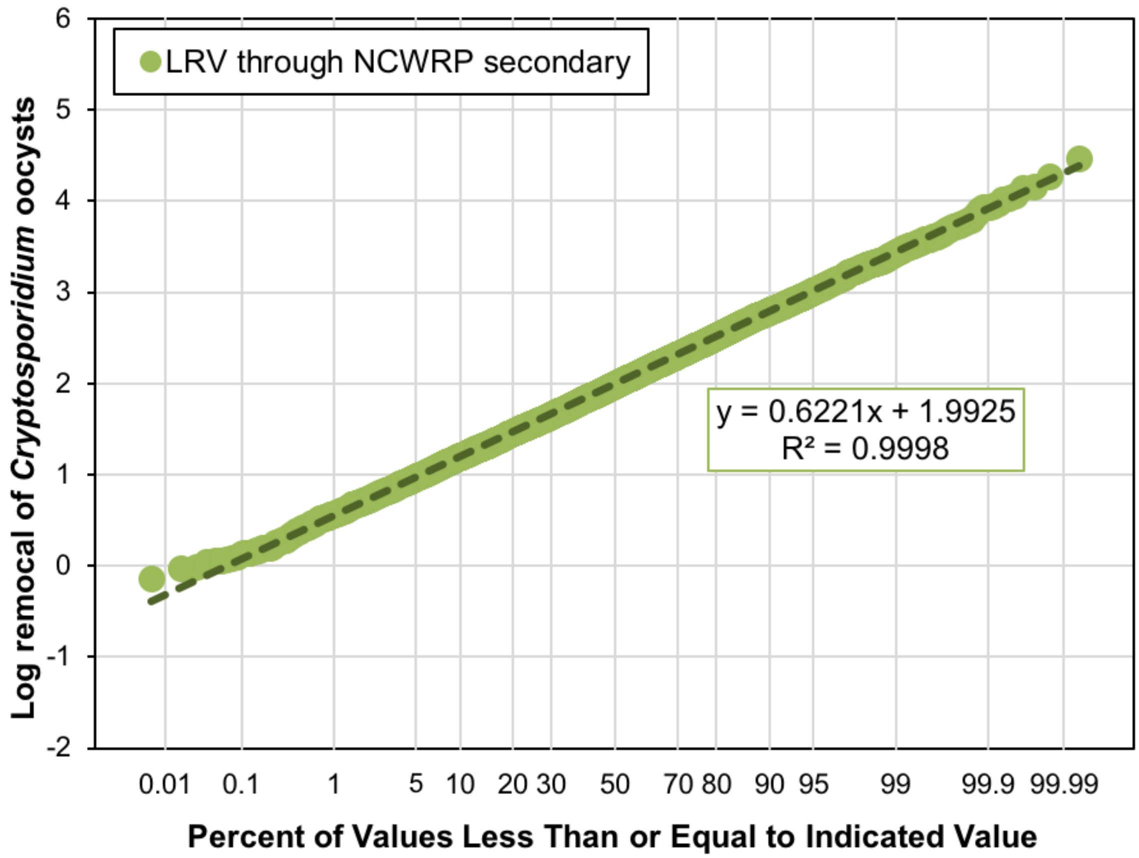


Figure 10-4: Monte Carlo LRV Distributions for *Cryptosporidium* Cysts through Secondary Treatment at NCWRP

Like *Giardia,* LRV credit for *Cryptosporidium* through tertiary treatment will not be pursued at this time. The probability distributions for the log removal of *Cryptosporidium* oocysts through secondary treatment at the NCWRP are illustrated on Figure 10-4. The resulting 5th percentile LRV associated with this distribution is presented in Table 10-3. After rounding down to the nearest tenths place, the proposed *Cryptosporidium* oocyst LRV for the NCWRP is 0.9.

Table 10-3: *Cryptosporidium* Oocyst LRV through NCWRP

Cryptosporidium Oocysts	5th Percentile LRV
Raw through secondary treatment	0.97
Proposed Credit for NCWRP	0.9

In summary, the recommended LRVs for enteric virus, *Giardia* cysts, and *Cryptosporidium* oocysts were based on the approach developed with the City's IAP. The results from the infectivity assay on Buffalo Green Monkey cells, the gold standard for measuring infective enteric virus on live host cells, showed a 5th percentile LRV of 0.7 through the secondary treatment process at the NCWRP. *Giardia* cysts exhibited a 5th percentile LRV of 3.2 through secondary treatment. The 5th percentile *Cryptosporidium* LRV through secondary treatment was 0.9. These proposed LRVs reflect the sampling results from the 2016-2017 sampling year, but are subject to change if additional samples are collected. This includes sampling to characterize pathogen LRVs through the tertiary filtration process at elevated filter loading rates.

In order to meet the pathogen removal credits proposed in this study, which are presented in Table 10-5, the NCWRP must meet the following recommended critical control limits:

- 30-day average of aeration SRT must be greater than 9 days;
- Daily average secondary effluent ammonia-N must not exceed 1 mg/L;
- Combined filter effluent turbidity should not exceed any of the following[1]; and
    - An average of 1.5 NTU within a 24-hour period
    - 2.5 NTU more than 5 percent of the time within a 24-hour period
    - 5 NTU at any time
- Daily average combined filter effluent TOC should not exceed 11 mg/L.

Aeration SRT and secondary effluent ammonia will indicate the performance of the biological treatment and secondary clarification at the NCWRP. Filter effluent turbidity and TOC will indicate the overall finished water quality of the NCWRP effluent, including the performance of both the secondary treatment process and the NCWRP's deep-bed anthracite tertiary filtration process. These proposed critical control limits are based on the NCWRP performance during the course of the NCWRP Pathogen Study. A summary of the performance of the NCWRP is presented in Table 10-4.

Table 10-4: NCWRP Performance Summary

Parameter (units)	Min	Mean	Max	Critical Control Limit Breached During Study?
30-day Average Aeration SRT (days)[a]	9.7	10.0	10.3	No; the minimum 30-day average SRT was 9.7 days
Secondary Effluent Ammonia-N (mg/L)[b]	ND	<1.2	2.9	Yes; the maximum daily average ammonia-N was 2.9 mg/L[e]
Daily Average Filter Effluent Turbidity (NTU)[c]	0.26	0.47	1.3	No; the maximum daily average turbidity was 1.3 NTU
Daily 95th Percentile Filter Effluent Turbidity (NTU)[c]	0.30	0.58	1.4	No; the maximum 95th percentile value was 1.4 NTU and 2.5 NTU was exceeded <1% of the time
60-Second Filter Effluent Turbidity (NTU)[c]	0.20	0.47	4.4	No; the maximum 60-second value recorded was 4.4 NTU
Daily Average Filter Effluent TOC (mg/L)[d]	5.1	8.1	10.7	No; the maximum daily average TOC was 10.7 mg/L

[a] Calculated daily from June 2016 through June 2017.
[b] Daily composite samples taken from June 2016 through June 2017 (weekends/holidays excluded).
[c] On-line Filter #4 meter data recorded 60-second on sampling days.
[d] On-line ozone influent meter data recorded every 2-20 minutes on sampling days.
[e] This limit was exceeded on an isolated event (9/15/16) at a concentration of 2.9 mg/L. Only 4 of 265 samples, however, were at levels of detection (mean of the 4 detects was 1.2 mg/L and none of the three other detects exceeded 1 mg/L).

[1] The combined filter effluent turbidity critical control limits listed were approved by DDW in the approval for the Filter Loading Rate Evaluation for Water Reuse Study at the North City Water Reclamation Plant (7.5 gpm/ft^2), dated January 18, 2018.

Table 10-5: Proposed Pathogen LRVs Through Secondary Treatment at the NCWRP

Pathogen	Proposed LRV[a]
Virus	0.7
Giardia cysts	3.2
Cryptosporidium oocysts	0.9

[a] Subject to change upon additional pathogen monitoring.

10.2 North City Pure Water Facility

The NCPWF treatment train consists of ozone and BAC, MF, RO, UV/AOP, and chlorine disinfection. The expected pathogen LRVs for each process and the surrogate performance limits to confirm pathogen removal credits are detailed in the following sections.

10.2.1 Ozone and Biological Activated Carbon

Ozone and BAC are the first treatment processes at the NCPWF. The primary purpose of Ozone/BAC is to improve the performance of the downstream MF process by breaking down and reducing the size of large organic molecules in the NCWRP tertiary treated water, which is the source water for the NCPWF. Ozone also oxidizes CECs and other organic contaminants, either removing them through oxidation or making them readily biodegradable through the BAC filter. In addition, ozone is a strong disinfectant and pathogen removal is expected through this process. The ozone system is being designed to reliably achieve 1-log inactivation of *Cryptosporidium*. At an ozone dose necessary to achieve 1-log inactivation of *Cryptosporidium*, greater than 6-log inactivation of virus and *Giardia* is anticipated. All of the pathogen inactivation credit is being sought for the ozonation process, and no LRV credit is sought for the BAC filters.

10.2.1.1 Pathogen LRV Equations

The CT values for inactivation by ozone are provided in the EPA's SWTR Guidance Manual for *Giardia* cysts and virus, and in the Long-Term 2 Enhanced Surface Water Treatment Rule (LT2SWTR) Toolbox Guidance Manual for *Cryptosporidium* oocysts, for water temperatures between 0.5 degrees Celsius (ºC) and 25ºC. Equations derived from these CT tables are shown below (EPA 2010). These equations will be used to calculate log reduction credit.

$$\textit{Cryptosporidium oocyst}\text{ log credit} = 0.0397 \times (1.09757)^{\text{Temperature(ºC)}} \times CT \quad \text{Eqn. 1}$$

$$\textit{Giardia}\text{ cyst log credit} = 1.038 \times (1.0741)^{\text{Temperature(ºC)}} \times CT \quad \text{Eqn. 2}$$

$$\text{Virus log credit} = 2.1744 \times (1.0726)^{\text{Temperature(ºC)}} \times CT \quad \text{Eqn. 3}$$

Figure 10-5 illustrates the LRV provided by ozone for each of these pathogens as a function of CT at a temperature of 20˚C. The key point shown is that *Cryptosporidium* is significantly more resistant to ozone than the other two pathogens. The ozone CT that provides 1-log of *Cryptosporidium* inactivation provides greater than 6-log inactivation of *Giardia* and virus. At the design temperature of 20ºC, the ozone CT that achieves 1-log *Cryptosporidium* inactivation will achieve 17.0-log *Giardia* inactivation and 34.6-log virus inactivation. Such high LRVs for *Giardia* and viruses cannot be readily validated, and the SWA regulations limit the LRV claimed for any single treatment process to 6-log. Pathogen inactivation will be calculated using the above LRV equations to verify compliance with the LRV credits sought.

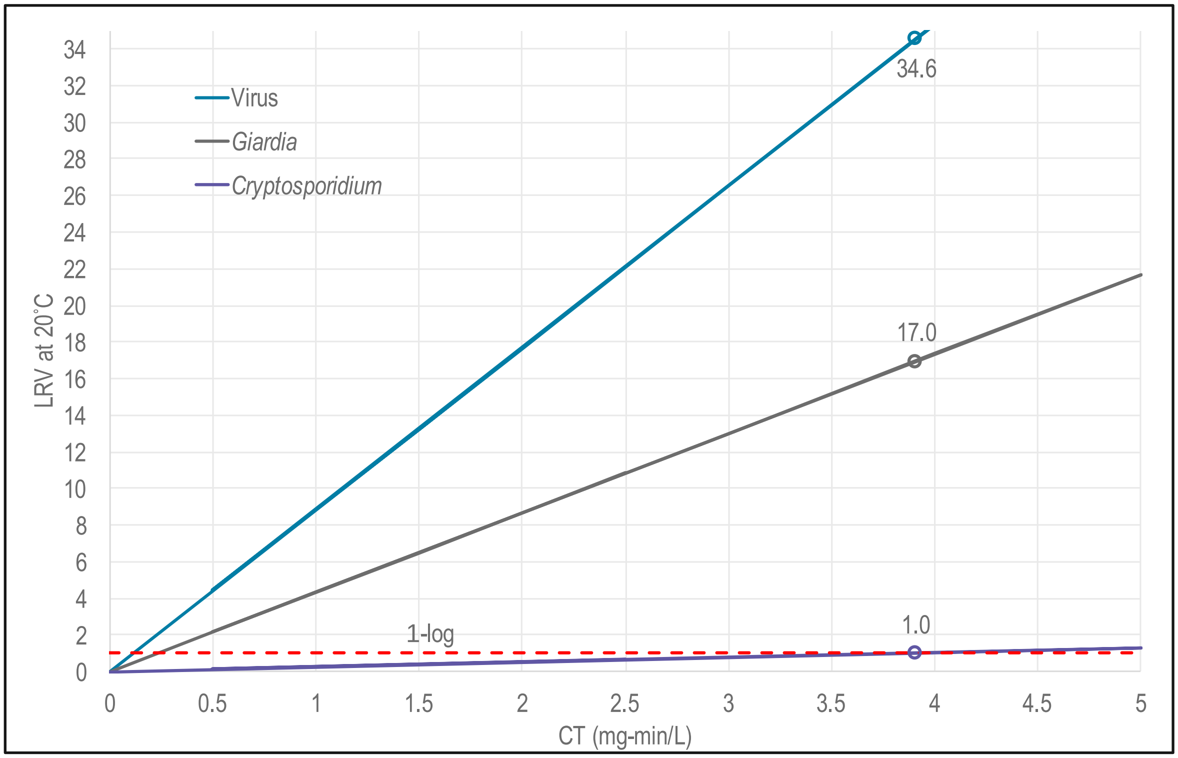


Figure 10-5: Comparative Ozonation CT Needed for V/G/C Inactivation

10.2.1.2 Ozone Contactor Design

The NCPWF will have two parallel ozone contactors. Ozone gas will be injected into a sidestream of water and the ozonated sidestream will mix with the main process flow. The design ozone dose is 14 mg/L, and the ozone transfer efficiency will be 90 percent or greater.

Each ozone contactor is a serpentine, vertically stacked type contactor, with an upper level and a lower level designed to minimize short circuiting and mixing. A plan view of the two ozone contactors is illustrated on Figure 10-6 and a section view on Figure 10-7. The ozonated water flows up to the upper level contactor and then around a bend to the lower level contactor. Baffling is included in the contactor design to straighten the flow and improve the plug flow characteristics. These baffles are highlighted in red on Figure 10-7. Based on computational fluid dynamics modeling, the baffle factor is determined by the time at which 10 percent of the water in the contactor or segment has passed through the contactor or segment (T_{10}) and the HRT. The baffle factor (T_{10}/HRT) for this contactor is 0.79. As required by DDW policy, this baffling factor will be confirmed with a tracer study when operation begins. Prior to the tracer study, a conservative baffling factor of 0.60 will be applied.

The pathogen inactivation calculation takes into account the calculated total CT (CT_{total}), the baffle factor (T_{10}/HRT) for the contactor, and the individual pathogen inactivation rate constants (k_p), as shown in Equation 4. This equation is the same as Equations 1, 2, and 3 for the individual pathogens, but multiplied by the baffle factor specific to the NCPWF's ozone contactors.

$$Log\ Inactivation = k_p \text{ x } CT_{total} \text{ x } \left(\frac{T_{10}}{HRT}\right) \qquad \text{Eqn. 4}$$

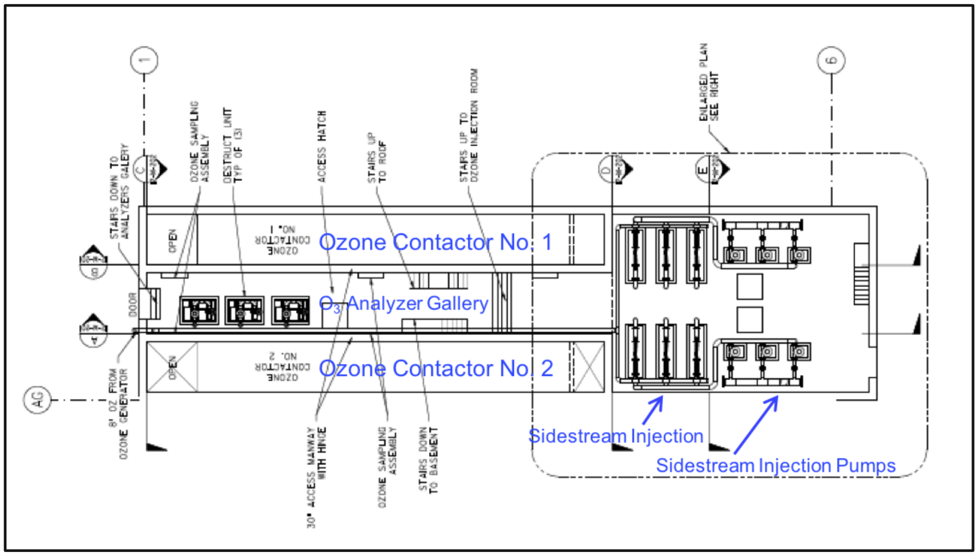


Figure 10-6: Ozone Contactor Plan View

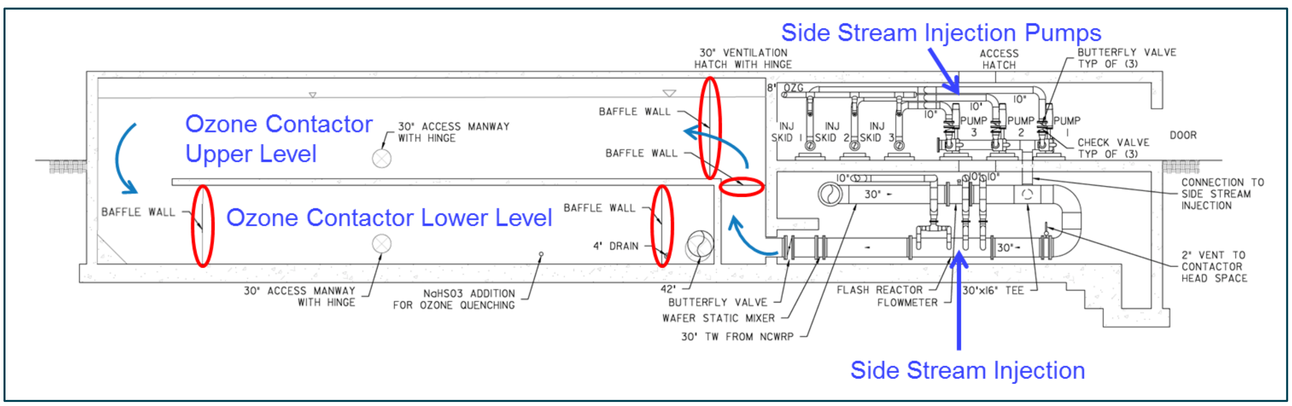


Figure 10-7: Ozone Contactor Section View: Baffle Walls (circled)

Pathogen inactivation will be calculated according to the guidelines provided in EPA's LT2ESWTR Guidance Manual (EPA 2010). EPA's guidelines designate a dissolution zone and reactive zone for an ozone contactor. The dissolution zone is where ozone is added to the water, and the reactive zone is where ozone is decaying without concurrent ozone addition. Defining these two zones is important because, per the LT2ESWTR, *Cryptosporidium* inactivation credit cannot be earned in the dissolution zone. The dissolution and reactive zones of the NCPWF's ozone contactors are illustrated on Figure 10-8, along with the proposed locations of the three dissolved ozone residual analyzers that will be used to continuously measure ozone residual concentrations through the contactors for CT calculation.

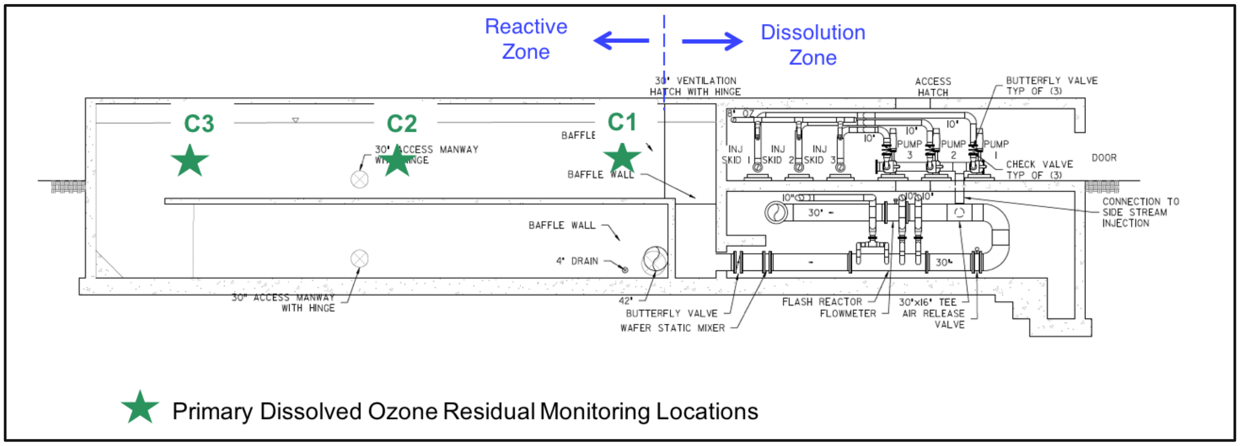


Figure 10-8: Ozone Contactor Section View: Dissolved Ozone Residual Monitoring Locations

10.2.1.3 Pathogen LRV Calculation Methodology

Pathogen inactivation with ozone will be calculated in accordance with the procedures provided in EPA's SWTR Guidance Manual (EPA 1991) and LT2ESWTR Toolbox Guidance Manual (EPA 2010). LRVs will be calculated using the "Truncated" Extended Integration CT Method, which is a conservative modification of the Extended Integration CT Method. In brief, ozone residual is measured continuously at three locations in the ozone contactor, and CT is calculated as the area under the ozone decay curve, as illustrated by the highlighted region on Figure 10-9. In this figure, C_1, C_2 and C_3 represent ozone residuals measured by residual analyzers numbered 1, 2, and 3. C_0 is the back-calculated ozone residual concentration at the start of the reactive zone. In order to avoid the possibility of over-estimating CT, a conservative approach is used to calculate CT where the ozone decay curve is truncated back to the start of the reactive zone based on the C_1 measurement rather than relying on a back-calculated C_0 concentration. The Effluent CT Method (described in the SWTR Guidance Manual) is used to calculate CT from the first residual ozone analyzer back to the start of the reactive zone (CT_1 illustrated on Figure 10-9), and the Extended Integration CT Method is used to calculate CT from meter 1 to the end of the ozone contactor or a residual of 0.05 mg/L (CT_2 on Figure 10-9), whichever occurs first. The Total CT is used to calculate pathogen LRV, and is the sum of the two segments. Equations used for these calculations are the following:

$$CT_1 = C_1 \, x \, \frac{T_{10}}{HRT} \, x \, HRT_{(0-1)} \qquad \text{Eqn. 5}$$

$$CT_2 = \frac{T_{10}}{HRT} \, x \, \frac{C_1}{k^*_{max}} \, x \left(e^{k^*_{max} \, x \, HRT} - 1\right) \qquad \text{Eqn. 6}$$

$$k^*_{1-2} = \frac{\ln\left(\frac{C_1}{C_2}\right)}{HRT_{1-2}} \qquad k^*_{1-3} = \frac{\ln\left(\frac{C_1}{C_3}\right)}{HRT_{1-3}} \qquad \text{Eqn. 7}$$

where: k^*_{1-2} = ozone decay rate between analyzers 1 and 2
k^*_{1-3} = ozone decay rate between analyzers 1 and 3
C_1 = measured ozone residual at analyzer 1
C_2 = measured ozone residual at analyzer 2
C_3 = measured ozone residual at analyzer 3.

Using the maximum ozone decay rate rather than the average decay rate, as discussed in the EPA guidance documents, is another conservative element of the LRV calculation approach used for this Project. Ozone CT calculated with the maximum decay rate results in a lower value than if the average rate is used.

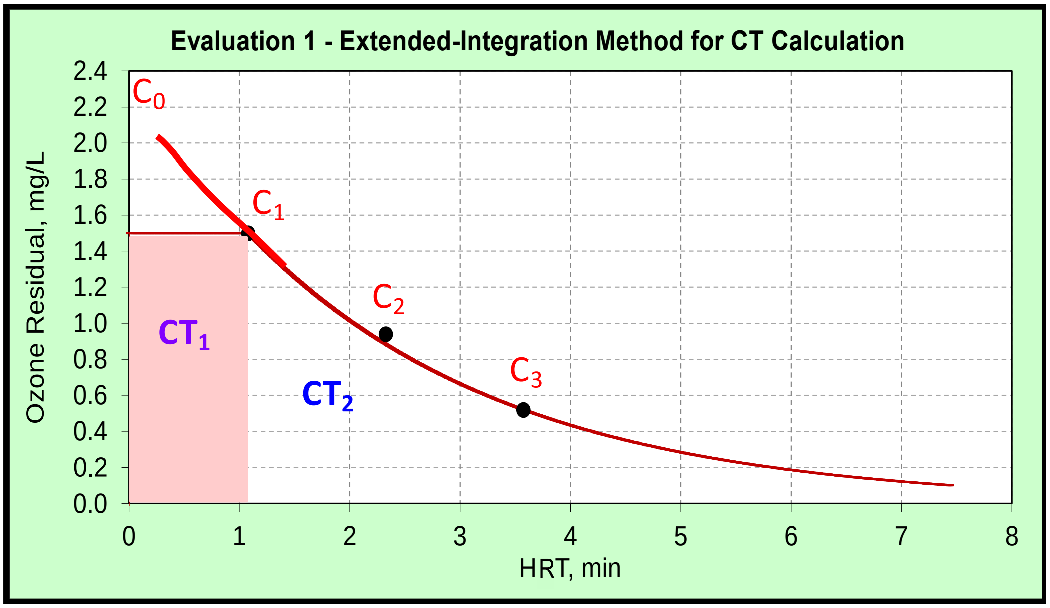


Figure 10-9: Example of Ozone CT Calculation Using Three Dissolved Ozone Analyzers

Ozone CT tables developed for drinking water extend to a maximum of 4/3/3-LRV for V/G/C, respectively (EPA 2003, EPA 2006a, EPA 2010). These upper limits were determined based on the amount of treatment needed for a surface water. Given the higher pathogen loading in recycled waters, higher degrees of treatment are needed to reach the same level of treatment for potable reuse (Trussell, Salveson et al. 2013). For this project, 6-log virus, 6-log *Giardia,* and 1-log *Cryptosporidium* credit is being sought. It is appropriate to extend the ozone CT tables for *Giardia* and virus inactivation since ozone is exceedingly more effective for *Giardia* and virus inactivation than for *Cryptosporidium*. As discussed previously and illustrated on Figure 10-5, the ozone dose needed for 1-log *Cryptosporidium* inactivation will achieve 17.0-log *Giardia* inactivation and 34.6-log virus inactivation.

The reliability of the ozone process in controlling virus, *Giardia*, and *Cryptosporidium* was evaluated over a 12-month period through the WRRF 14-12 Study and was shown to provide consistent ozone residual necessary to achieve the target pathogen reduction. A copy of the WRRF 14-12 Study final report, including ozone disinfection performance demonstration testing, will be submitted to DDW in a future appendix to this Title 22 Engineering Report.

10.2.1.4 Dissolved Ozone Residual Monitoring

Each ozone contactor will have three dissolved ozone residual monitors for continuous measurement of ozone residual and LRV calculation. The anticipated location of these three monitors was illustrated on Figure 10-8 and is described in more detail in Section 6.3.1.3.d. LRV calculations will be made using rolling averages of individual dissolved ozone analyzer readings - a procedure consistent with the EPA guidance documents. Rolling averages are needed to facilitate stable process control and to smooth LRV calculations. The monitoring frequency will be determined in a later phase of design and will be defined in the North City Project's OP.

The accuracy of the ozone monitor readings is important for accurate LRV calculations. Of the three monitors, the accuracy of the first is most important to CT calculation since it is used in both the CT_1 calculation and ozone decay rate calculation used for CT_2 calculation (refer to Equations 5, 6, and 7). A quality control protocol will be in place when the plant is brought on-line to verify the accuracy of all three monitors and to allow LRV calculation even when a monitor is off-line for maintenance, calibration, or repair. In brief, to verify monitor accuracy, grab samples of the ozonated water will be collected at all monitor locations and analyzed by the indigo method for comparison with meter readings. In order to track the performance of the first monitor (C_1 monitor), a "historical" upper limit and lower limit will be set for the calculated ozone demand, defined as:

$$\text{Ozone Demand} = \text{Transferred Ozone Dose} - C_1 \text{ Ozone Residual}$$

Based on data from the NCDPWF during the WRRF 14-12 Study (see Section 9.1 for a description of the WRRF 14-12 Study), ozone demand data are a fairly stable parameter as illustrated on Figure 10-10. These data were based on a constant ozone dose of 10.8 mg/L and C_1 residual concentrations were based on grab samples analyzed by the indigo method. If the demand goes outside the upper limit or lower limit, the operators will be signaled to check the calibration and performance of the C_1 monitor. If the C_1 monitor has to be taken out of service for a short time for maintenance, pathogen LRV can continue being calculated using either the upper limit or lower limit value, as appropriate, in the LRV calculation as long as C_2 monitor and C_3 monitor readings are within their respective upper limit or lower limit. The upper limit and lower limit are tracking tools that can be changed by the operators in relation to seasonal or other water quality changes. The North City Project's OP will define the details of this quality control protocol for all three on-line ozone residual monitors.

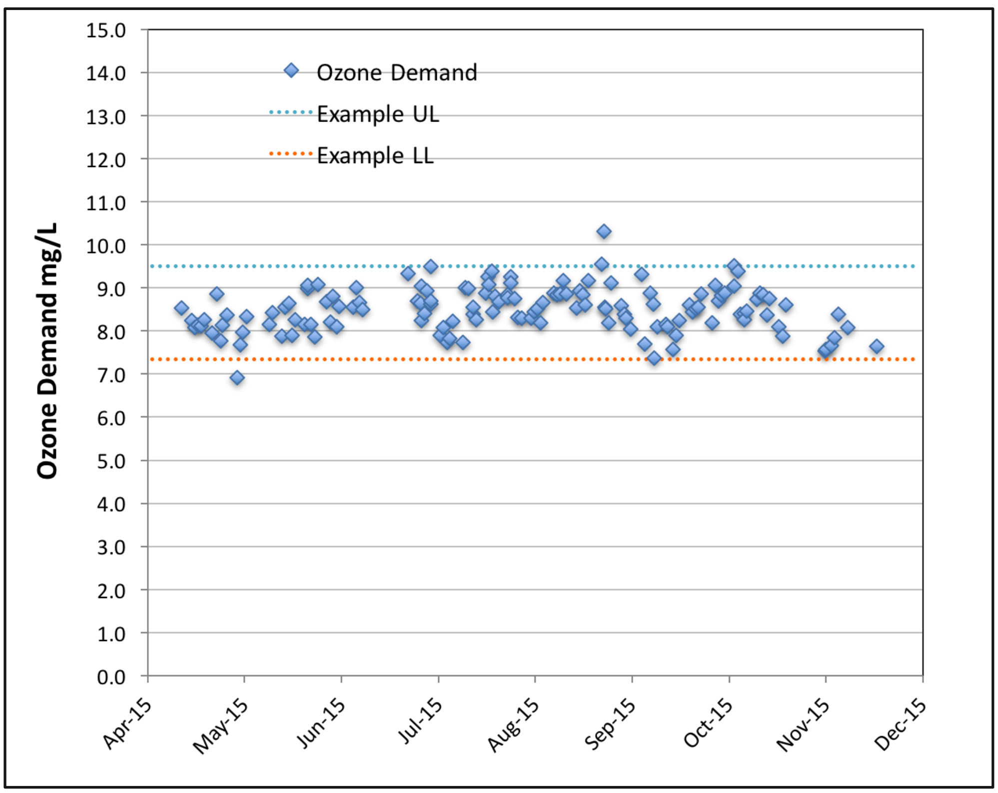


Figure 10-10: Ozone Demand Measured at the NCDPWF

10.2.1.5 NCPWF Ozone Crediting Approach

The V/G/C LRV will be determined based on calculated ozone CT using the temperature corrected truncated extended integration method provided in EPA's SWTR Guidance Manual and the LT2ESWTR Toolbox Guidance Manual. Based on the LT2ESWTR manual, the expected LRV values through the ozone process at the NCPWF are presented in Table 10-6.

Table 10-6: Expected LRV Through Ozone/BAC

Pathogen	LRV Expected Through Ozone
Virus	6
Giardia	6
Cryptosporidium	1

10.2.2 Membrane Filtration

Membrane filtration, using either micro- or ultrafiltration membranes, serves as a physical barrier for pathogen removal. Drinking water regulations provide a framework for MF to receive log reduction credit for virus, *Giardia*, and *Cryptosporidium*. The California SWTR allows the use of MF as an alternative filtration technology, provided the technology demonstrates at least 1-log virus reduction, 2-log *Giardia* reduction, and 2-log *Cryptosporidium* reduction and meets certain turbidity performance standards, per the CCR, Title 22, Division 4, Environmental Health Chapter 17, Article 2, Section 64653(e). Demonstration of these minimum requirements is product-specific, as detailed in CCR Section 64653(f). The state and federal LT2ESWTR provide further regulations and guidance on achieving additional reduction credit for *Cryptosporidium*. Under LT2ESWTR, MF falls under the MF category of the microbial toolbox options for meeting *Cryptosporidium* treatment requirements. Similar to the requirements under the California SWTR, log reduction credit is based on product-specific demonstration testing with testing requirements described in detail in the rule (EPA 2006a) and in associated guidance documents (EPA 2005, EPA 2010).

As such, in California, manufacturers typically perform one study for each of their MF products that would satisfy the demonstration testing requirements of the California SWTR and the state and federal LT2ESWTR. These studies, which are submitted to DDW, provide acceptance of the product for use in drinking water treatment facilities and assign log reduction credits for virus, *Giardia*, or *Cryptosporidium* based on the information provided by the manufacturer. The MF modules to be used in the NCPWF will be required to carry the certification by the state for use in drinking water with at least 4-log reduction credits for *Giardia* and *Cryptosporidium*, each, as part of the MF system procurement process. These are the same log reduction credits (i.e., 4-log reduction of *Giardia* and 4-log reduction of *Cryptosporidium*) being sought for the Project.

The state and federal LT2ESWTR require that the MF system regularly pass both indirect and direct integrity testing. The indirect integrity testing requirement shall be met by continuous MF filtrate turbidity monitoring, while the direct integrity testing requirement shall be met by daily PDTs. Both are described further in the following sections.

10.2.2.1 Indirect Integrity Testing – Continuous MF Filtrate Turbidity Monitoring

The state and federal LT2ESWTR requirement for indirect integrity testing shall be met by continuous MF filtrate turbidity monitoring, with a frequency of no less than once every 15 minutes. Should the filtrate turbidity exceed a set performance-based control limit (such as 0.15 NTU) for a period exceeding 15 minutes, then the direct integrity test shall be triggered (in accordance with EPA 2005). The start of a direct integrity test (in this case, a PDT) will mean that the MF rack that did not pass the indirect integrity will be taken off-line and checked for any breaches. A PDT triggered due to a high filtrate turbidity is a separate test from the regularly scheduled daily PDT for each MF rack.

10.2.2.2 Direct Integrity Testing – PDTs and Associated LRV Calculations

As described above, direct integrity testing is also required of the MF system, per the state and federal LT2ESWTR, and the PDT is one accepted method. The PDT is a test that pressurizes the modules with air and then measures the pressure decay after a valve is closed to isolate the system. This procedure directly tests any breaches in the membrane hollow fibers. There are a number of requirements associated with having a valid PDT system for an MF unit. These include:

- Setting the minimum applied test pressure to achieve a 3-µm resolution;
- Determining the sensitivity of the PDT in terms of LRV;
- Determining the upper control limit for the pressure decay; and
- Setting an acceptable frequency for the PDT to occur.

Because the 3-µm resolution is set based on the lower bound of the size range of *Cryptosporidium* oocyst (3 to 7 µm), the PDT can also apply simultaneously to achieving log reduction credit for *Giardia cysts*, which range from 5 to 15 µm.

The minimum applied test pressure necessary to achieve a resolution of 3 µm can be calculated using the following equation:

$$P_{test} = (0.193 \times \kappa \times \sigma \times \cos\theta) + BP_{max}$$ Eqn. 4.1 of EPA 2005

where,

P_{test} = minimum test pressure (psi),
κ = pore shape correction factor
σ = surface tension at air-liquid interface (dynes/cm)
θ = liquid-membrane contact angle (degrees)
BP_{max} = maximum backpressure on system during test (psi)
0.193 = constant that includes defect diameter (i.e., 3 µm resolution requirement) and unit conversion factors

The sensitivity of the direct integrity test, which in this case is the PDT, refers to the maximum LRV that can be determined by the PDT. This would need to be greater than the log reduction credits sought. The sensitivity of the PDT is system-specific, and is calculated using the following equations:

$$LRV_{DIT} = \log\left(\frac{Q_p \times ALCR \times P_{atm}}{\Delta P_{test} \times V_{sys} \times VCF}\right)$$ Eqn. 4.9 of EPA 2005

$$ALCR = 170 \times Y \times \sqrt{\frac{(P_{test}-BP) \times (P_{test}+P_{atm})}{(460+T) \times TMP}}$$ Eqn. C.4 of EPA 2005

$$Y \propto \left[\frac{1}{\left(\frac{P_{test}-BP}{P_{test}+P_{atm}}\right)}, K\right]$$ Eqn. C.5 of EPA 2005

$$K = f \times \frac{L}{d_{fiber}}$$ Eqn. C.6 of EPA 2005

where,

LRV_{DIT} = direct integrity test sensitivity in terms of LRV
Q_P = membrane unit design capacity filtrate flow (gpm)

ALCR = air liquid conversion ratio

P_{atm} = atmospheric pressure (psia)

ΔP_{test} = smallest rate of pressure decay that can be reliably measured and associated with a known integrity breach during an integrity test (psi/min)

V_{sys} = volume of pressurized air in the system during the test (gal)

VCF = volumetric concentration factor (dimensionless)

Y = net expansion factor for compressible flow through a pipe to a larger area (dimensionless)

P_{test} = direct integrity test pressure (psi)

BP = minimum backpressure (psi)

T = maximum anticipated temperature (°F)

TMP = maximum allowable transmembrane pressure (psi)

K = flow resistance coefficient

f = friction factor

L = length of defect (mm)

d_{fiber} = fiber diameter (mm)

A control limit is defined as a response that, if exceeded, indicates a potential problem with the system and triggers a response. The LT2ESWTR mandated control limit is referred to as the upper control limit. If the pressure decay obtained during the direct integrity test is below the upper control limit, the membrane unit should be achieving a LRV equal to or greater than the removal credit awarded to the process. Alternatively, if the pressure decay measured exceeds the upper control limit, the membrane unit is required to be taken off-line for diagnostic testing and repair (EPA 2005). The upper control limit may be calculated using the following equation:

$$UCL = \frac{Q_p \times ALCR \times P_{atm}}{10^{LRV} \times V_{sys} \times VCF}$$ Eqn. 4.17 of EPA 2005

where,

UCL = upper control limit in terms of pressure decay rate (psi/minute)

LRV = log reduction credit

Q_P = membrane unit design capacity filtrate flow (gpm)

ALCR = air liquid conversion ratio

P_{atm} = atmospheric pressure (psia)

V_{sys} = volume of pressurized air in the system during the test (gal)

VCF = volumetric concentration factor (dimensionless)

The MF system LRV shall be calculated based on Eqn. 4.9 of EPA 2005, using the pressure decay rate determined at each PDT and the water temperature at the time of the test, as shown below:

$$LRV = \log\left(\frac{Q_p \times ALCR \times P_{atm}}{\Delta P_{test} \times V_{sys} \times VCF}\right)$$ Eqn. 4.9 of EPA 2005

where,

LRV = log reduction value

Q_P = membrane unit design capacity filtrate flow (gpm)

ALCR = air liquid conversion ratio

P_{atm} = atmospheric pressure (psia)

ΔP_{test} = measured test decay rate (psi/min)

V_{sys} = volume of pressurized air in the system during the test (gal)

VCF = volumetric concentration factor (dimensionless)

The frequency of the PDT is expected to be daily for each MF rack. Should an MF rack fail a PDT, the PDT shall be repeated and if the second PDT fails, the operators shall take action to identify and correct the issue prior to placing the MF rack back in service.

The reliability of the MF process in controlling *Giardia* and *Cryptosporidium* was evaluated over a 12-month period through demonstration testing as part of the WRRF 14-12 Study and results of MF performance during demonstration testing can be found in the WRRF 14-12 Study Final Report (WRRF, 2017 in progress).

10.2.2.3 NCPWF MF Crediting Approach

The LRV for the MF system will be calculated daily based on the PDT. The indirect integrity testing using continuous turbidity measurements will ensure proper functioning of the MF system. The expected LRV values through the MF system are based on the EPA 2005 manual and are presented in Table 10-7.

Table 10-7: Expected LRV Through MF

Pathogen	LRV Expected Through MF
Virus	0
Giardia	4
Cryptosporidium	4

10.2.3 Reverse Osmosis

The RO consists of high pressure semi-permeable membranes capable of providing high levels of pathogen removal, predominantly through size exclusion and charge repulsion (Pype, Alvarez de Eulate et al. 2015). Pathogen rejection potential by RO is often interpreted as the extent to which RO membranes can preclude MS2 bacteriophage, an accepted surrogate for enteric virus for its physical similarities. Due to size alone, equal or greater rejection can be expected for *Cryptosporidium* (3-7 µm) and *Giardia* (7-15 µm), than what can be demonstrated for MS2 (0.03-0.1 µm). Although as much as 7-logs MS2 rejection has been demonstrated across RO membranes in challenge test events (Kumar, Adham et al. 2007), the implementation of such methods to monitor membrane integrity is infeasible at full-scale due to high cost and effort required to culture and plate the MS2 bacteriophage. For this reason, the use of molecular markers is alternatively employed to monitor the integrity of an RO system. The performance of the RO system, as determined through extensive field-testing of surrogate parameters, is presented in the following sections.

10.2.3.1 Surrogate Molecular Marker Testing

To date, TOC has been recognized for approximately 2.0-log reduction for V/G/C and EC has been recognized for approximately 1.5-log reduction for V/G/C. TOC and EC have been recognized for approximately 2.0- and 1.5-log reduction, respectively, for V/G/C. Additional markers have since been tested. The results of testing with different molecular markers are illustrated on Figure 10-11, where three different RO elements were evaluated. All testing was carried out on a 2-stage RO system (10:5 array) fitted with 8-inch elements from the NCDPWF.

Testing was also carried out to assess the capabilities of markers to conservatively track virus removal under intact and compromised conditions. This was performed by deliberately compromising the intact membranes by removing O-rings from strategic locations along the RO pressure vessels. The evaluated compromises were carried out in a single vessel as illustrated on Figure 10-12. Previous studies have shown that O-ring compromises cause the greatest impact on MS2 bacteriophage removal (Jacangelo, Cran et al. 2015), and was the basis for this investigation. Figure 10-13 illustrates marker rejection as a function of membrane integrity during testing with Hydranautics Energy Saving Polyamide Low Differential (ESPA2 LD) elements, and illustrates how each of the evaluated markers provide a conservative assessment, relative to MS2 bacteriophage, on RO membrane integrity under intact and compromised conditions.

From these results, at least 2.5/2.5/2.5 reduction credit for V/G/C can be demonstrated and secured for RO using alternative molecular markers. Strontium can be used to monitor RO integrity by measuring feed and combined permeate grab samples and analysis using UCMR3 EPA 200.8 method (Method Reporting Limit: 0.3 µg/L). Because naturally occurring strontium concentration is high enough to demonstrate at least 2.5-log reduction across an RO system (average RO Feed at NCDPWF: 914 µg/L; n=76), there is no need to augment the RO feed using this particular molecular marker. In contrast, it was necessary to augment RO feed sugar concentrations to reliably measure RO sugar rejection using grab/on-line TOC monitoring. Sucralose (397 Dalton) rejection data based on liquid chromatography/mass spectrometry analysis were illustrated on Figure 10-11 to support the accuracy of the TOC meters in assessing sugar rejection, a compound of similar molecular weight (342 Dalton).

The effect of element aging on marker rejection was also evaluated by assessing removal across Stage 2 fitted with used/aged ESPA2 LD elements against Stage 2 fitted with new/virgin Toray TMG20D elements. Given their location in the RO system, Stage 2 elements are the most prone to inorganic fouling and chlorine exposure.

Because aging of elements appears to influence marker rejection, the LRV that can be demonstrated by an RO system will lessen over the lifespan of the RO elements, particularly on trailing stages. In the context of obtainable LRV, the decrease in RO performance on molecular marker rejection should be considered as it is an embedded phenomenon of RO elements.

TRASAR® was continuously monitored across new/virgin Toray TMG20D elements during the same study. Integrity monitoring was achieved by continuously adding a proprietary dye from then Nalco Company (TRASAR 23299) to the RO feed (0.05 – 0.4 parts per million active compound) and measuring dye rejection using low-range fluorometers located on the RO feed and permeate. This marker consistently achieved above 3-logs on the train level during a three-month trial, as illustrated on Figure 10-14. In addition, TRASAR was consistently above the two commonly used markers to monitor RO integrity – TOC and EC.

An evaluation was also conducted to verify the capability of TRASAR to conservatively track MS2 rejection during intact and compromised conditions. Results from this effort are illustrated on Figure 10-15 and they show that TRASAR can provide a conservative estimate of MS2 rejection under both intact and compromised conditions.

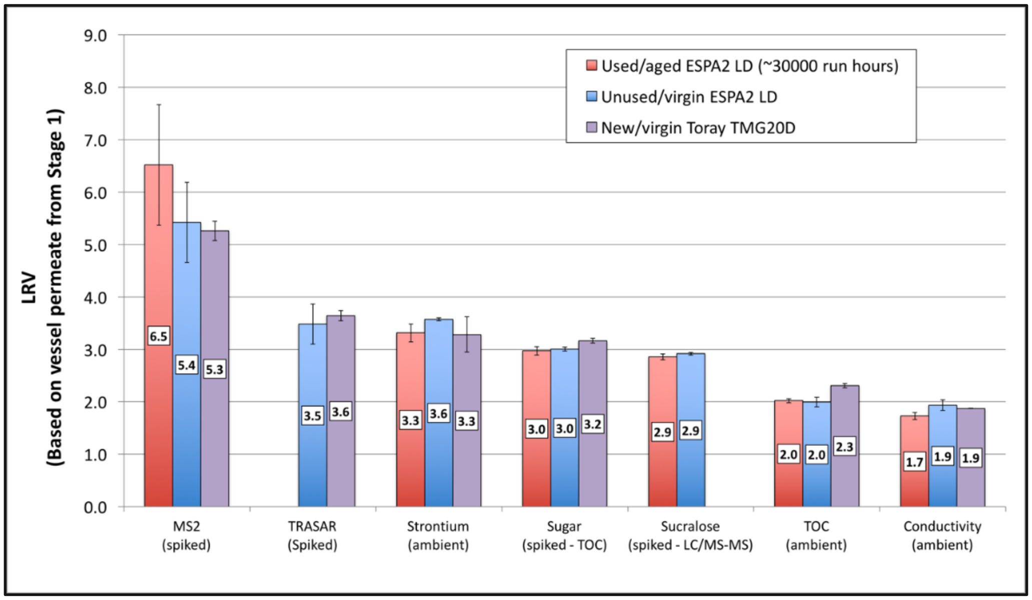


Figure 10-11: LRV for Selected Markers Across Intact RO Membranes

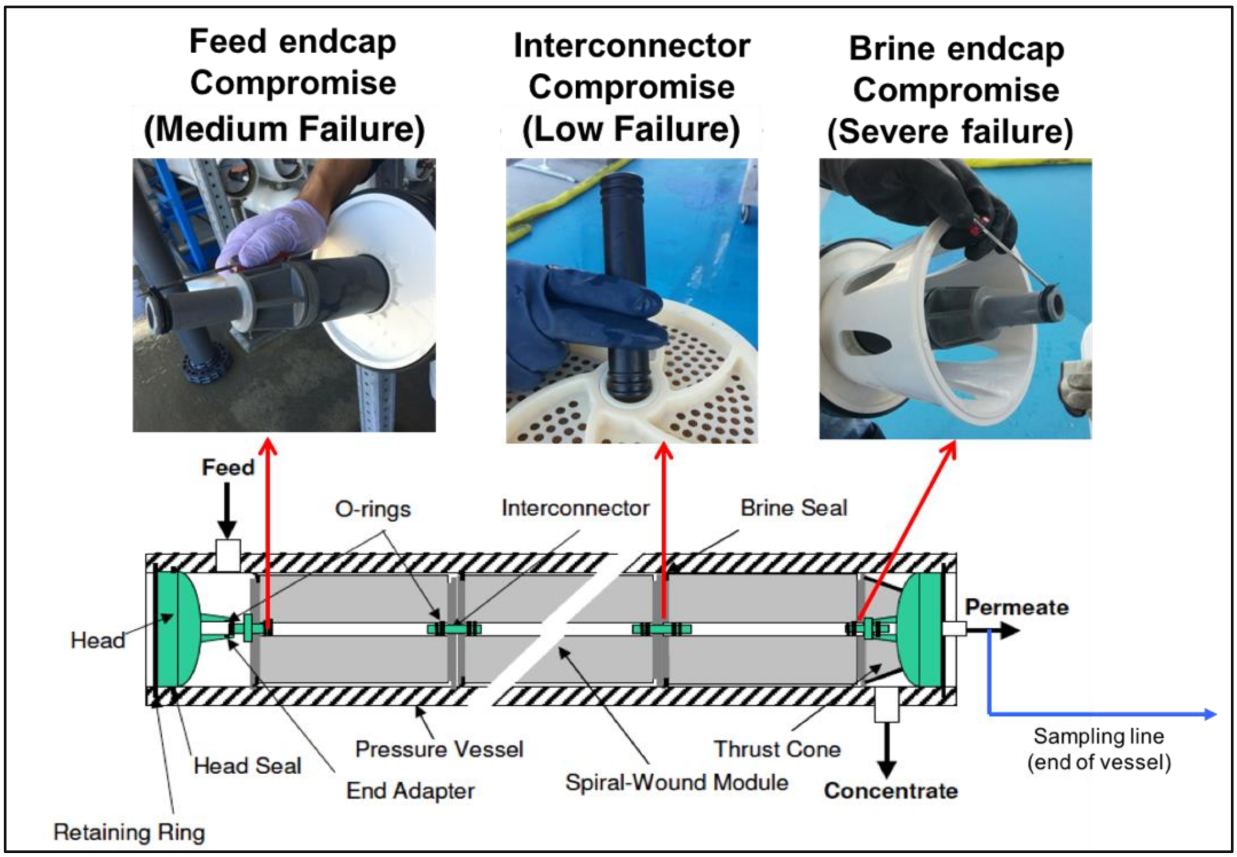


Figure 10-12: Illustration of Tested O-Ring Compromised Conditions

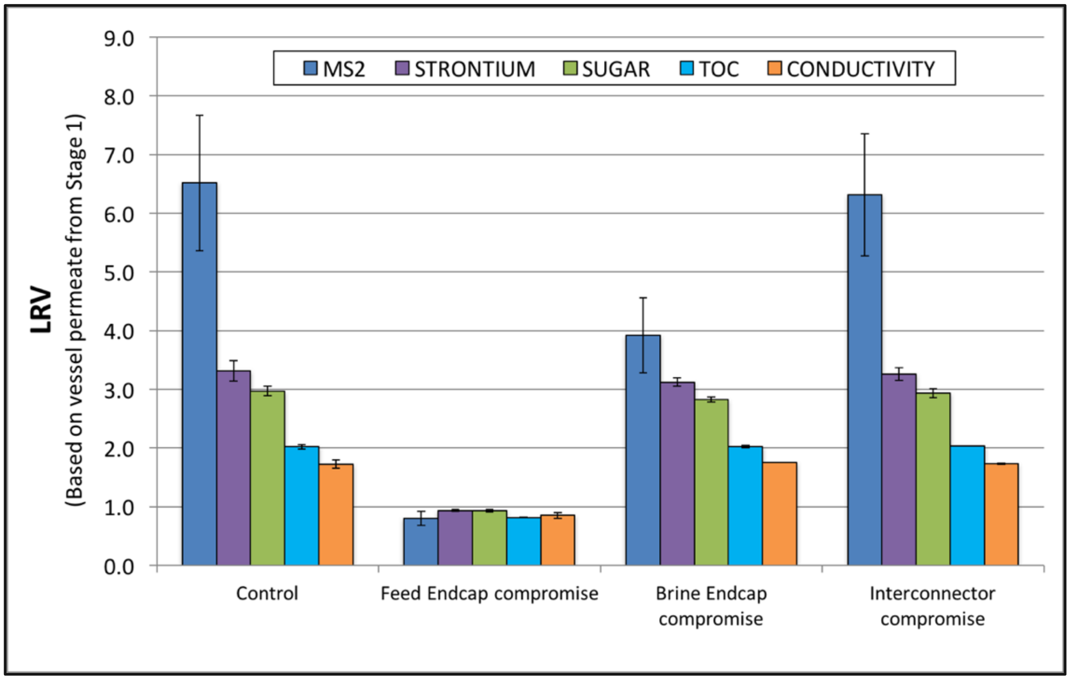


Figure 10-13: Vessel-level LRV with O-Ring Compromised Conditions (used/aged ESPA2 LD)

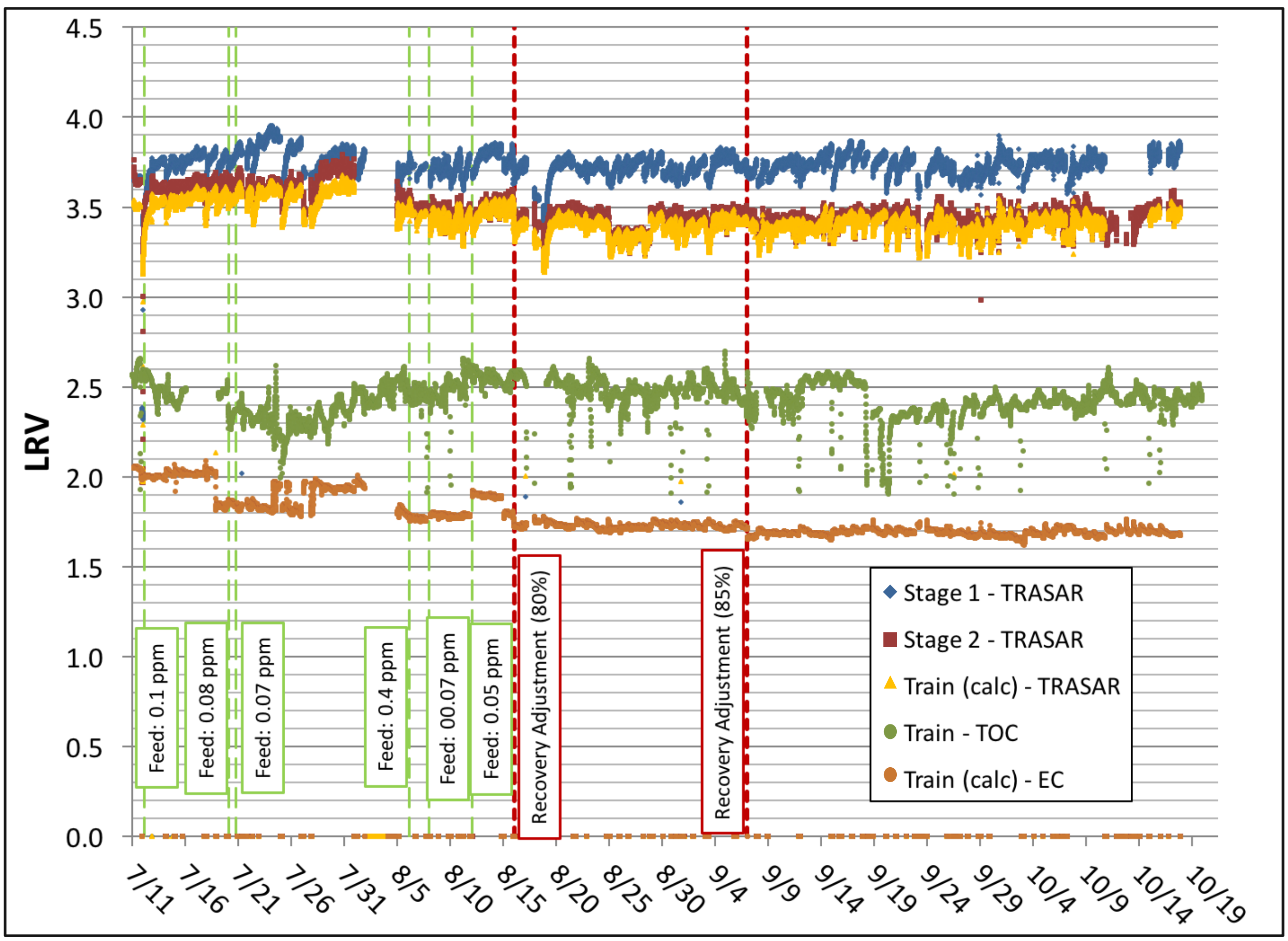


Figure 10-14: Results from TRASAR Integrity Monitoring Trial (new/virgin Toray TMG20D)

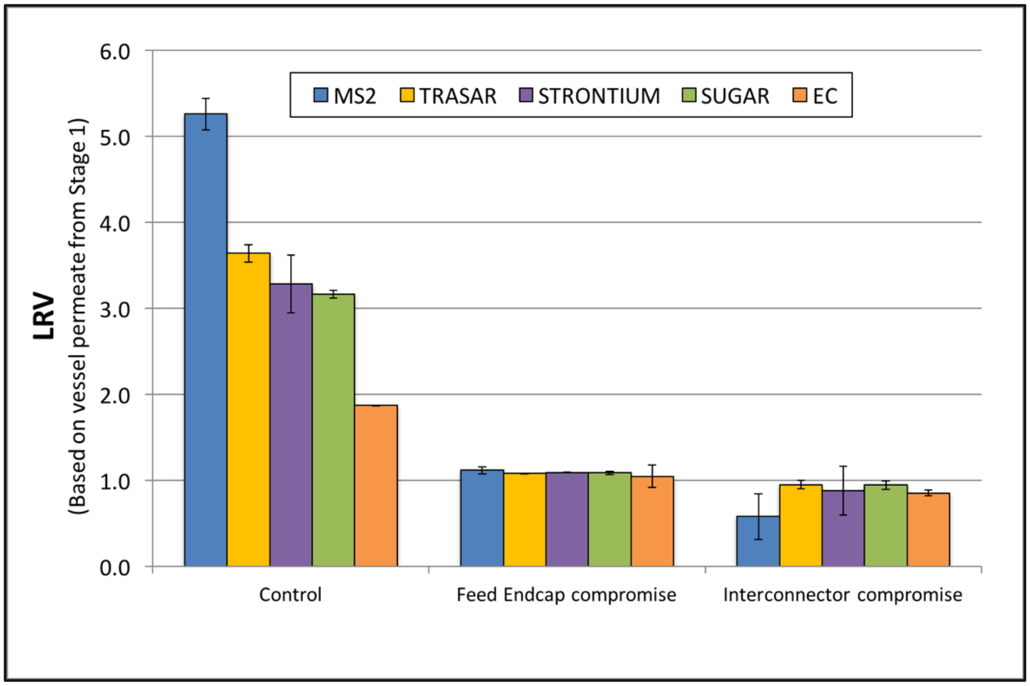


Figure 10-15: Vessel-level LRV for Intact and Compromised Membranes (new/virgin Toray TMG20D)

The following table presents obtained LRVs across different elements and sampling locations. All LRVs displayed are from intact membranes.

Table 10-8: LRVs Obtained for Different Sampling Locations and Tested Elements

Marker	Aged Hydranautics ESPA2 LD			Virgin Hydranautics ESPA2 LD	Virgin Toray TMG20D		
	Stage 1 vessel	Stage 2 combined	Train combined	Stage 1 vessel	Stage 1 vessel	Stage 2 combined	Train combined
MS2	6.5±1.2	-	-	5.4±0.8	5.3±0.2	7.0	5.0
TRASAR	-	-	-	3.5±0.4	3.6±0.1	3.4±0.1	3.5±0.1
Strontium	3.3±0.2	2.5±0.1	2.6±0.1	3.6±0.1	3.3±0.3	3.1±0.1	3.3±0.1
Sugar	3.0±0.1	2.4±0.1	2.5±0.1	3.0±0.0	3.2±0.1	3.0±0.3	3.1±0.1
TOC	2.0±0.0	1.9±0.0	2.1±0.1	2.0±0.1	2.3±0.0	2.4±0.1	2.2±0.1
EC	1.7±0.1	1.3±0.1	1.5±0.0	1.9±0.1	1.9±0.0	1.9±0.0	1.8±0.1

10.2.3.2 NCPWF Reverse Osmosis Crediting Approach

The RO monitoring strategy at the NCPWF will follow a tiered approach. The first tier will include monitoring of strontium, an alternative molecular marker, which has shown to provide a conservative assessment of MS2 rejection under both intact and compromised conditions, while providing higher LRVs than current methods. RO LRV credit will be determined by the calculated LRV of strontium from the combined RO feed through the permeate of each RO train. Strontium will be sampled every 24 hours at the combined RO feed and at the combined permeate of each RO train and analyzed using EPA Method 200.8. The lowest LRV from the RO trains will be input to SCADA. If strontium LRV data are not available, the RO LRV credit will be determined by the second tier.

The second tier will serve as a backup to the first, utilizing continuous TOC monitoring (15-min data) to assess membrane integrity. TOC will be continuously monitored at the combined RO feed and the combined RO permeate. TOC is expected to provide at least 2.0 LRV based on historical performance at the NCDPWF as presented in Table 10-8 and illustrated on Figure 10-14.

The third and last tier will consist of continuous EC monitoring (15-min data) to assess membrane integrity. Monitoring locations for this tier are identical to those of the first tier – combined feed and the permeate of each RO train. Tier 3 LRV will be applied to the entire RO system if no more than 2.0-logs can be demonstrated by the preceding tiers during normal operation.

Table 10-9 presents a summary of the tiered approach to monitor RO membrane integrity at the NCPWF. Figure 10-16 illustrates a layout of the RO system at the NCPWF with the monitoring location for each of the proposed tiers.

Table 10-9: Summary for Tiered Approach to Monitor RO System Integrity at the NCPWF

RO Monitoring Approach	Tier 1	Tier 2	Tier 3
Marker used to monitor integrity	Strontium	TOC	TDS as EC
Frequency	No less than once every 24 hours of operation	Continuous (15-min data)	Continuous (15-min data)
Monitoring location	Combined RO feed & permeate of each RO train	Combined RO feed & combined RO permeate	Combined RO feed & permeate of each RO train
Expected LRV for V/G/C	at least 2.5	at least 2.0	no less than 1.0
Proposed awarded LRV	Based on actual removal determined by tiered methodology (must meet 1.0 minimum to run at normal operation)		
Notes	Supersedes all other tiers under normal operation	Is applied if strontium data are not available	Is applied if strontium and TOC data are not available

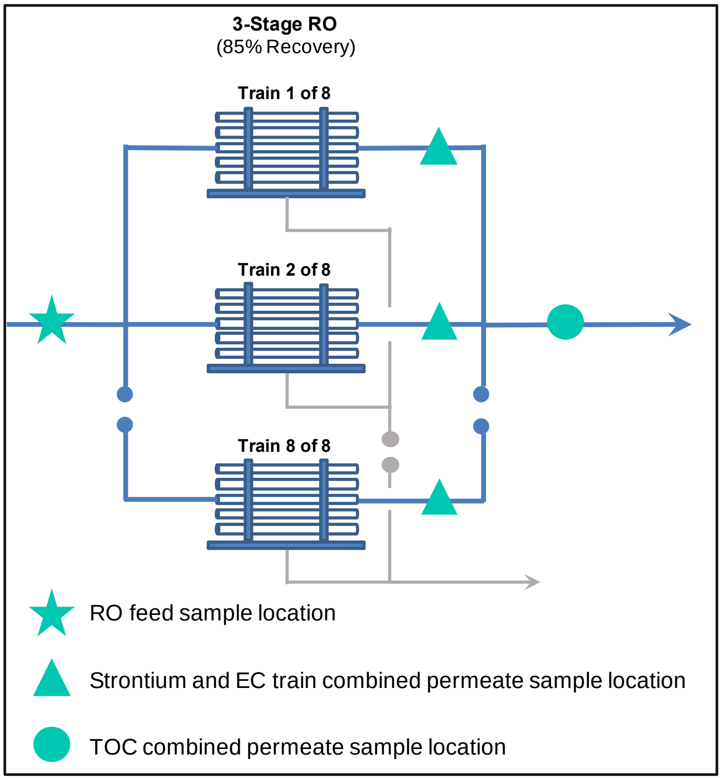


Figure 10-16: Monitoring Locations for the Tiered Approach on the NCPWF RO System

In addition to offering a tiered approach to monitor integrity, the NCPWF RO monitoring program will include scheduled vessel EC probing (i.e., vessel integrity) to identify small breaches before becoming a compliance concern for the system. Each of the 1,216 vessels will have their conductivity measured on a quarterly basis and kept in an electronic logbook to establish a historical dataset and profile on vessel conductivity. Control limits will be established to trigger a breach response whenever the vessel's conductivity is discernibly higher than a historical baseline. The breach response proposal will be included in the North City Project's OP where two types of breaches will be described: (1) severe plant-wide breaches, and (2) minor vessel level breaches. In summary, severe breaches are expected to be detected through the tiered LRV monitoring approach, such that flow would be diverted when needed. RO trains would be retroactively inspected using EC profiling until the failing vessel is located. The failing vessel would then be taken off-line and repaired. Minor breaches would be detected during quarterly scheduled vessel inspections. A minor breach would be defined as when the permeate conductivity of a vessel is above a threshold based on the historical baseline. In the case of a minor breach, the failing vessel would be taken off-line and repaired.

The reliability of the RO process in controlling virus, *Giardia,* and *Cryptosporidium* was evaluated over a 12-month period through the WRRF 14-12 Study. A copy of the final report of that study, including RO performance demonstration testing, will be submitted to DDW in a future appendix to this Title 22 Engineering Report.

10.2.3.3 NCPWF RO Crediting Approach

The LRV for the RO system will be calculated using a tiered approach:

- Tier 1: Daily calculated strontium reduction from the combined RO feed through the RO train with the highest effluent strontium (if strontium data are not available, then use Tier 2);
- Tier 2: Continuous calculated TOC reduction of overall RO system (if strontium data and TOC data are not available, then use Tier 3); and
- Tier 3: Continuous calculated EC reduction from the combined RO feed through the RO train with the highest effluent EC.

Based on the testing results presented above, the expected LRV through the RO process is presented in Table 10-10.

Table 10-10: Expected LRV Through RO

Pathogen	LRV Expected Using Tier 1	LRV Expected Using Tier 2	LRV Expected Using Tier 3
Virus	2.5	2.0	1.0
Giardia	2.5	2.0	1.0
Cryptosporidium	2.5	2.0	1.0

10.2.4 Ultraviolet Light and Advanced Oxidation Process

The next treatment process at the NCPWF is UV/AOP with free chlorine. The design UV dose for the Project is a minimum of 850 mJ/cm^2. The UV dose for the Project is driven by two requirements: (1) achieve 0.5-log reduction of 1,4-dioxane as required in the SWA regulations, and (2) ensure NDMA removal to comply with the CTR limit of 0.69 ng/L (discussed in Section 6.3.1); however, pathogens are removed with much lower UV doses.

For pathogen inactivation, the EPA's UV Disinfection Guidance Manual specifies UV doses required to achieve up to 4/4/4 reduction of V/G/C as presented in Table 10-11 (EPA 2006b). Figure 10-17 illustrates that a UV dose of 300 mJ/cm^2 provides at least 6/6/6 of inactivation for V/G/C through extrapolation of the values in Table 10-11; therefore, the minimum design UV dose of 850 mJ/cm^2, which is needed to accomplish the AOP requirements will also provide at least 6/6/6 LRV for V/G/C.

Table 10-11: UV Dose (mJ/cm^2) Required for Pathogen Inactivation (EPA, 2006b)

Pathogen	Log Inactivation							
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
Virus	39	58	79	100	121	143	163	186
Giardia	1.5	2.1	3.0	5.2	7.7	11	15	22
Cryptosporidium	1.6	2.5	3.9	5.8	8.5	12	15	22

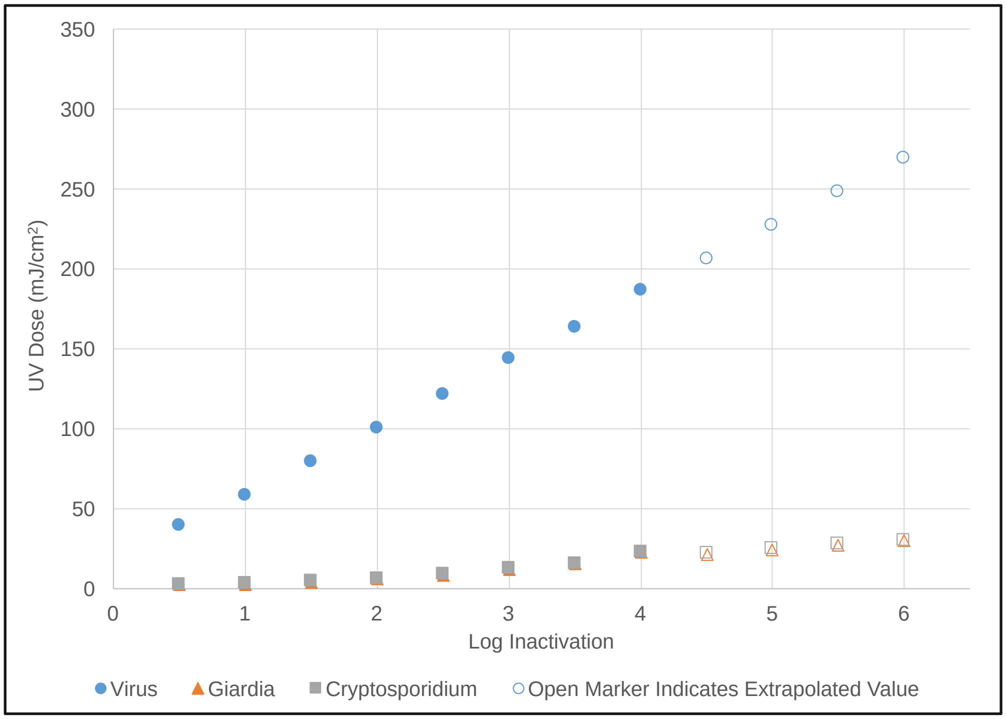


Figure 10-17: UV Dose Required for Pathogen Inactivation

Several parameters, including UV intensity, UV transmittance, and total chlorine will be continuously monitored to ensure proper functioning of the UV/AOP system and to ensure the appropriate UV and chlorine doses are being delivered. The actual dose provided by the system is a function of the intensity of the entire group of UV lamps, the UV transmittance of the water, and the flow regime. Total chlorine also provides relevant information on system performance, since the destruction of total chlorine through the reactor (calculated as influent minus effluent concentrations) can be tied to the performance of the reactor while accounting for variations in UV transmittance, flow regime, and lamp failures.

The reliability of the UV/AOP process in controlling virus, *Giardia* and *Cryptosporidium* was evaluated over a 12-month period through the WRRF 14-12 Study. A copy of the final report of that study, including UV/AOP performance, will be submitted to DDW in a future appendix to this Title 22 Engineering Report.

10.2.4.1 NCPWF UV/AOP Crediting Approach

Based on the EPA UV Disinfection Guidance Manual, the expected LRV through the UV/AOP process is presented in Table 10-12. The LRVs of 6/6/6 for V/G/C are expected if the following conditions are met:

- Feed UV Transmittance ≥ 95 percent; and
- UV Dose ≥ 300 mJ/cm^2

These conditions are indicators of the proper functioning of the UV system and are used to calculate the UV dose. If UV dose drops below 300 mJ/cm^2, no credit will be received.

Table 10-12: Expected LRV Through UV/AOP

Pathogen	LRV Expected Through UV/AOP
Virus	6
Giardia	6
Cryptosporidium	6

10.2.5 Chlorine Disinfection

Free chlorine is a powerful chemical disinfectant used with great success in improving the microbial quality of water. It is a significantly more powerful disinfectant than combined chlorine (monochloramine), reacting more rapidly and with a wider range of waterborne constituents (Tchobanoglous, Burton et al. 2004, Crittenden, Trussell et al. 2012). Free chlorine has been proven to provide superior protection compared to chloramines against both pathogens and chemical contaminants. Consequently, free chlorine requires lower doses than combined chlorine to achieve a given level of disinfection. CT requirements for both bacteria and virus inactivation in drinking water are typically two orders of magnitude lower for free chlorine than for combined chlorine (LACSD 2013, Williams 2015).

The EPA CT tables for surface water only extend to 4-log inactivation of virus. Based on the CT tables, in surface water at 20˚C with a pH of 6 to 9, a CT of 3 mg-min/L is necessary to achieve 4-log inactivation of virus (EPA 2003). Free chlorine testing in ultrafiltration filtrate has shown that a CT greater than 2 mg-min/L is capable of providing 6-log inactivation of virus (Pecson et al., submitted 2017a). Figure 10-18 illustrates the log inactivation of MS2 in ultrafiltration filtrate with different CTs, and Figure 10-19 illustrates the 5th percentile values of MS2 log inactivation with different CT ranges (Pecson et al., submitted 2017a). Given that free chlorination through the NCPW Pipeline will provide a CT much greater than 2 mg-min/L, 6-log inactivation credit for virus is expected as this is the maximum credit allowed by any treatment process.

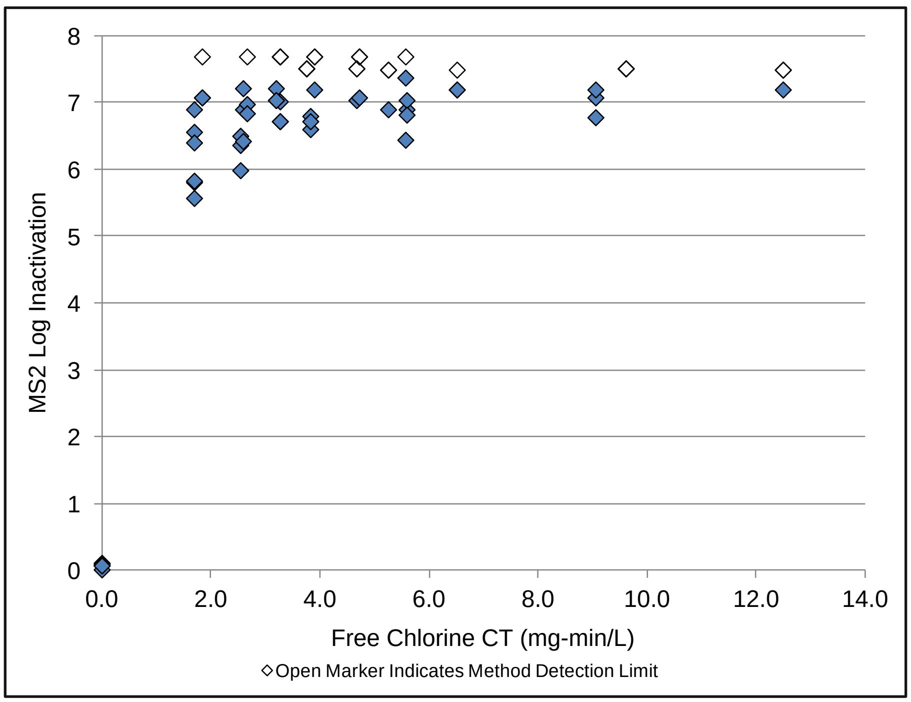


Figure 10-18: MS2 Log Inactivation in UF Filtrate with Free Chlorine (Pecson et al., submitted 2017a)

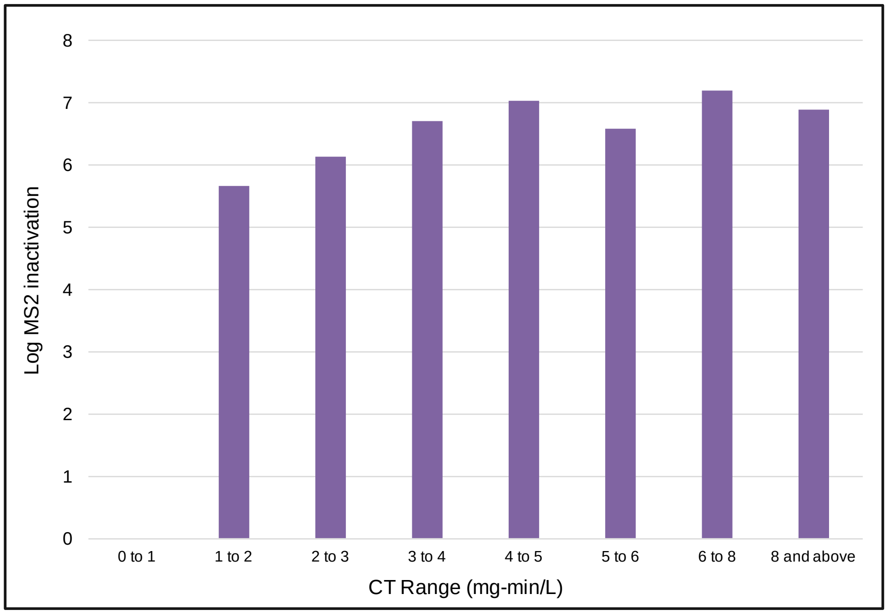


Figure 10-19: 5th Percentile Log Inactivation of MS2 in UF Filtrate with Free Chlorine (Pecson et al., submitted 2017a)

The EPA CT tables for surface water provide the required CT for *Giardia* inactivation at different temperatures and pHs. The finished water from the NCPWF is expected to have a temperature ranging from 19˚C to 29˚C and pH of 7.5 to 8.5 (MWH Americas, Brown and Caldwell et al. 2016). Based on the EPA CT tables, the maximum CT that would be required to achieve 1-log of *Giardia* inactivation in the expected water quality is 54 mg-min/L and occurs at 15˚C at a pH of 8.5 (EPA 1999).

Free chlorine will be injected into the NCPW Pipeline that will carry the NCPWF purified water to Miramar Reservoir. The NCPW Pipeline is approximately 8 miles long, with dechlorination occurring prior to discharge. Assuming a maximum daily flow of 32.8 mgd and a pipe diameter of 48 inches, the maximum velocity in the pipeline will be 4 ft per second. With this velocity, and a travel distance of 6.8 miles prior to dechlorination, the theoretical detention time in the pipe is 148 minutes or about two and a half hours. The free chlorine dosing system will be designed to achieve a chlorine residual of 1 mg/L at the dechlorination point (just upstream of dechlorination). This results in a minimum expected CT of approximately 148 mg-min/L.

10.2.5.1 NCPW Pipeline Chlorination Crediting Approach

The NCPW Pipeline is expected to receive 6-log inactivation of virus, 1-log inactivation of *Giardia,* and no *Cryptosporidium* credit as presented in Table 10-13. Chlorine residual, temperature, and pH will be continuously measured at the point of compliance to calculate a CT and log reduction for *Giardia*. Pathogen reduction for *Giardia* will be calculated using the equations below from Appendix E of the EPA Disinfection Profiling and Benchmarking Guidance Manual.

For temperature (<12.5˚C):

$$LRV = \frac{CT}{(0.353)(12.006+e^{(2.46-(0.073\times temp)+(0.125\times C)+(0.389\times pH))})}$$

Eqn. 3-3 of Appendix E of (EPA 1999)

For temperature (≥12.5˚C) and ≤ 25˚C:

$$LRV = \frac{CT}{(0.361)(-2.261+e^{(2.69-(0.065\times temp)+(0.111\times C)+(0.361\times pH))})}$$

Eqn. 3-4 of Appendix E of (EPA 1999)

where,

LRV = log reduction value
temp = temperature (˚C)
C = residual chlorine concentration (mg/L)
pH = the negative log concentration of the hydrogen ion
e = 2.7183, the base for the natural logarithm

If temperature is greater than 25˚C, a maximum of 25˚C will be used in equation 3-4 above.

Virus LRV credit of 6-log will be achieved if the calculated CT is greater than 10 mg-min/L. If the CT is less than 10 mg-min/L, Table C-7 from Appendix C of the EPA Disinfection Profiling and Benchmarking Guidance Manual will be used to determine the virus LRV.

Table 10-13: Expected LRV Through Pipeline Chlorination

Pathogen	LRV Expected Through Pipeline Chlorination
Virus	6
Giardia	1
Cryptosporidium	0

10.3 Pathogenic Microorganism Control Summary

The expected and required pathogen log reduction credits are presented in Table 10-14. The Project greatly exceeds the minimum pathogen log reduction credits that are required prior to discharge to Miramar Reservoir. An additional 4/3/2 of V/G/C will also be provided at the Miramar DWTP. Continuous and regular monitoring of the surrogate parameters used to determine LRV and monitoring of each critical control point will ensure that the Project is protective of public health at all times. A summary of the monitoring framework for each critical control point and the crediting approach for each unit process is presented in Table 10-15.

Table 10-14: Pathogen Log Reduction Expectations and Requirements

Pathogen	NCWRP[a]	Ozone/ BAC	MF	RO[b]	UV/ AOP	Pipeline Cl_2	Total Prior to Discharge to Reservoir	Required Prior to Discharge to Reservoir
Virus	0.7	6	0	2.5	6	6	21.2	10
Giardia	3.2	6	4	2.5	6	1	22.7	9
Cryptosporidium	0.9	1	4	2.5	6	0	14.4	10

[a] Subject to change upon additional pathogen monitoring
[b] RO credits based on Tier 1 and may exceed this value.

Table 10-15: Summary of Critical Control Point Framework and Pathogen LRV Credit Strategy

Process	Monitored Parameters and Locations	Performance Criteria Used to Determine Pathogen Log Reduction Credit	
		Surrogate Parameters	Credit Strategy
NCWRP	Daily SRT Continuous on-line ammonia at end of aeration basin Continuous on-line NCPWF feed turbidity (NCWRP tertiary treated water) Continuous on-line TOC feed turbidity (NCWRP tertiary treated water)	SRT running 30-day average of at least nine days Daily average ammonia ≤ 1 mg/L as N; Combined filter effluent turbidity not to exceed: ✓ Average of 1.5 NTU within 24-hour period; ✓ 2.5 NTU more than 5% of the time within 24-hour period; and ✓ 5 NTU at any time. Daily average TOC ≤ 11 mg/L	Credit received on a Pass/Fail basis if surrogate requirements are met
Ozone/BAC	Continuous ozone residual concentration at three approved locations: ✓ C_1 ✓ C_2 ✓ C_3 Continuous temperature Continuous flowrate	Rolling average of continuous calculated ozone CT based on Truncated Extended Integration and temperature corrections	Virus and *Giardia* LRV up to 6-log calculated based on ozone CT; *Cryptosporidium* LRV up to 1-log calculated based on ozone CT
MF	Continuous on-line MF filtrate turbidity for each rack Daily PDT of each rack	Indirect integrity measure: ✓ Continuous turbidity of ≤0.15 NTU for each rack in accordance with EPA 2005; Direct integrity measure: ✓ Daily PDT in accordance with EPA 2005	*Cryptosporidium* and *Giardia* LRV based on daily PDT

Continues on next page...

<table>
<tr><th rowspan="2">Process</th><th rowspan="2">Monitored Parameters and Locations</th><th colspan="2">Performance Criteria Used to Determine Pathogen Log Reduction Credit</th></tr>
<tr><th>Surrogate Parameters</th><th>Credit Strategy</th></tr>
<tr><td>RO</td><td>Daily combined:
✓ feed strontium
✓ permeate of each RO train strontium
Continuous on-line combined:
✓ feed TOC
✓ permeate TOC
✓ feed EC
✓ permeate of each RO train EC</td><td>LRV based on the removal of:
✓ Strontium
✓ TOC
✓ EC</td><td>LRV based on calculated value using a tiered approach:
<u>Tier 1:</u> Daily calculated strontium reduction from RO feed through permeate of each RO train (lowest train reduction selected) (if strontium data are not available, then use Tier 2)
<u>Tier 2:</u> Continuous calculated TOC reduction of overall RO system (if strontium and TOC data are not available, then use Tier 3)
<u>Tier 3:</u> Continuous calculated EC reduction from RO feed through permeate of each RO train (lowest train reduction selected)</td></tr>
<tr><td>UV/AOP</td><td>Continuous on-line:
✓ influent UV Transmittance
✓ influent chlorine residual
✓ flow rate
✓ UV power
✓ UV intensity</td><td>Feed UV Transmittance ≥ 95%;
UV Dose ≥ 300 mJ/cm^2</td><td>Credit received on a Pass/Fail basis if surrogate requirements are met</td></tr>
<tr><td>NCPW Pipeline Chlorination</td><td>Continuous free chlorine residual:
One-min from end of the mixing zone
✓ at dechlorination point
Continuous:
✓ temperature
✓ pH
✓ flowrate</td><td>Continuous free chlorine CT, temperature, and pH</td><td>Giardia LRV based on calculated value using equations 3-3 and 3-4 from Appendix E of the EPA Disinfection Profiling and Benchmarking Guidance Manual (EPA 1999). Virus LRV assumed to be 6 if CT is >10 mg-min/L. If CT is ≤10 mg-min/L, virus LRV determined using Table C-7 from Appendix C of the EPA Disinfection Profiling and Benchmarking Guidance Manual.</td></tr>
</table>

11. Miramar Reservoir

This section summarizes the results of a limnology and water quality study of Miramar Reservoir. It assesses the overall ability of the reservoir to accept purified water at an average annual inflow rate of 30 mgd, under different operating scenarios, with a diffuser system to distribute the inflow through a subaqueous pipeline. A more detailed description of all the information provided in this section will be included in a comprehensive report to be submitted separately (WQS 2018a).

11.1 Background on Reservoir Modeling

The City has previously completed limnological assessments and water quality modeling of San Vicente Reservoir and Otay Reservoir under various operating conditions, in support of the Pure Water Program. These modeling studies, which used state-of-the-art three-dimensional hydrodynamic and water quality models, were used to investigate the mixing and dilution of purified water in San Vicente and Otay Reservoirs, as well as the chemical and biological effects of adding purified water to the reservoirs. In particular, the mixing and dilution of a non-decaying tracer injected with purified water for 24 hours were evaluated. The results of the limnology studies indicate that both San Vicente Reservoir and Otay Reservoir will satisfy SWRCB's (DDW) proposed criteria for SWA (WQS, 2015; WQS 2018b).

In 2015, the City initiated a comprehensive limnology and water quality study of Miramar Reservoir. The study evaluates the dilution, mixing, and transport of purified water in Miramar Reservoir under various future reservoir operating scenarios. That modeling effort used the same approach and three-dimensional hydrodynamic and water quality models as those used for San Vicente and Otay Reservoirs. Figure 11-1 illustrates the location of these reservoirs. The models were calibrated using real-world data and validated against real-world tracer studies conducted at San Vicente and Otay Reservoirs. The modeling setup, calibrations, and validation were also vetted and approved by the North City Project IAP (see Section 2.6 for a description of the IAP).

The background and facilities' descriptions for Miramar Reservoir are presented in Section 6.3.3. The subaqueous pipeline design presented in Section 6.3.2.9, which includes a diffuser-type system to distribute the purified water within the reservoir, was incorporated in the model (refer to Figure 11-2). The study results include calculating dilution of purified water in the reservoir and evaluating nutrients (phosphorus and nitrogen), dissolved oxygen, and chlorophyll α concentrations (a surrogate for algal productivity).

11.2 Study Objectives

The overall objective of this limnology and water quality study is to answer the following four questions, each of which represents a possible operating scenario:

1. Does Miramar Reservoir provide adequate mixing and blending of the purified water at an inflow rate of 30 mgd at nominal reservoir level?
2. Does Miramar Reservoir still provide adequate dilution of the purified water at an inflow rate of 30 mgd at low reservoir level?
3. Does Miramar Reservoir still provide adequate dilution of the purified water at a high outflow rate of 75 mgd (maximum outflow rate from Miramar Reservoir) at nominal reservoir level?
4. Does the purified water at an inflow rate of 30 mgd affect the water quality of Miramar Reservoir, specifically algal dynamics?

One of the main criteria imposed by the SWRCB (DDW) for SWA is a 10:1 dilution of a 24-hour pulse of purified water, if an additional treatment step at the NCPWF is incorporated; therefore, the criterion of 10:1 dilution of a one-day production of purified water, simulated by a 24-hour conservative tracer, is used to evaluate dilution in Miramar Reservoir for a purified water inflow rate of 30 mgd.

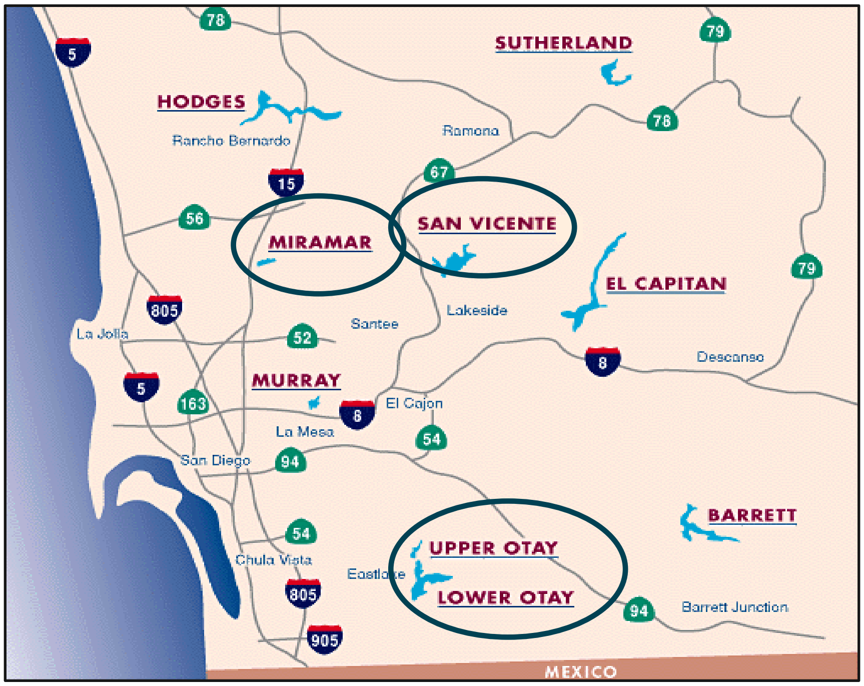


Figure 11-1: Location of Miramar, San Vicente and Otay Reservoirs

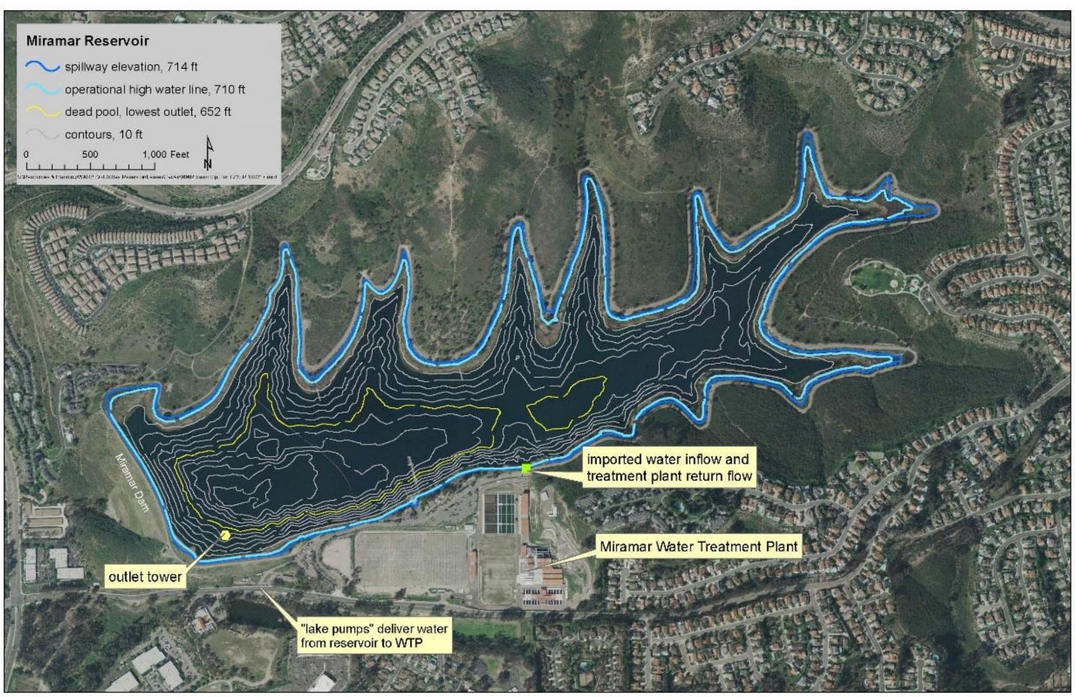


Figure 11-2: Miramar Reservoir

11.3 General Approach

The models used in this study are AEM3D for hydrodynamics and CAEDYM for water quality. AEM3D is the newer version of ELCOM, which was used in the preliminary limnology study of Miramar Reservoir (WQS, 2016). Other than a few minor upgrades, AEM3D is very similar to ELCOM, including model inputs and outputs, and solution methodologies.

The AEM3D and CAEDYM model computational grids were created using bathymetry data from a July 2015 survey of the reservoir basin. The model grid was rotated 21 degrees clockwise from North in order to align the major channels of the reservoir with the model grid axes to reduce numerical approximations. For the hydrodynamic simulations, a grid with a resolution of 20 × 20 x 0.61 meters was used. A slightly coarser grid with a resolution of 30 x 30 x 0.61 meters was used in the nutrient and algae simulations to allow for reasonable computational times. Figure 11-3 illustrates the model grid used for hydrodynamic simulations of Miramar Reservoir. It also illustrates the location of the outlet tower where water is withdrawn, as well as the imported water inflow location.

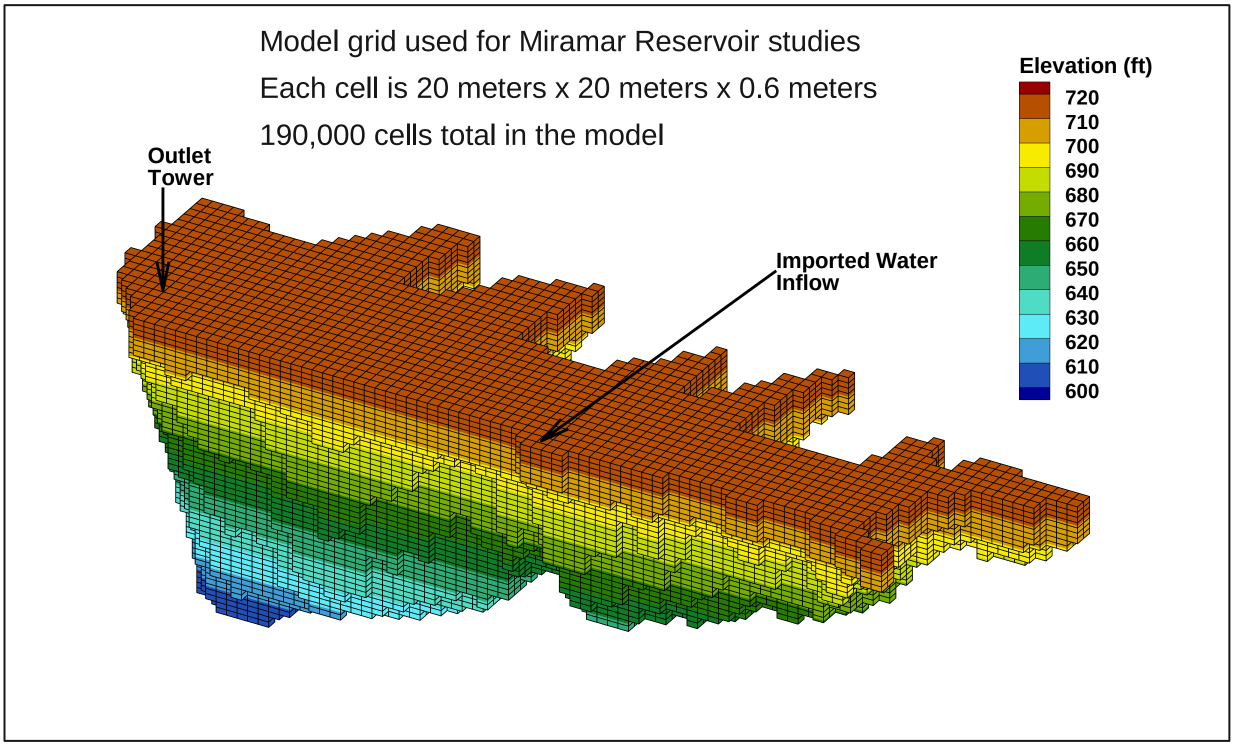


Figure 11-3: AEM3D Model Grid

Model calibration is an initial step in hydrodynamic and water quality modeling. The purpose of model calibration is to match the simulation results with the measured field data. During this process, input data specific to Miramar Reservoir are corrected if errors are identified and, consequently, some model parameters are adjusted. The model was calibrated using a two-year dataset from years 2013 and 2014, as further described in Section 11.4. Following calibration, the next step is characteristically model validation. In the case of this study at Miramar Reservoir, the model was considered validated based on model validations at San Vicente and Otay Reservoirs using real-world tracer studies.

The analytical approach for hydrodynamic modeling uses conservative tracers in AEM3D to examine the dilution of the purified water inflow to Miramar Reservoir. Conservative tracers, with an initial concentration of 100, are used to simulate dilution of the purified water inflow. The tracers are injected into the reservoir's inflow over a 24-

hour period, representing a one-day production of purified water. The tracer concentration contours visually illustrate the movement of purified water in the reservoir. The instantaneous dilution of the tracers at a specified location is obtained by dividing the source tracer concentration (i.e., 100) by the simulated tracer concentration at that location. The key location to calculate tracer concentration is the reservoir outlet (i.e., the reservoir's outlet tower).

Specific approaches and methodologies were used to provide the necessary information to address the four questions stated above, including:

- Statistical comparisons of the simulation results with the measured field data for Miramar Reservoir were used in model calibration to correct model input data and adjust model parameters;
- Statistical comparisons of the simulation results in the validation process with the measured field tracer study data for San Vicente and Otay Reservoirs were used to adjust model parameters;
- The injection of conservative tracers during both the stratified and un-stratified periods was used to examine the corresponding concentrations and peak times of these tracers in the reservoir outflow; and
- Concentrations of the 24-hour conservative tracer in the outflow under the condition of a water surface level lower than a normal operation level were used to assess the mixing ability of Miramar Reservoir at low reservoir levels.

Statistical analysis of the dilutions of these conservative tracers provided estimates of the dilution of the purified water inflow.

The goal of nutrient and chlorophyll α modeling using the CAEDYM model is to determine the effects of the purified water inflow on the reservoir's water quality, with a special emphasis on chlorophyll α, used as a surrogate for algal productivity. The analysis approach is to examine the water quality of the reservoir under the purified water inflow rate of 30 mgd and compare the results with the reservoir's water quality before augmentation with purified water.

11.4 Model Calibration

The AEM3D model describes the reservoir's hydrodynamics and the movement of the water as it is influenced by wind, solar radiation, and inflows and outflows. AEM3D's boundary conditions are set based on reservoir morphology and the structure of inlets and outlets. During calibration, model parameters are adjusted based on real-world data on inflow, outflow, solar radiation, and wind data so that model output accurately matches real-world measurements of temperature and salinity throughout the reservoir. Model validation is a separate exercise where a real-world tracer study is conducted in a reservoir and the model is used to demonstrate that it can accurately predict the movement of the tracer. In the CAEDYM model calibration, biological and chemical parameters (nutrient uptake by algae, algal growth rates, and oxygen demand) are adjusted based on real-world data. This is performed so that CAEDYM output accurately matches real-world measurements of dissolved oxygen and nutrients in the reservoir. The model calibration is discussed in this section, while the model validation is discussed in Section 11.5.

In this study, the model calibration matched simulation results with measured field data over a two-year period spanning January 1, 2013 through December 31, 2014. The comparison between the AEM3D simulation results and measured in-reservoir field data focuses on three parameters: (1) water surface elevation, (2) water temperature, and (3) conductivity. For calibrating the water quality component, the comparison between the CAEDYM simulation results and measured in-reservoir field data were performed for the following water quality parameters: dissolved oxygen, nutrients, chlorophyll α, and pH. The City routinely monitors these parameters in the reservoir and archives the data.

In general, the calibrated model well replicated the overall behaviors of the reservoir, including surface and bottom temperatures, thermocline depth, surface and bottom conductivities, dissolved oxygen, and nutrient levels in both the epilimnion and hypolimnion, and surface algal levels. Table 11-1 presents the statistical metrics for the calibration of these parameters.

Table 11-1: Summary of Model Calibration Metrics

Parameters	RMSE	Relative RMSE[a]	Mean Error[b]
Surface and Bottom Temperature	0.64 °C	4.4 %	0.09 °C
Surface and Bottom Conductivity	16.5 µS/cm	5.9 %	6.1 µS/cm
Surface and Bottom Dissolved Oxygen	0.82 mg/L	7.4 %	0.23 mg/L
Surface and Bottom Total Nitrogen	0.18 mg/L	17.2 %	0.03 mg/L
Surface and Bottom Total Phosphorus	0.05 mg/L	14.8 %	0.01 mg/L
Surface Chlorophyll α	0.44 µg/L	18.4 %	-0.06 µg/L
Surface and Bottom pH	0.20	14.2 %	0.08

[a] Relative RMSE = RMSE/$|PAR_{max} – PAR_{min}|$, where PAR_{max} and PAR_{min} are from measured data.

[b] Mean error is the average of ($PAR_{measured} – PAR_{simulated}$). PAR = parameter.

The relative root-mean-square errors (RMSEs) of a variable are affected by both the absolute values of the RMSEs and the range of the measured values of the variable. For variables with a small range in the measured values, an insignificant RMSE may result in a high value of relative RMSE. In the calibrations of the Miramar Reservoir models, the relative RMSEs vary across different parameters. In particular, water temperature, conductivity, and dissolved oxygen were predicted with lower relative RMSEs, while the nutrients, chlorophyll α, and pH were predicted with relatively higher relative RMSEs; however, for all variables, the predicted values match the measured values well. Furthermore, the temporal and spatial agreement between the model results and the data are deemed good. Thus, it is considered that the calibrations of the AEM3D and CAEDYM models were successful. More details on the model calibration are provided in Limnology Study for Miramar Reservoir (WQS, 2016; WQS, 2018a). PAR_{max} and PAR_{min} are the maximum and minimum values of a parameter (temperature, conductivity, etc.), respectively. $PAR_{measured}$ refers to a particular measured value of in-reservoir parameter, while $PAR_{simulated}$ refers to the corresponding simulated value.

11.5 Model Validation

The predecessor of AEM3D, the ELCOM model, has been validated in many studies world-wide. For the City reservoirs, a total of four model validation studies have been performed on the ELCOM and CAEDYM models. Two validation studies were performed at San Vicente Reservoir in 2012 using real-world tracer studies done in the mid-1990s. Both validation studies, one during the winter and one during the summer, showed that the models accurately predicted the movement of the tracer in the reservoir. The San Vicente Reservoir validations of the reservoir models is documented in a report titled, “Reservoir Augmentation Demonstration Project; Limnology and Reservoir Detention Study for San Vicente Reservoir – Calibration of the Water Quality Model” (FSI, 2012).

More recently, two validation studies were performed at Otay Reservoir in the spring and summer of 2014 and documented in WQS 2018b. Both Otay Reservoir tracer study datasets were rigorously compared to model predictions and vetted by the City’s IAP.

Figure 11-4 and Figure 11-5 illustrate a direct point-to-point comparison between the measured field tracer data and model predictions for the tracer studies conducted at Otay Reservoir in the spring and summer of 2014. Overall, the plot shows good agreement between the model and in-reservoir data. Results with similar accuracy were obtained for the summer 2014 validation as the spring validation. The salient statistical comparisons for both tracer studies are presented in Table 11-2. As a result of these comparisons, the IAP concluded that the ELCOM and CAEDYM models are adequately validated and stated that, “the Miramar Reservoir modeling effort by the Project Team is exemplary” (NWRI, 2016). Miramar Reservoir has no unique properties when compared to Otay Reservoir and San Vicente Reservoir that would be expected to affect the validation process; therefore, the City considers both the AEM3D and ELCOM models to be validated for Miramar Reservoir.

Table 11-2: Summary of Model Validation Metrics at Otay Reservoir

Parameter	Number Of Data Points	RMSE	Relative RMSE[a]	Mean Error[b]
Spring 2014: Tracer Concentrations at All Monitoring Stations	1412	902	5.2 %	-84
Summer 2014: Tracer Concentrations at All Monitoring Stations	1302	650	4.9 %	-70

[a] Relative RMSE = RMSE / $|Conc_{max} – Conc_{min}|$, where $Conc_{max}$ and $Conc_{min}$ are from measured data.

[b] Mean error is the average of ($Conc_{measured} – Conc_{simulated}$). Conc= concentration.

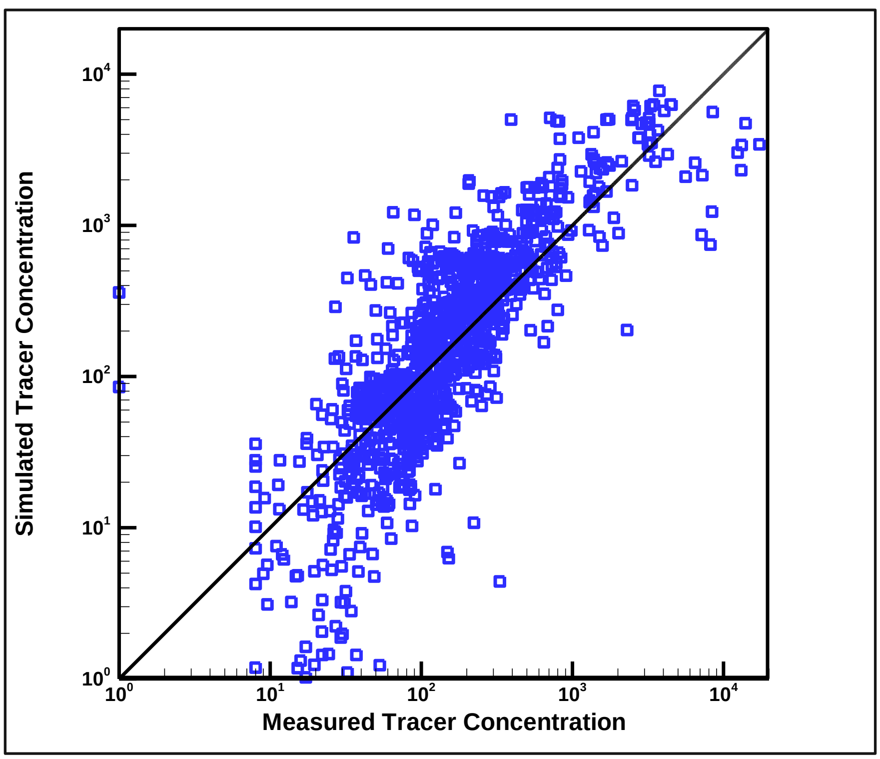


Figure 11-4: Scatter Plot of Measured vs. Simulated Tracer Data for Spring 2014 Tracer Study at Otay Reservoir

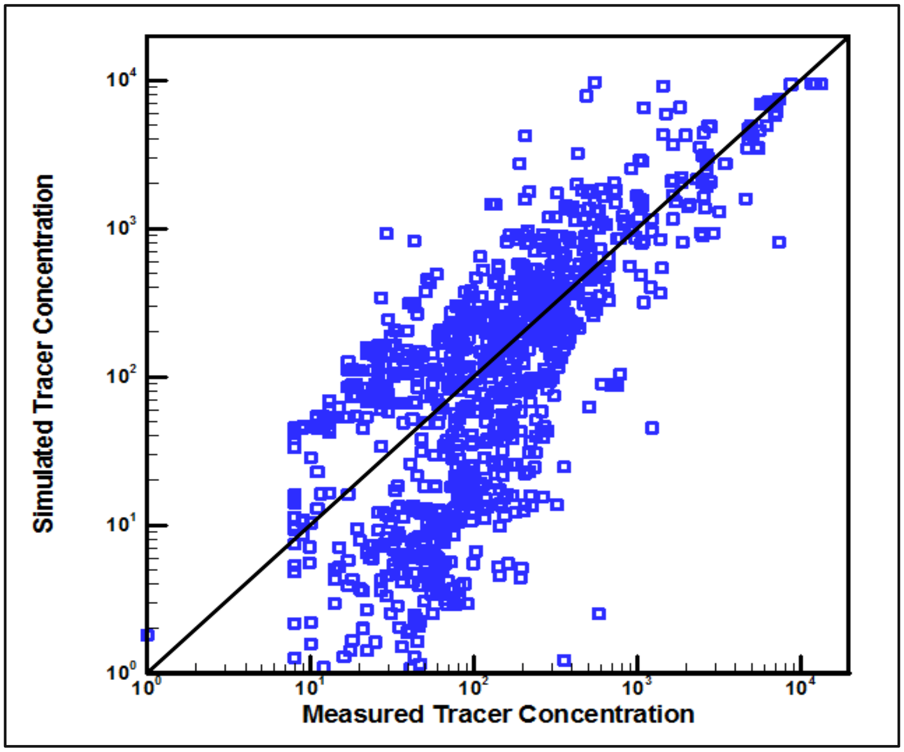


Figure 11-5: Scatter Plot of Measured vs. Simulated Tracer Data for Summer 2014 Tracer Study at Otay Reservoir

11.6 Modeling Conditions

After calibrating the model for Miramar Reservoir, and validation at San Vicente and Otay Reservoirs, various reservoir operating conditions at Miramar Reservoir were simulated using AEM3D and CAEDYM in order to achieve the study goals.

11.6.1 Hydrodynamic Modeling

The modeling conditions used for this hydrodynamic study are:

- Two-year model runs using meteorological and hydrological data from years 2013 and 2014;
- One average annual purified water inflow rate of 30 mgd (design value for the project) with daily inflow rates ranging from 23 mgd in (summer months) to 33 mgd (winter months);
- Two different reservoir outflow rates; and
    - Nominal Outflow Rate of 30 mgd (nominal reservoir water withdrawal operating scenario) with the reservoir volume staying relatively constant by matching inflows and outflows.
    - Outflow Rate of 75 mgd (high rate reservoir water withdrawal operating scenario) with the reservoir's volume staying relatively constant by limiting the high outflow rate to a period of three days.
- A diffuser system to distribute the inflow through a subaqueous pipeline. The diffuser system is illustrated on Figure 11-6 and discussed in Section 6.3.2.9. The inflow is distributed through diffuser ports. The diffuser design has 94 ports, (depicted as outlets on Figure 6-34), with approximately 20-ft spacing between every two adjacent ports. Each port features two openings discharging at a 60-

degree angle above the horizontal in opposite directions. The outflow velocity from each port is in the range of 12 to 16 ft per second;

- Two reservoir operating levels;
    - Nominal Reservoir Level: Operating reservoir level of 706 ft, which corresponds to a water volume of approximately 5,500 AF. This is the level that Miramar Reservoir is expected to be operated at with a relatively constant water surface elevation.
    - Low Reservoir Level: Operating reservoir level of 696.6 ft, which corresponds to a water volume of approximately 4,275 AF. This is what is considered the low level at which the reservoir may be drawn down on occasion.
- Various open outflow ports on the reservoir outlet tower. Figure 6-36 illustrates the cumulative reservoir volume, the water surface elevation, and the elevations of the outlet tower's four outlet ports. All simulations presented in this report used the highest available port for withdrawals from the reservoir, which are Port #4 for the Nominal Reservoir Level, and Port #3 for the Low Reservoir Level.

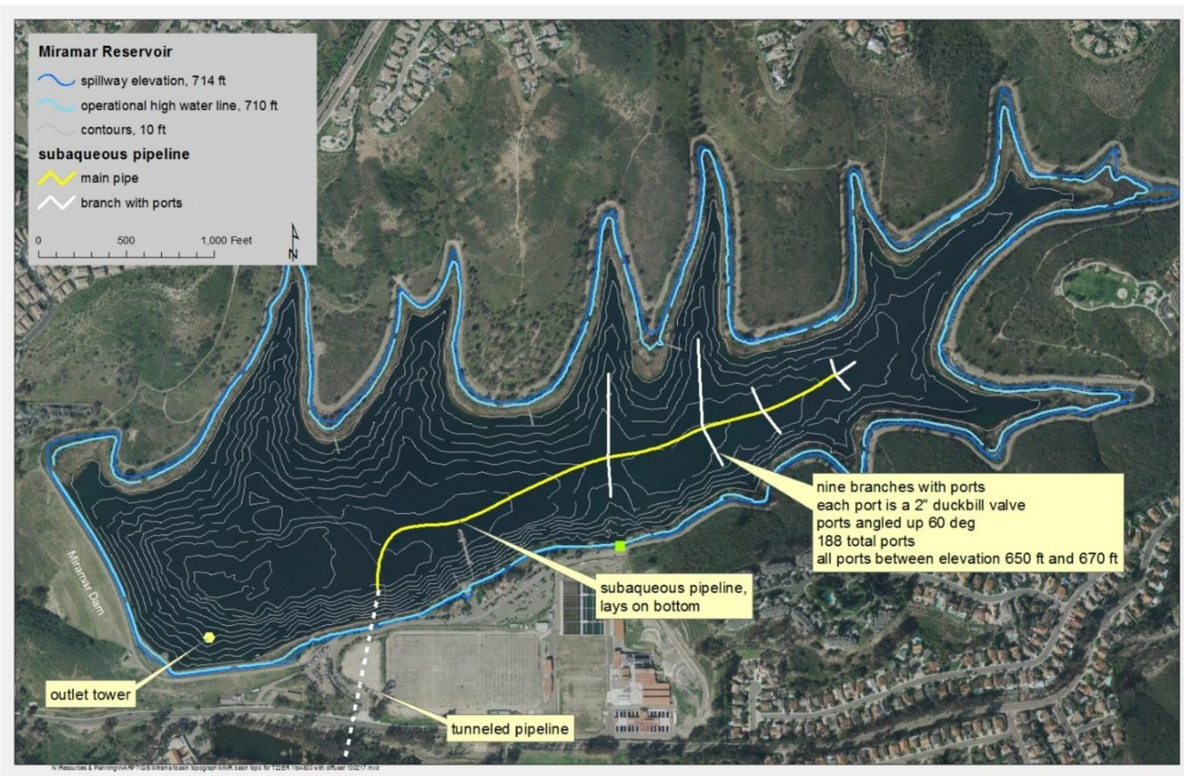


Figure 11-6: Miramar Reservoir Subaqueous Pipeline and Diffuser System

In each hydrodynamic model run, conservative tracers were introduced through the purified water diffuser system. For the model runs of Nominal Reservoir Level and Low Reservoir Level, one tracer was injected each week for two years. Thus, for these two-year model runs, 104 conservative tracers were injected into the reservoir in order to calculate the lowest dilution factor at a certain degree of confidence. For the model run of High Outflow, one tracer was injected on each date when high-rate outflow was withdrawn, and there were a total of 10 conservative tracers in this run. The tracer injection dates (or the high outflow dates) were a combination of days with lowest dilutions from the model run at Nominal Reservoir Level and a few seasonal days to represent year-round conditions. Table 11-3 presents the operating conditions for the three AEM3D model runs performed in this study. The model run number reflects the order in which the runs were performed.

Table 11-3: Summary of AEM3D Model Runs at Miramar Reservoir

Model Run No.	Operating Scenario	Initial/Final Reservoir Water Volume (AF/AF)	Outflow Rates	Open Outlet Port	Number of Tracers
1	Nominal Reservoir Level	5,500/5,500	Nominal (30 mgd)	#4	104
2	Low Reservoir Level	4,275/4,275	Nominal (30 mgd)	#3	104
3	Nominal Reservoir Level	5,500/5,500	High (75 mgd)	#4	10

After the model runs were performed, statistical analysis of the dilutions of the 104 conservative tracers provided estimates of the dilution of the purified water inflow. The dilution factors, which are the minimum dilutions of the tracers, were assumed to follow normal or log-normal distribution. An “outlier” analysis was conducted to separate the dilution factors data into different groups if they did not fall in a single group of normal or log-normal distributed data. The data in the lowest dilution factor group were plotted as a probability graph, and a best-fit straight line through this group of data were used to calculate the lowest dilution factor at 99.9 percent degree of confidence (p=0.1 percent). An example of this probability analysis for the calculation of the lowest dilution factor is illustrated in Figure 11-7. Further, details of the statistical methodology can be found in the Limnology and Detention Study for Miramar Reservoir (WQS, 2018a in progress). Additional discussion on this methodology can be found in an IAP technical memorandum dated September 27, 2016 (NWRI, 2016).

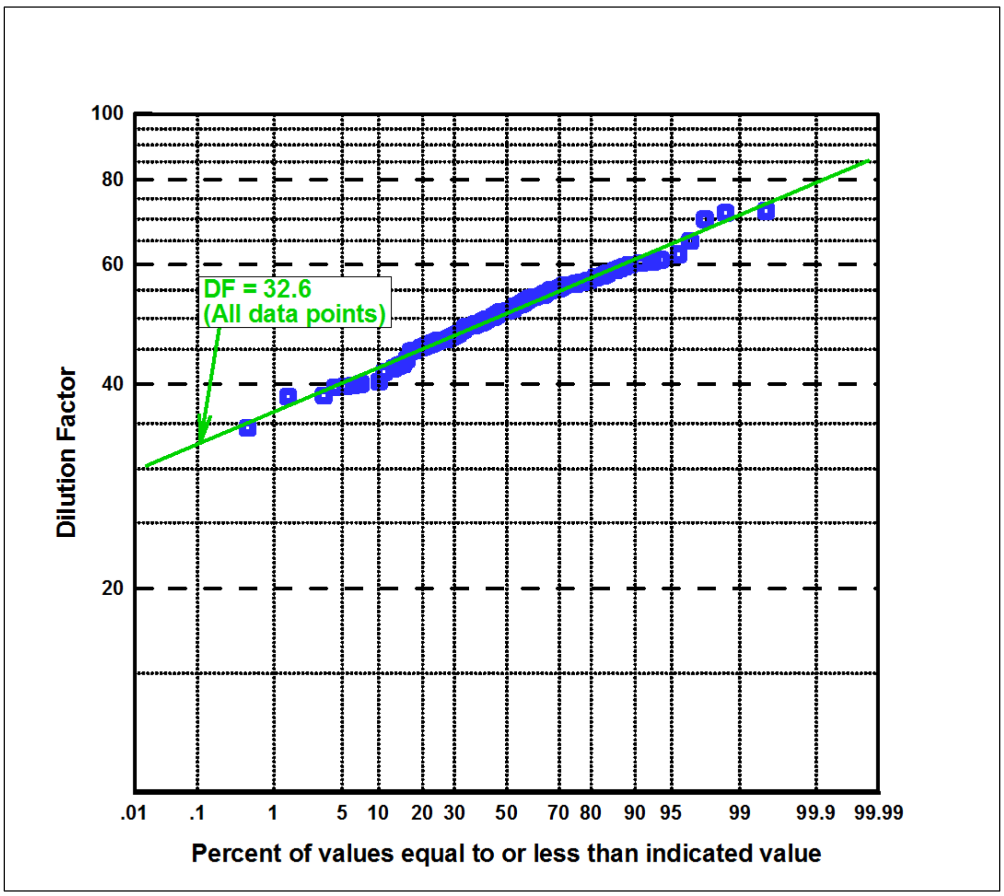


Figure 11-7: Probability Analysis of Dilution Factors

11.6.2 Nutrient and Algae Modeling

Using CAEDYM, four nutrient and algae modeling runs were performed for the purified water inflow rate of 30 mgd under the nominal reservoir level. A summary of the modeling conditions for these four model runs is presented in Table 11-4. In addition to the nutrient loadings from inflows and internal nutrient loadings from anoxic sediments, this study also considered some newly-identified nutrient loadings from atmospheric deposition, birds, aquatic shoreline plants, etc. These newly-identified nutrient loadings were assessed to have magnitudes comparable to the nutrient loadings from water inflows. Since the algal growth in Miramar Reservoir is controlled by phosphorus (WQS, 2016), it is important to add these newly-identified nutrient loadings, especially phosphorus, to the water quality modeling of Miramar Reservoir. The additional total phosphorus loading is estimated to be between 0.308 kg/day – 0.654 kg/day for the moderate loading scenario, and between 0.613 kg/day – 1.055 kg/day for the high loading scenario (Dudek 2017). In this study, one of the model runs simulated the condition of high newly-identified nutrient loadings, while the other three model runs simulated the conditions of moderate newly-identified nutrient loadings.

The water quality parameters of the purified water inflow used in the CAEDYM model runs were based on the first year of operation at the NCDPWF. The purified water inflow has relatively high total nitrogen concentrations (0.78 mg/L) and relatively low phosphorus concentrations (three different concentrations considered here: 0.004 mg/L, 0.007 mg/L, and 0.010 mg/L), departing from the typical algal usage of N:P of approximately 10:1 (Horne and Goldman, 1994).

Unlike the two-year hydrodynamic model runs, the nutrient and algae model runs were performed for a four-year period in order to investigate the longer-term effects of the purified water on water quality in Miramar Reservoir. To achieve a four-year model period, the overall model inputs of the second two-year simulation period (inflows, outflows, and meteorological data) are simply a repetition of the first two years. Similar to the hydrodynamic model runs, the nutrient and algae model runs simulate the distribution of the purified water inflow into the reservoir through the diffuser system.

Table 11-4: Summary of CAEDYM Model Runs[a]

Model Run No.	TP Concentration in PW (mg/L)	Newly-identified Nutrient Loadings
1	0.004	Moderate
2	0.004	High
3	0.007	Moderate
4	0.010	Moderate

[a]Note all CAEDYM model runs are based on nominal reservoir level with an initial reservoir water volume of approximately 5,500 AF and a final reservoir water volume of approximately 5,500 AF.

11.7 Model Run Results

Results from the modeling of Miramar Reservoir are provided in this section. Table 11-5 and Table 11-6 present the results of the hydrodynamic model runs; including various dilution factor statistics of mean, standard deviation, minimum observed value, and calculated value at 99.9 percent confidence level. Note that the comparison between the model run of High Outflow and the model run of Nominal Reservoir Level shows that the outflow rate (at constant WSEL) does not significantly affect the dilution. Tables 11-7 and 11-8 present the results of the nutrient and algae model runs. Specific answers to the four main study questions outlined earlier in this section are also provided below. Also note that these results are for model runs using Port #4 (nominal reservoir level) or Port #3 (low reservoir level).

Table 11-5: Summary of AEM3D Model Run Results (Nominal Reservoir Level and Low Reservoir Level)

Model Run No.	Operating Scenario	Outflow Rates	Open Outlet Port	Dilution Factor Statistics			
				Mean	Standard Deviation	Minimum	Value at 99.9% Confidence Level
1	Nominal Reservoir Level	Nominal	#4	51.2	7.3	34.5	32.6
2	Low Reservoir Level	Nominal	#3	37.6	5.5	24.9	23.9

Table 11-6: Comparison of AEM3D Model Run Results (Nominal Reservoir Level vs. High Outflow)

Operation Scenarios	Average Dilution Factor[a]	Minimum Dilution Factor[a]	Maximum Dilution Factor[a]
Nominal Reservoir Level	42.7	34.5	50.8
High Outflow	42.7	35.0	51.3

[a] Based on the 10 conservative tracers used in the model run of High outflow.

Table 11-7: Summary of Simulated Dissolved Oxygen

Year	Before Purified Water		Moderate Nutrient Loadings[a]		High Nutrient Loadings	
	Bottom Anoxia Period[b]	Days Under Anoxia: Total Days (Percentage)	Bottom Anoxia Period[b]	Days Under Anoxia: Total Days (Percentage)	Bottom Anoxia Period[b]	Days Under Anoxia: Total Days (Percentage)
Year 1	5/11 –12/11	214 (59%)	4/5 – 12/9	249 (68%)	4/5 – 12/9	249 (68%)
Year 2	5/10 – 12/19	224 (61%)	5/4 – 12/1	212 (58%)	5/4 – 12/1	212 (58%)
Year 3	N/A	N/A	5/21 – 12/5	199 (55%)	5/21 – 12/5	199 (55%)
Year 4	N/A	N/A	5/6 – 11/25	204 (56%)	5/6 – 11/29	208 (57%)

[a] Dissolved oxygen does not change greatly with phosphorus loadings in purified water. All three model runs with moderate nutrient loadings had similar results for dissolved oxygen.

[b] Anoxia is defined here as the bottom dissolved oxygen being less than 0.5 mg/L.

Table 11-8: Summary of Chlorophyll α

Year	Average Surface Chlorophyll α (µg/L)				
	Calibration	High Nutrient Loadings	Moderate Nutrient Loadings		
		TP = 0.004 mg/L in PW	TP = 0.004 mg/L in PW	TP = 0.007 mg/L in PW	TP = 0.010 mg/L in PW
Year 1	0.47	0.28	0.26	0.31	0.36
Year 2	0.37	0.21	0.21	0.22	0.23
Year 3	N/A	0.24	0.22	0.27	0.34

Continues on next page…

Year	Average Surface Chlorophyll α (µg/L)				
	Calibration	High Nutrient Loadings	Moderate Nutrient Loadings		
		TP = 0.004 mg/L in PW	TP = 0.004 mg/L in PW	TP = 0.007 mg/L in PW	TP = 0.010 mg/L in PW
Year 4	N/A	0.21	0.21	0.21	0.23
First-Two-Year Average	0.42	0.25	0.24	0.27	0.30
Four-Year Average	N/A	0.24	0.23	0.25	0.29

1. ***Does Miramar Reservoir provide adequate mixing and blending of the purified water at an inflow rate of 30 mgd at a nominal reservoir level?*** Yes, with the use of the diffuser system, Miramar Reservoir provides adequate mixing and blending of the purified water at an inflow rate of 30 mgd and a nominal reservoir level. The observed overall minimum dilution was 34.5, and is greater than the required dilution of 10:1 for a 24-hour tracer. The predicted minimum dilution at a 99.9 percent degree of confidence was 32.6, and meets the requirement.

2. ***Does Miramar Reservoir still provide adequate dilution of the purified water at an inflow rate of 30 mgd at a low reservoir level?*** Yes, with the use of the diffuser system, Miramar Reservoir provides adequate mixing and blending of the purified water at an inflow rate of 30 mgd and a low reservoir level. The observed overall minimum dilution was 24.9, and is greater than the required dilution of 10:1 for a 24-hour tracer. The predicted minimum dilution at a 99.9 percent degree of confidence was 23.9, and meets the requirement.

3. ***Does Miramar Reservoir still provide adequate dilution of the purified water at an outflow rate of 75 mgd at a nominal reservoir level?*** Yes, with the use of the diffuser system, Miramar Reservoir provides adequate mixing and blending of the purified water at an inflow rate of 75 mgd and a nominal reservoir level. The observed overall minimum dilution was 35.0, and is greater than the required dilution of 10:1 for a 24-hour tracer.

4. ***Does the purified water at an inflow rate of 30 mgd affect the water quality of Miramar Reservoir, specifically algal dynamics?*** Yes, with the use of the diffuser system, the purified water will affect the water quality of Miramar Reservoir. The water quality study shows that a purified water inflow rate of 30 mgd is predicted to produce lower algal levels (i.e., lower surface chlorophyll α concentrations) and higher water clarity. The purified water inflow will gradually reduce algal levels and increase water clarity. In the calibrations, the two-year average chlorophyll α level is 0.42 µg/L; while the average chlorophyll α levels for the first two years were predicted to range from 0.24 µg/L to 0.30 µg/L for the future scenarios with various TP concentrations in the PW inflow. This is related to the generally low phosphorus concentrations in the purified water. Based on the nutrient data in the inflows, algal growth in Miramar Reservoir is expected to be limited by phosphorus.

11.8 Compliance with Dilution Criteria Using Selected Outlet Ports

To optimize treatability at the Miramar DWTP, the City needs to preserve the option of selective level draft from Miramar Reservoir. To do this, the City will preserve the option of using any outlet port, or combination of ports, so long as it can be demonstrated that the 10:1 dilution will be achieved. Dilution will be demonstrated by the following two methods:

1. Complete a modeling run for a scenario of open port(s), WSEL, and outflow rate using a number of hypothetical tracers over a long span of time, yielding sufficient data such that a statistical analysis shows 10:1 dilution at a 99.9% confidence level; this is the approach described above and illustrated on Figure 11-7; or

2. Perform a model run under unique time-specific conditions (i.e., “in-the-moment” conditions of WSEL, inflow, outflow, open outlet port, reservoir, and meteorological data) that shows the 10:1 dilution is achieved for that specific situation.

Earlier hydrodynamic modeling of Miramar Reservoir (WQS, 2016) had focused on the use of Port #2. Additional hydrodynamic modeling completed in late 2017 demonstrates that using outlet ports other than Port #2 achieves the 10:1 dilution criteria. Completed model simulations and statistical analyses of the model outputs demonstrate the four following conclusions:

1. At nominal WSEL of 706 feet, outlet Port #4 (the shallowest port) will yield greater than 10:1 dilution, with 99.9 percent confidence.
2. At low WSEL of 696.6 feet, outlet Port #3 (the shallowest available port at this WSEL) will yield greater than 10:1 dilution, with 99.9 percent confidence.
3. A combination wherein Ports #1, #3, and #4 are open, or all four ports are open, will likely achieve the 10:1 dilution. While the package of modeling scenarios and statistical analysis for these situations has not been completed, it is expected that further work will demonstrate the required dilution at 99.9 percent using these combinations of ports.
4. Dynamic (i.e., in-the-moment) modeling using contemporaneous reservoir and meteorological data can demonstrate the required dilution at a specific time and under specific conditions.

Based on the above, the following five measures will be used to demonstrate compliance with the 10:1 dilution criteria:

1. Use of Port #4, at a WSEL of 706 feet, under any conditions, is expected to be approved. Port #4 provides 10:1 dilution with a high confidence level; and is considered “set and forget.” However, for safety reasons, an outlet port must not be less than 5 feet deep; therefore, Port #4 will not be available at lower WSEL.

2. At WSEL between 696.6 and 701 ft , use of Port #3, under any conditions, is expected to be approved. At these lower WSELs, Port #3 provides 10:1 dilution with a high confidence level; and is considered “set and forget.”

3. Use of Ports #1, #3, and #4 (all three open), or use of Ports #1, #2, #3, and #4 (all four open), under any conditions, is expected to be approved after completion of further hydrodynamic modeling. These combinations will be shown to provide 10:1 dilution with a high confidence level. The City will complete the appropriate modeling scenarios before project startup, and these port combinations would then become approved “set and forget” options.

4. For other ports or port combinations, dynamic modeling using contemporaneous data will be used to demonstrate the required dilution is achieved. This is an “in-the-moment” assessment of dilution under specific conditions. After consultation with DDW, the specific conditions and port(s) will be allowed.

5. The City may choose to complete a package of model scenarios for other ports or combinations of ports (e.g., Port #1 alone, or Ports #1 and #2 together), or WSELs lower than 696.6, to demonstrate 10:1 dilution is achieved at a 99.9 percent confidence level. After consultation with DDW, these would become approved “set and forget” options.

11.9 Mean Theoretical Hydraulic Retention Time

To protect public health, potable reuse projects can use a number of system elements: source control, treatment, monitoring, dilution, response time, and failure response features. The water industry is becoming increasingly aware that there is no “ideal” combination of these elements, and there are multiple ways to configure these elements to provide equivalent levels of public health protection. This awareness is evident in the existing Title 22 Water Recycling Criteria for groundwater replenishment using recycled water (CCR, 2014), where shorter retention times in the environment are allowed provided that higher degrees of treatment and monitoring are achieved[1]. A similar balance is evident in SWRCB (DDW) SWA regulations with regard to treatment and dilution – lower levels of dilution (10:1) are acceptable if additional treatment barriers are implemented (additional 1-log required).

The Miramar Project proposes an alternative that is a progression of this same logic. The provision of treatment, monitoring, and resiliency features have been enhanced to reduce the need for long reservoir theoretical retention time requirements. It should be stressed that this reservoir augmentation project continues to benefit from the many advantages provided by the reservoir. The project alternative maintains the spirit of the SWA regulations, differing only in its rebalancing of the theoretical retention time requirement with other system elements.

At an average reservoir withdrawal rate of 30 mgd (33,600 AFY) and a typical reservoir volume of 5,600 AF, the theoretical average retention time for purified water in Miramar Reservoir will be at least sixty days. The reservoir volume and reservoir outflow (withdrawal rate) are the two variables that will determine retention time. The City will develop operational guidelines for Miramar Reservoir that will ensure compliance with the theoretical average retention time criteria of the SWA regulations.

Per the SWA regulations, the calculation of mean theoretical hydraulic retention time is based on the reservoir volume at the end of a month and the total water withdrawn from the reservoir during that month. Mean theoretical hydraulic retention time is expressed in units of days. Thus, three pieces of information are needed, as follows:

1. $V_{RESERVOIR}$ – storage volume in the reservoir. The reservoir volume is determined from the water surface elevation (WSEL); this shows on the DWTP daily report as “lake level.” WSEL is read and recorded daily; the reading for the last day of the month will be used. Reservoir volume is then determined by referring to the area-capacity table for Miramar Reservoir. Units are AF.

[1] The Title 22 Water Recycling Criteria for groundwater replenishment using recycled water require a minimum of six-month theoretical retention time for projects utilizing tertiary, disinfected recycled water, whereas theoretical retention times down to two months are allowed for projects utilizing full-advanced treatment.

2. $V_{OUTFLOW}$ – volume of outflow from the reservoir. The volume of the outflow from the reservoir is accurately measured by a meter on the pipeline from the lake pumps to the Miramar DWTP. This shows on the Miramar DWTP daily report as MLPS Flow. The data are both an instantaneous flow rate and daily totalizer reading. Daily totalized values will be summed for the month. Units are AF.
3. d – days. The number of days in the month. Units are days.

The formula for calculation of mean theoretical hydraulic retention time is:

$$\text{MTHDT, days} = (V_{RESERVOIR} / V_{OUTFLOW})\ d$$

12. Drinking Water Supply System

The City's drinking water supply system is divided into three service areas that are served by three water treatment plants (Miramar, Alvarado, and Otay DWTPs) utilizing several treatment processes to provide safe drinking water to the public. The plants are managed by the City's PUD; most of the water treated at the City's three DWTPs is imported water that is delivered through the SDCWA System. All three DWTPs are located adjacent to source water reservoirs that dually serve to regulate the availability of water to each DWTP and function as emergency and operational storage. Connection points for both raw and treated water are illustrated on Figure 12-1, along with the City's larger reservoirs and pipelines.

The Miramar DWTP began operation in 1962. The City recently completed a 14-year multi-phase expansion and upgrade to ensure future customer demands and more stringent drinking water standards and regulations are met. Currently, the Miramar DWTP has a capacity of 144 mgd and provides drinking water to an estimated 500,000 customers in the northern section of the City and is located in the Scripps Miramar Ranch community.

The Miramar DWTP has participated in the American Water Works Association's Partnership for Safe Water Program since 2012. The mission of that program is to improve the quality of drinking water delivered to customers of public water supplies by optimizing system operations. Participation in that program has involved an extensive self-assessment, the optimization of plant operations, and a report documenting the City's efforts and plant performance. Based on the Miramar DWTP's staff efforts, the plant was awarded the Partnership's Director's Award in November 2012. In continuing its efforts to achieve a more fully optimized system, the Miramar DWTP was subsequently awarded the Partnership's President's Award in June 2013. Currently, there are only five other treatment plants in the United States that have received this prestigious award.

This section details the key components of the drinking water supply system that are relevant to the Project. These three components include: (1) Drinking Water Source Waters, (2) DWTP, and (3) Drinking Water Distribution System.

12.1 Drinking Water Source Waters

Under current operating conditions, influent to the Miramar DWTP is almost exclusively imported water delivered via a single connection to the SDCWA Second San Diego Aqueduct. This aqueduct contains a blend of water from the Colorado River and rivers in Northern California delivered through the Colorado River Project and State Water Project, respectively. As illustrated on Figure 6-40, imported water can be delivered directly to the Miramar DWTP or stored in Miramar Reservoir before being pumped to the Miramar DWTP. Miramar Reservoir's dominant use is municipal water supply and subordinate uses are limited to recreational activities. As mentioned in Section 6.3.3, the local watershed contributes essentially no runoff to Miramar Reservoir.

Following Project start-up, purified water from the NCPWF will flow into Miramar Reservoir continuously at an average annual rate of 30 mgd. At start-up, the reservoir will mainly contain imported water. Over time, this imported water will be replaced by the purified water, eventually reaching a steady state condition where the reservoir comprises essentially 100 percent purified water. The annual rainfall runoff will be less than 1 percent of the purified water volume that will be delivered to Miramar Reservoir; therefore, water quality in the reservoir will largely reflect the characteristics of purified water. The drinking water source for the Miramar DWTP will be a blend of the purified water stored in Miramar Reservoir and imported water delivered through the SDCWA system. The two water sources will be delivered to the Miramar DWTP independently and mixed upon entering the plant; this blend will serve as the DWTP influent.

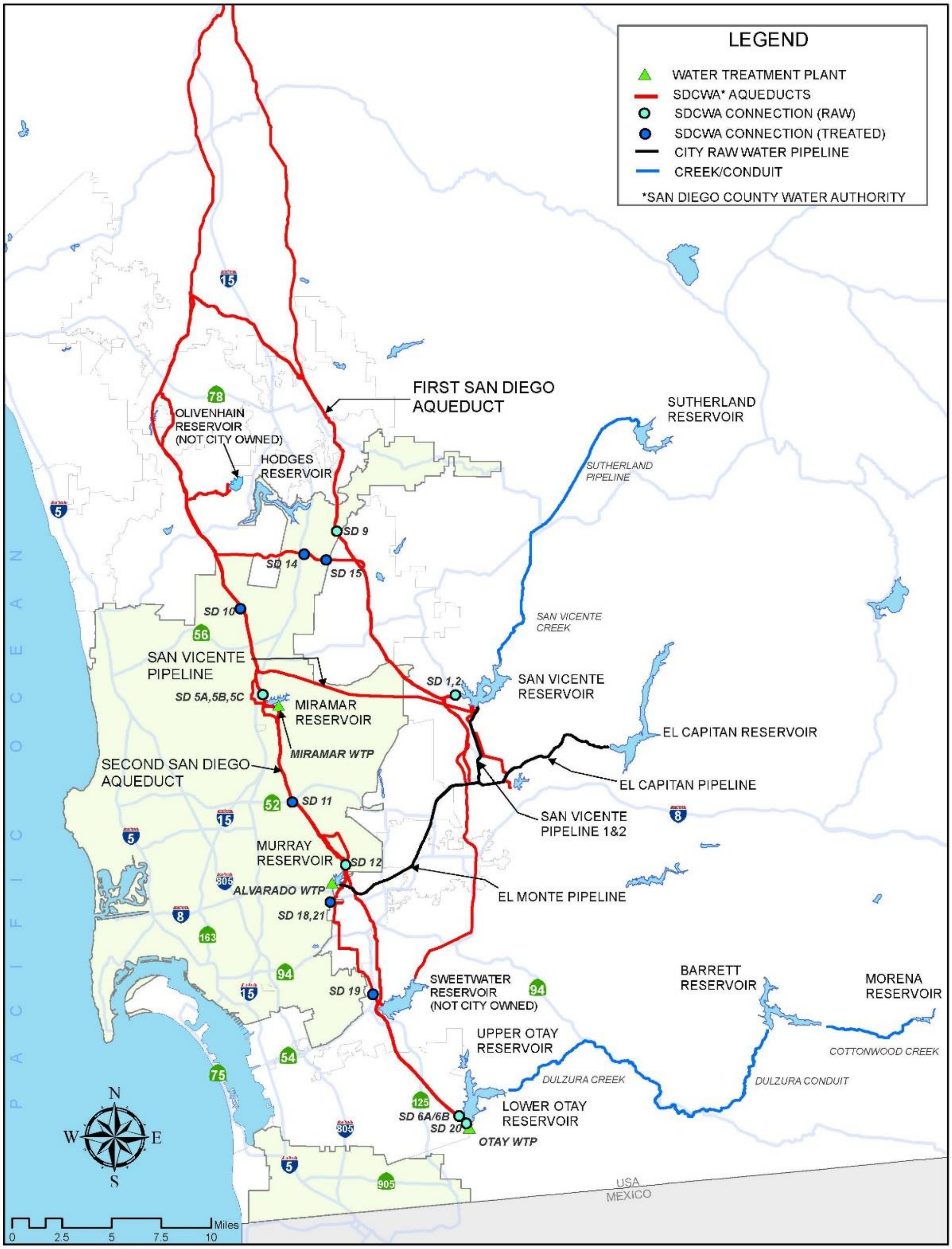


Figure 12-1: Conceptual Illustration of City of San Diego Water System

12.1.1 Miramar Drinking Water Treatment Plant Influent Flow Rate

The Miramar DWTP influent flow rate varies throughout the year to meet the water demand in the Miramar Service Area. The monthly influent flow rates at the Miramar DWTP are illustrated on Figure 12-2. During a typical year, the DWTP flow is at its highest during the summer (typically around July and August) and is at its lowest during the winter (typically around January and February). As illustrated on Figure 12-2, the Miramar DWTP has operated in recent years at an average rate of approximately 67 mgd, with a minimum and maximum of 37[1] mgd and 101 mgd, respectively.

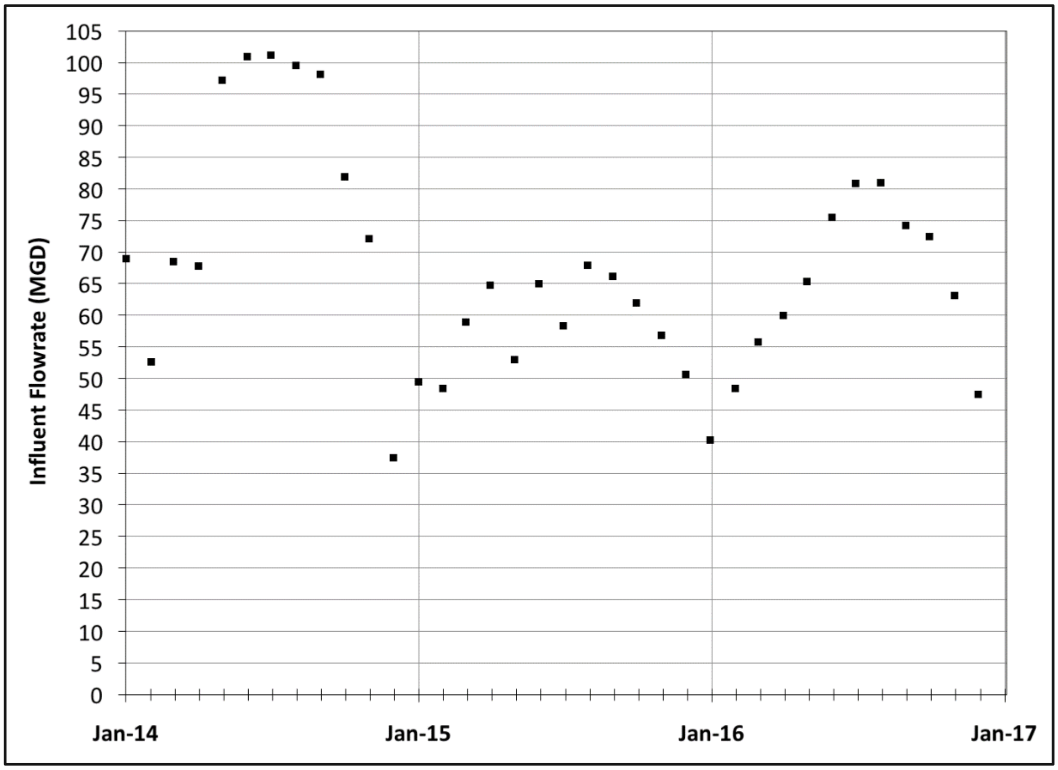


Figure 12-2: Miramar DWTP Flow Rate, 2014 through 2016

Under normal Project operating conditions, it is anticipated that water stored in Miramar Reservoir, which will essentially consist of purified water, will be pumped continuously to the Miramar DWTP at an average rate of 30 mgd. The remaining influent will continue to be imported water from the SDCWA System. The actual blend of source water in the Miramar DWTP will vary depending on the pumping rate at the Miramar Reservoir Pump Station (often referred to as Lake Pumps), and the service area demands. In general, higher demands will result in a lower purified water to imported water ratio. Table 12-1 presents the spectrum of source water blend ratios that are expected to be encountered in the influent of the Miramar DWTP during a normal year of Project operations. These estimates assume:

- Intake to the Miramar DWTP is equal to the 2016 actual influent flows (on a monthly basis), plus additional demands that could be met by the Miramar DWTP[2];

[1] The minimum monthly average flow falls below the 50-mgd turndown capacity of the Miramar DWTP due to periods of low demand where the plant has been shut off. During this time, demand is met with clearwell storage.
[2] The City currently purchases treated water from SDCWA to provide potable water to some areas in the Miramar service area. Improvements are underway to allow the Miramar DWTP to provide this additional demand in the future.

- Flow withdrawn from Miramar Reservoir is equal at all times to the input to the reservoir from the NCPWF; and
- Difference between reservoir supply and the total demand is made up by imported water from the SDCWA Second San Diego Aqueduct.

Table 12-1: Miramar DWTP Expected Source Water Blends Example for 2016

Month	Total Influent Flow[a], mgd	Purified Water Contribution, mgd	Purified Water Contribution, Percent
January	47	30	64
February	64	30	47
March	69	30	43
April	75	30	40
May	79	30	38
June	87	30	35
July	92	30	33
August	92	30	32
September	86	30	35
October	84	30	36
November	74	30	40
December	59	30	51
Minimum	47	30	32
Maximum	92	30	64

[a] 2016 actual monthly flow averages used as projected Total Influent Flow.

12.1.2 Miramar Drinking Water Treatment Plant Influent Water Quality

Under current operating conditions, the Miramar DWTP influent quality depends on the relative composition of the imported water provided by the Metropolitan Water District via the SDCWA system. Although the quality of the imported water is generally stable, water from the Colorado River Aqueduct tends to have higher hardness, be more alkaline, and contain higher TDS levels than water from Northern California via the State Water Project. Under average operating conditions, the quality of the Miramar DWTP influent will be the quality that results from blending purified water and imported water. Purified and imported water quality characteristics are presented in Table 12-2. A compilation of the Miramar DWTP's projected water quality, depending on the various possible blend ratios are presented in Table 12-3.

Table 12-2: Water Quality Comparison of Imported Water and Purified Water

Parameter	Imported Water Average (Range) 2014 - 2016	Purified Water[a] Average or Median (Range)
Alkalinity, mg/L as $CaCO_3$	123 (95-140)	125 (100-145)
Calcium, mg/L	68 (42-76)	120 (92-146)
Chloride, mg/L	92 (80-102)	11 (5-25)
pH, pH units	8.0 (7.2-8.5)	8.0 (7.5-8.5)
Sulfate, mg/L	219 (123-253)	5 (4-10)
TDS, mg/L	587 (409-657)	130 (50-195)
Turbidity, NTU	0.52 (0.24-1.7)	0.60 (0.45-0.75)
TTHMs, µg/L	27 (2-66)	3.8 (2.0-5.0)

[a] Values extracted from Section 9, which was based on five years of NCDPWF testing, source water investigations, literature sources, and modeling.

Table 12-3: Projected Water Quality of Miramar DWTP

Parameter	Projected Water Quality of Miramar DWTP Influent[a]
Alkalinity, mg/L as $CaCO_3$	124
Calcium, mg/L	88
Chloride, mg/L	60
pH, pH units	8.0
Sulfate, mg/L	136
TDS, mg/L	409
Turbidity, NTU	0.55
TTHMs, µg/L	18

[a] Projected water quality is based on the flow blend using the median total influent flow from 2016 and the water quality averages presented in Table 12-2.

12.2 Drinking Water Treatment Plant

A description of the existing Miramar DWTP is provided in Section 6.3.4.

12.2.1 Treatment Performance of the Miramar Drinking Water Treatment Plant

The Miramar DWTP operation is governed by a set of compliance goals based on Safe Drinking Water Act requirements. The Miramar DWTP must comply with the MCLs for drinking water as promulgated by the EPA. These include the pMCLs, which are legally enforceable for the protection of public health, and the sMCLs, which serve as guidelines to prevent negative aesthetic, cosmetic, and technical effects. Under current operating conditions, the key water quality targets for the Miramar DWTP in light of compliance goals are presented in Table 12-4.

Table 12-4: Miramar DWTP Historic Performance

Parameter	Unit	Goal	Goal Type	Miramar DWTP Effluent 2014 through 2016 Average (Range)
Turbidity	NTU	0.3	EPA Treatment Technique	0.06 (0.04-0.20)[a]
Turbidity	NTU	0.1	Miramar DWTP treatment goal	
Total turbidity removal	Percent	80	Miramar DWTP permit requirement	88 (57-96)
Virus log removal value	log	4	MCL/SWTR	>10-log[b]
Giardia log removal value	log	3	MCL/SWTR	>6-log[c]
Total coliform samples	Percent positive	5.0	MCL/Total Coliform Rule	0.0
Heterotrophic plate count	CFU/mL	500	MCL/SWTR	<1 (<1-1)
Finished water pH	pH units	6.5-8.5	sMCL	8.11 (7.53-8.61)
Finished water pH	pH units	8.0-8.5	Miramar DWTP treatment goal	

[a] Plant probably qualifies for 1-log of *cryptosporidium* removal credit through the turbidity removal requirements in the LT2ESWTR Toolbox, but a detailed analysis has not been completed.

[b] The log removal value shown is typical of actual removal credits per LT2ESWTR requirements. The CT values maintained for chlorine during normal operations are several times those required, such that extrapolated removals for viruses range from 55 to 100-log, averaging 75-log.

[c] The log removal value shown is typical of actual removal credits per LT2ESWTR requirements. Based on a single snapshot, the log removal break down is 2.5-log for conventional filtration, 1.6-log for chlorine disinfection, and 2.7-log for ozone disinfection, which results in an overall removal of greater than 6-logs. The average inactivation from chlorine alone is 2.0-log, ranging from 1.5- to 2.5-log.

Various processes at the Miramar DWTP have been optimized and tailored by operational experience and the resulting operational strategies have been implemented to meet key water quality targets. Optimization of the coagulant and polymer dosing (for flocculation and settling) and filter operations to achieve consistently low turbidities in the finished water ensures that pathogen removal goals are met. Currently, the Miramar DWTP uses 4 mg/L of ferric chloride to produce filtered turbidities averaging 0.06 NTU. The conventional treatment process is credited with 2.0-log virus, 2.5-log *Giardia,* and 2.0-log *Cryptosporidium* removal and the remaining 0.5-log *Giardia* and 2.0-log virus (plus any additional inactivation requirements due to degraded raw water quality) are met through ozone and chlorine disinfection to attain the total log removal values of 4/3/2 for V/G/C throughout the Miramar DWTP treatment process. Ozone and chlorine dosing operations are well understood, thus allowing the DWTP to achieve virus and *Giardia* disinfection log removals, coliform samples, and heterotrophic plate counts that greatly exceed the respective performance goals. To maintain a chemical equilibrium that prevents pipe corrosion and metal leaching, the finished water is closely monitored to determine caustic soda addition to appropriately elevate the pH and maintain a favorable LSI.

The Miramar DWTP includes in-line instrumentation to ensure continued compliance with all water quality goals. This instrumentation allows for continuous monitoring of the treatment processes to verify their performance for turbidity removal, pathogen removal, and pH. Historical turbidity, pathogen removal, and pH values are presented in Table 12-4. In addition, the Miramar DWTP operators take samples from various points in the process (e.g., raw, rapid mix, settled, filtered, final effluent) and directly measure pH, turbidity, and chlorine residual in the Miramar DWTP lab every two hours, to confirm the performance of the plant and the accuracy of the in-line instruments.

12.2.2 Potential Project Impacts on Treatability

Currently, the Miramar DWTP operations staff have a finely tuned understanding of the range of incoming water quality and the respective coagulant requirements. The addition of purified water into the raw water supply at the Miramar DWTP will change the existing water quality and water chemistry. This change has the potential to impact the treatability of the influent under current operational practices. Preliminary bench-scale studies were conducted in 2015 to determine the specific water quality implications of augmenting the DWTP influent with purified water. The Water Quality and Treatability Study Technical Memorandum (see Appendix E) and DWTP Operational Evaluation Technical Memorandum (see Appendix F) (MWH/BC, 2016d and 2016e) were generated from this evaluation effort.

The 2015 bench-scale study evaluated various coagulant doses on different purified water and imported water blends to simulate the impact on the flocculation, sedimentation, and filtration processes. The purified water used for these experiments was effluent from the NCDPWF. Some purified water was conditioned with lime or carbonate, sometimes both, and some was left as an unconditioned control. Jar tests were used for the evaluation of flocculation and sedimentation. Size exclusion tests at 5 µm were used for the evaluation of filtration.

Overall, the findings of the 2015 study demonstrated that treatability was remarkably robust for all test conditions, and purified water blended with existing water supplies can be successfully coagulated and filtered. Independent of purified water conditioning, the blend ratios (ranging from 0 to 100 percent purified water), coagulant type (ferric chloride and ployaluminum chloride), and coagulant dose (1 to 15 mg/L), filtered water turbidities were consistently low – a turbidity range of 0.07 to 0.14 NTU was observed. Although the Miramar DWTP can achieve low turbidity in the finished water for a variety of operational conditions, the importance of properly conditioning the purified water did surface. Without proper conditioning of the purified water, at blend ratios comprising of mostly purified water, the finished water is outside the targeted pH and LSI range to mitigate stability and corrosion issues within the plant and distribution system.

Under the conditions tested, the observed pH and LSI ranged from 7 to 9.25 pH units and -1.75 to 0.75 LSI values, respectively. This finding supports the decision to include both lime addition and carbon dioxide injection at the NCPWF to maintain an alkalinity greater than 80 mg/L as calcium carbonate and hardness greater than 100 mg/L as calcium carbonate to yield favorable LSI values. Properly post-conditioned purified water adds to the robustness of the Miramar DWTP and aids in the continued achievement of performance goals and protection against possible corrosion issues at the plant and in the distribution system. In fact, the finished water turbidity and pH when using post-conditioned purified water are similar to those achieved under current plant operation.

Two new studies were recently initiated to investigate the potential impacts of influent water quality changes at the Miramar DWTP more thoroughly: (1) a pilot-scale treatability study to assess the effects of the blend of imported and purified water as the new influent to the Miramar DWTP, as well as associated training of City operators regarding operational changes identified during this pilot-scale study, and (2) a bench-scale pipe loop study to assess the impact of introducing a blend of the Miramar DWTP-treated imported and purified water into the existing distribution system.

For the 2017 pilot-scale study, future Miramar DWTP feed water will be simulated using a blend of conditioned (with carbon dioxide and lime) purified water from the NCDPWF and imported water. This high-purity blend may change the optimal settings used for existing coagulation, flocculation, sedimentation, filtration, and ozonation processes. To refine and verify potential changes at the Miramar DWTP, experiments will be conducted on this blend to assess:

- Relationship between blended water quality and required coagulant dose;
- Turbidity removal by the media filters as a metric for coagulation and flocculation effectiveness;
- Changes in visible feedback from the flocculation and sedimentation process;
- Effects on filter head loss accumulation rate and run time, as well as the stability of filter performance;
- LSI in finished water;
- Use of sodium hydroxide at upstream dosing points to operate the plant at higher settled water pH and reduce concrete corrosion; and
- Effects on ozone demand and decay characteristics.

Sampling and analysis will focus on major ion profiles for the purposes of calculating the saturation and stability indices of the raw blend and treated water.

12.2.3 Modifications to the Miramar Drinking Water Treatment Plant and Its Operation

A key goal in implementing new operations with purified water is to mimic, as best as possible, the chemical stability of the raw and finished water from the Miramar DWTP. Based on the 2015 bench-scale testing results, there are several recommendations to maintain treatment performance and mitigate stability and corrosion issues within the plant and distribution system. These operational recommendations are as follows (details on strategy, monitoring, feedback, and alarms for each treatment step is provided in the DWTP Operational Evaluation Technical Memorandum):

- ***Ozonation.*** The blended influent water will likely require lower ozone doses due to lower TOC concentrations in the blend.
- ***Coagulation.*** The blended influent water will require less coagulant because it will contain lower suspended solids concentrations. Coagulant dose will be closely evaluated based on filtered water turbidity. Jar tests and filterability tests will be completed when major changes in influent blend ratio is expected.
- ***Flocculation.*** Most likely flocculator settings will not have to change. The 2015 bench-scale study used average and peak energy dissipation rates equivalent to those currently used in the Miramar DWTP flocculators.
- ***Sedimentation.*** It is anticipated that the lower TSS in the new blend water will reduce total solids generated, but the sedimentation process will require no major modifications, except the Project may cause a change in tank cleaning frequency.
- ***Filtration.*** Most likely the filtration process will require no modifications, except that the Project may cause a change in backwash frequency, either causing it to increase due to less removal by sedimentation tanks or decrease due to lower overall suspended solids loading.
- ***Post-Conditioning.*** The following conditions will continue to be targeted through the addition of sodium hydroxide to the finished water to maintain stability in the distribution system: pH > 8.0 and LSI > 0.

Data from the 2015 bench-scale studies suggest that the DWTP will have no difficulty meeting the EPA turbidity standard of 0.3 NTU in the filtered water; however, Section 644660(b)(9) also requires at least 80 percent reduction in turbidity through the plants, or that other means be used to demonstrate that optimal coagulation is being achieved. Under Project operations, there will be lower influent turbidity, and meeting the 80 percent reduction requirement is uncertain. For example, 80 percent turbidity removal from 0.25 NTU raw water requires filtered water turbidities of 0.05 NTU. This is typical of levels seen in current operation, but slight variations in filtered water turbidity, as are possible under current or Project operation, could lead to less than 80 percent overall removal.

In 2015, a bench-scale study was conducted to assess potential impacts of the blended source water quality changes at the Miramar DWTP and the City operators were trained regarding any operational changes identified during the study. The findings demonstrated that treatability was remarkably robust for all test conditions and purified water blended with imported water can be successfully coagulated and filtered.

The results of the bench and pilot testing demonstrated that maintaining filtered water turbidity is the key indicator of successful coagulation. Proper conditioning of the purified water to maintain sufficient alkalinity to avoid undesirable reductions in pH during coagulation will be important to maintain proper coagulation. Starting in 2013, the Miramar WTP has received the President's Award from the Partnership for Safe Water for its filtered water quality performance. Therefore, filtered water turbidity will be used to gauge coagulation effectiveness when 80 percent removal of turbidity cannot be measured as a result of very low raw water turbidity, and alkalinity measurement will remain a part of regular monitoring to ensure that adequate buffering capacity is available to maintain coagulation pH in an optimal range.

It is recommended that this portion of the plant permit be revisited with regulators. With highly effective source control, disinfection systems (ozone and chlorine), and filtered water turbidities well below the EPA treatment technique requirement, there is a strong argument for relief from this permit provision, perhaps (for example) when the plant raw water turbidity is lower than a certain threshold value.

Another important consideration is the LSI of the finished water to protect the distribution system against corrosion of pipes, degradation of mortar linings, and mobilization of metals in home plumbing. One of the operational goals for the Miramar DWTP will include sodium hydroxide addition to adjust the plant's finished water pH to a value above 8.0 (as is the current practice) to yield LSI values around +0.2 to sufficiently match pre-Project finished water chemistry. Increased sampling for hardness, alkalinity, and TDS will be implemented to verify that the LSI remains positive and confirm proper post-conditioning at the NCPWF. There will also be additional monitoring in the distribution system, as discussed in Section 12.3.2.

12.3 Drinking Water Distribution System

The existing operational plans for lead and copper control will be used to identify possible problem areas in the distribution system. Furthermore, a complete inventory of materials in the Miramar DWTP service area will be undertaken, to study their potential vulnerability to coagulated water with negative LSI.

The water chemistry of the effluent produced by the Miramar DWTP has important implications on the protection of public health as this water flows through the distribution system to customer taps. To understand the impacts of the new water source thoroughly and mitigate the potential for corrosion and leaching of harmful metals, bench-scale pipe loop studies are being developed. These studies are being implemented to investigate the possible effects the Miramar DWTP future effluent may have on the existing distribution system. To provide insight into possible chemical and biological effects, the following will be assessed:

- Post-conditioning steps and dosing ranges of the purified water;
- Possible effects on corrosion and metal mobilization to determine whether the design conditioning is sufficient to prevent problems; and
- Possible effects on biofilms in the distribution system.

Each pipe loop apparatus will be designed to recirculate test water through several parallel loops, each containing pieces of different materials representative of the current conditions in the distribution system. The following parameters will be analyzed by the City laboratory:

- Copper and lead;
- Major ion profiles;
- Turbidity;
- Temperature;
- Dissolved oxygen;
- Color;
- pH; and
- Chlorine residual.

12.3.1 Description of Distribution System

The current Miramar Service Area is defined as all of the zones supplied by the Miramar DWTP and treated water SDCWA Connections 10, 11, 14, and 15. This area includes all hydraulic zones north of Highway 8. The City can also feed the southern portions of the Miramar Service Area from the Alvarado DWTP. The Miramar Service Area includes water delivered to the City of Del Mar through wholesale meters located in the northwest region of the City. The Miramar Service Area is illustrated on Figure 12-3. The Miramar Service Area average daily demand for the five-year period between 2012 and 2016 is just less than 89 mgd, with year to year variations of no more than 10 mgd from the average, as presented in Table 12-5.

Table 12-5: Demands in Miramar Service Area Flows[a]

Year	Average Daily Demand (mgd)
2012	77.3
2013	85.1
2014	88.5
2015	68.5
2016	74.1
5-Year avg (2012-2016)	78.7
3-Year avg (2014-2016)	77.0

[a] The source of data is the “Miramar Service Area Demand Analysis (2015),” prepared by the Engineering & Program Management Division, PUD.

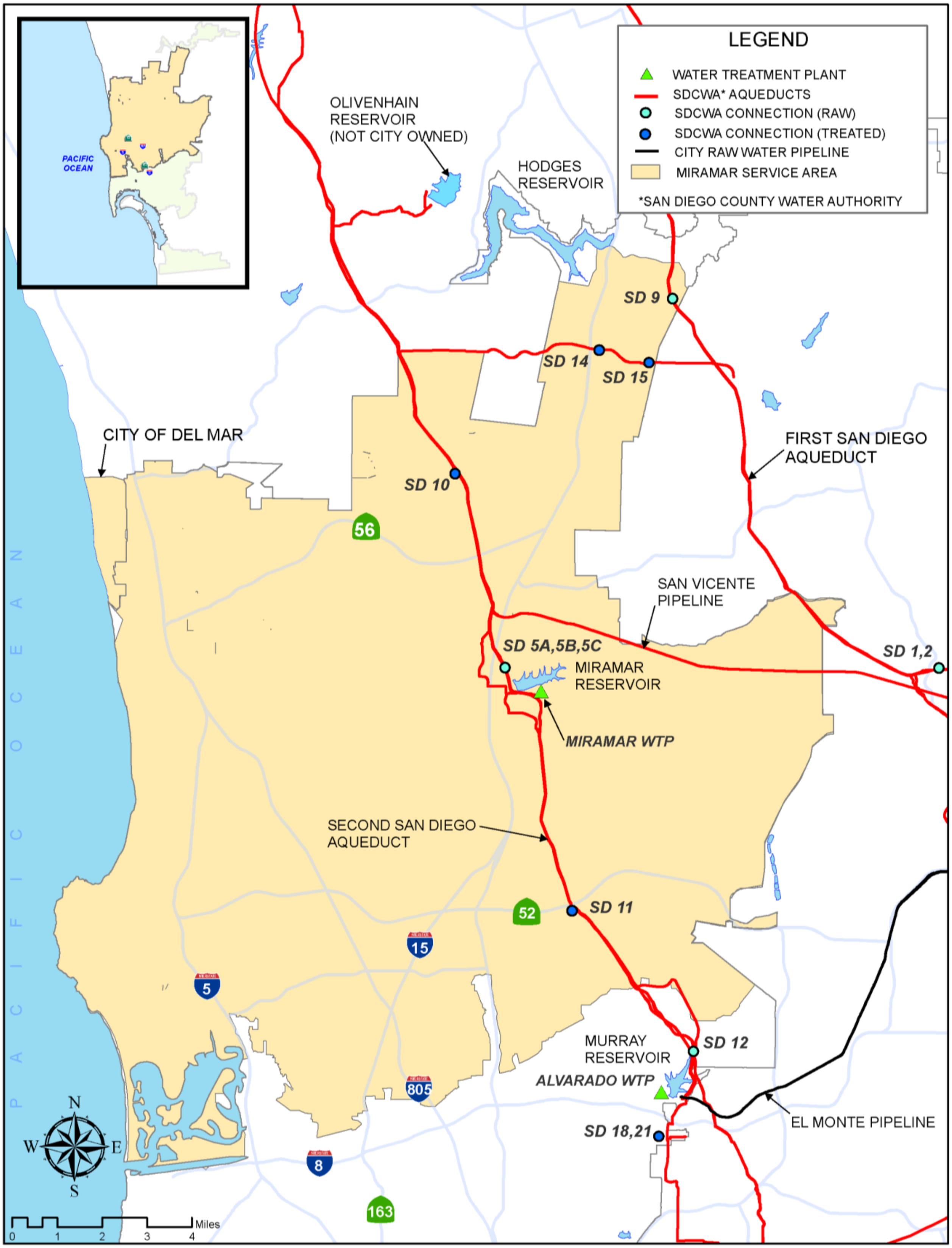
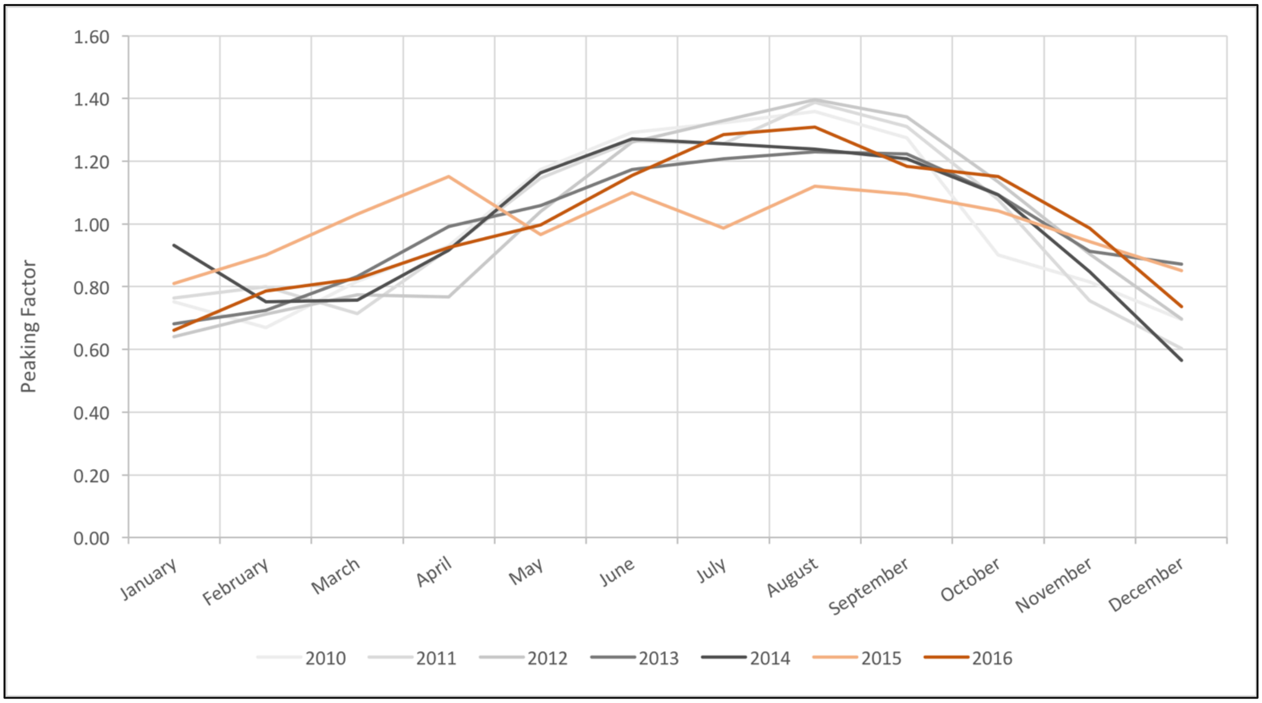


Figure 12-3: Map of Miramar DWTP Service Area

Peaking factors are illustrated on Figure 12-4 and are based on historical demand data for the total service area demand and not just the Miramar DWTP supply. Future capital improvements projects will replace the City's use of SDCWA treated water with drinking water produced at the Miramar DWTP, making Miramar Service Area demand equal to future Miramar DWTP supply. Monthly variations in daily demand flow between peak and low months vary from year to year, but follow a predictable pattern as shown. The high monthly average for daily demand occurs between June and September, with a five-year high monthly peaking factor of 1.40 occurring in 2012. The low demand period occurs between the months of December and March, with a five-year low monthly peaking factor of 0.57 occurring in 2014.



The source of data is the "Miramar Service Area Demand Analysis (2015)," prepared by the Engineering & Program Management Division, PUD."

Figure 12-4: Miramar Service Area Peaking Factors (Draft Miramar Service Area Demand Analysis)

12.3.2 Distribution System Water Quality Monitoring

The City operations staff have an extensive and thorough monitoring program currently in place to verify that water quality from the Miramar DWTP is preserved through the distribution system. The current distribution system monitoring program includes the monitoring of lead and copper (Lead and Copper Rule and City of San Diego Lead and Copper Monitoring Study), TTHM and haloacetic acids, (Stage 2 Disinfection Byproducts Rule), total coliforms (Total Coliform Rule), chlorine residual and heterotrophic plate count bacteria (SWTR), mineral analysis, and water quality parameters required for calculation of the LSI.

12.3.2.1 Current Distribution System Sampling

The general structure of each of these current distribution system sampling efforts is outlined below:

12.3.2.1.a General Mineral, Physical, and Inorganic Analysis

- ***Purpose.*** Monitoring of general Miramar DWTP influent and effluent water quality parameters to verify chemical stability.

- ***Sampling.*** Monthly monitoring of total hardness, conductivity, pH, Aggressiveness Index, major cations and anions (including calcium, sulfate, and chloride), and numerous minerals (including lead and copper).
- ***Compliance.*** Results are reported to DDW monthly.

12.3.2.1.b Lead and Copper Rule

- ***Purpose.*** Verify that metal mobilization due to corrosion is not occurring in the distribution system, including consumer residences.
- ***Sampling.*** Triennial lead, copper, pH, alkalinity, calcium hardness, and total hardness sampling at >50 customer taps throughout distribution system[3] selected by structure age and plumbing materials present[4].
- ***Compliance.*** 90th percentile concentrations must fall below Action Levels of 15 parts per billion and 1.3 parts per million for lead and copper, respectively.

12.3.2.1.c SDCWA-Treated LSI Water Quality Monitoring Routine[5]

- ***Purpose.*** Verify that metal mobilization due to corrosion is not occurring in the distribution system due to incorporation of SDCWA water to the Miramar Service Area.
- ***Sampling.*** Monthly samples of alkalinity, pH, hardness, chloride, sulfate, conductivity, temperature, TDS, lead, and copper at six locations known to receive SDCWA water (two of which occur in the Miramar Service Area). LSI and sulfate to chloride mass ratios are calculated from the measured parameters.
- ***Compliance.*** Results are monitored for the mitigation of corrosion (e.g., positive LSI), but this effort is internal to the City to ensure the protection of public health and is not governed by existing regulations.

12.3.2.1.d Stage 2 Disinfection ByProducts Rule

- ***Purpose.*** Reduce the risk of public exposure to disinfection byproducts in the distribution system.
- ***Sampling.*** Quarterly TTHM and haloacetic acids sampling at 16 locations throughout distribution system[3].
- ***Compliance.*** Locational Running Annual Average must fall below 60 parts per billion and 80 parts per billion for haloacetic acids and TTHMs, respectively.

12.3.2.1.e Total Coliform Rule

- ***Purpose.*** Reduce the risk of pathways for bacterial contamination in the distribution system.
- ***Sampling.*** Minimum of 85 total coliform samples per week at representative locations throughout the distribution system per approved sampling plan[3].
- ***Compliance.*** <5 percent of samples collected each month are total coliform positive.

[3] Number of sampling locations shown reflects the entire City of San Diego drinking water distribution system. The Miramar Service Area comprises roughly one-third of the total system.
[4] Sampling sites must contain copper pipes with lead solder installed after 1982, lead pipes, and/or are served by a lead service line.
[5] A portion of the water supplied to the Miramar Service Area from SDCWA comes from the Carlsbad Desalination Plant, necessitating a monitoring program for this new water source.

12.3.2.1.f SWTR

- ***Purpose.*** Improve public health protection from pathogens by maintaining disinfectant residual in the distribution system.
- ***Sampling.*** Minimum of 85 residual disinfectant samples per week at representative locations throughout the distribution system per approved sampling plan[6] (same as Total Coliform Rule sampling points). Heterotrophic plate count measurements can be taken in lieu of disinfectant residual (the City currently measures total chlorine at each of the Total Coliform Rule locations and heterotrophic plate count if the chlorine residual is below 0.2 parts per million).
- ***Compliance.*** Residual disinfectant concentrations cannot be undetectable in greater than 5 percent of samples in a month for any two consecutive months and the distribution average must fall below the Maximum Residual Disinfectant level of 4.0 parts per million. Heterotrophic plate counts of ≤ 500/milliliter are deemed to have a detectable residual disinfectant.

In addition to the routine distribution system monitoring efforts discussed above, the City was required by DDW to perform two rounds of a special, limited Lead and Copper Rule Study in 2016 due to the implementation of SDCWA desalinated water. This monitoring was a separate effort from the monthly SDCWA-Treated LSI Water Quality Monitoring Routine and existing Lead and Copper Rule monitoring. The additional sampling targeted approximately 70 residences in the areas identified to receive SDCWA water with the goal of sampling a total of 10 residences. Analyses of the customer tap samples included lead and copper (90^{th} percentile values subject to the 15 parts per billion and 1.3 parts per million Action Levels), as well as the Lead and Copper Rule Water Quality Parameters, pH, alkalinity, calcium, and conductivity.

12.3.2.2 Short-term Monitoring Program During Operational Ramp-up

In response to the introduction of purified water, a short-term distribution monitoring plan will be implemented in addition to the current monitoring plan to help identify any water quality changes that occur as a result of introducing this new source composition into the distribution system. This short-term monitoring program will tentatively include, but is not limited to: (1) monitoring and tracking of complaints raised by the public; (2) lead, copper, and corrosion indicator studies; and (3) LSI monitoring routine. The LSI index of treated water at different blends of pure water was evaluated on both the bench and pilot scale. Proper conditioning of the pure water with both calcium and alkalinity is important. The post-treatment conditioning process of CO_2 and lime addition at the NCPWF are provided for that reason. In addition, the Miramar DWTP also has chemical feed to allow for pH and alkalinity modification to achieve a positive LSI and mitigate corrosion.

12.3.2.2.a Monitoring and Tracking of Complaints Raised by the Public

React to any complaints that are unusual based on a historic database of public feedback. Visualization tools such as “heat maps” using a geographic information system that display the isopleths of complaint intensity, will be considered.

12.3.2.2.b Lead, Copper, and Corrosion Indicator Studies

Lead and Copper Rule Study performed in the areas of the distribution system that receive treated water from Miramar DWTP and are at highest risk of metal mobilization. This study is expected to have a similar structure to the special Lead and Copper Rule Study requested by DDW in 2016 for the implementation of SDCWA desalinated water. The City will conduct the study, which will be completed by a date agreed to with DDW.

[6] Number of sampling locations shown reflects the entire City of San Diego drinking water distribution system. The Miramar Service Area comprises roughly one third of the total system.

- ***Purpose:*** Verify that metal mobilization due to corrosion is not occurring in the distribution system (including consumer residences) due to the introduction of purified water.
- ***Sampling:*** Measurement of lead, copper, pH, alkalinity, calcium, and conductivity at customer taps in the Miramar Service Area.
    - This may entail on the order of 10-20 additional residences to be sampled, subject to DDW review.
    - This monitoring effort is expected to last for approximately two six-month monitoring periods at which point the existing Lead and Copper Monitoring efforts will suffice if Action Levels are met and water quality parameters are optimal.
- ***Compliance:*** 90^{th} percentile values must fall below the Action Levels of 15 parts per billion and 1.3 parts per million for lead and copper, respectively.

12.3.2.2.c LSI Monitoring Routine

LSI monitoring routine in the areas of the distribution system that receive treated water from the Miramar DWTP and are at highest risk of metal mobilization; this monitoring effort is expected to be similar to the City's current SDCWA-Treated LSI Water Quality Monitoring Routine discussed above.

- ***Purpose:*** Verify that metal mobilization due to corrosion is not occurring in the distribution system due to incorporation of SDCWA water to the Miramar Service Area.
- ***Sampling:*** Monthly samples of alkalinity, pH, hardness, calcium, chloride, sulfate, conductivity, temperature, TDS, lead, and copper at various locations throughout the Miramar Service Area, including known problem areas as identified from historical monitoring efforts. LSI and sulfate to chloride mass ratios will be calculated from the measured parameters.
- ***Compliance:*** Results are monitored for the mitigation of corrosion (e.g., positive LSI), but this effort is internal to the City to ensure the protection of public health and is not governed by existing regulations.

Operations with the Miramar DWTP-treated blends is not anticipated to cause substantial changes to the chemistry or biology of the contact surfaces of the distribution system. Proper carbon dioxide and lime post-treatment stabilization at the NCPWF will provide the conditions necessary to prevent downstream corrosion, therefore mitigating the impacts of the new water source. The 2017 pilot-scale treatability study and bench-scale pipe loop study will allow the City to investigate the impacts of the new water source on the drinking water infrastructure (Miramar DWTP and distribution system) more rigorously, and refine the operation of the carbon dioxide and lime post-treatment stabilization system.

The short-term monitoring of the distribution system will cease once the surface biology and chemistry have re-equilibrated. Once water quality parameters become stable (e.g., measured concentrations of iron, manganese, and turbidity are the same as those measured during baseline - measurements taken one year prior to introducing the new source water), the system will be deemed at equilibrium and the original sample program will resume. The City operations staff will be responsible for incorporating the added short-term effort to their routine monitoring to verify the chemical stability within the distribution system following introduction of purified water.

12.3.3 Coordination with Other Agencies

The City will coordinate with the City of Del Mar to ensure that adequate sampling is being done in the Del Mar portion of the service area. The monitoring regime described above will be recommended to the City of Del Mar, and the Cities of San Diego and Del Mar will share water quality data.

In addition, there is a treated water connection from the Miramar DWTP to a SDCWA treated water pipeline. Water from that pipeline serves portions of the City's service area, as well as the Sweetwater Authority, Padre Dam Municipal Water District, Helix Water District and Otay Water District. This "pump-back" of treated drinking water from the Miramar DWTP into a SDCWA-owned pipeline is not frequent, but is used occasionally as needs are coordinated between the SDCWA and the City.

As such, the City will coordinate with the downstream agencies to ensure that adequate sampling is performed according to DDW requirements.

13. Reliability Features

This section presents the reliability features of the Project to protect public health.

13.1 Reliability

The first and most important goal of all drinking water systems is to ensure the consistent protection of public health. While there are other goals like the continuous supply of water, the reliability of public health protection takes priority. A framework for potable reuse safety has been developed based on the following four "Rs": reliability, redundancy, robustness, and resilience (Pecson et al., 2016). The overarching concept is "reliability," which can be achieved by two different strategies: (1) failure prevention, and (2) failure response. Figure 13-1 illustrates the relationship between the four Rs, which forms the overall treatment safety strategy for the Project.

Within the failure prevention strategy, two "R" concepts can be employed: (1) redundancy, and (2) robustness. Designing potable reuse systems based on these two concepts decreases the probability that constituents will pass through treatment barriers into the treated effluents, and provides a buffer against treatment excursions or failures.

Failure prevention strategies are further supported by resilience, or the ability to respond to failures. Even projects with significant failure prevention features may need to respond to rare failure events; therefore, resilience should be included as a complementary feature. This is particularly important for first-of-a-kind projects, such as the North City Project.

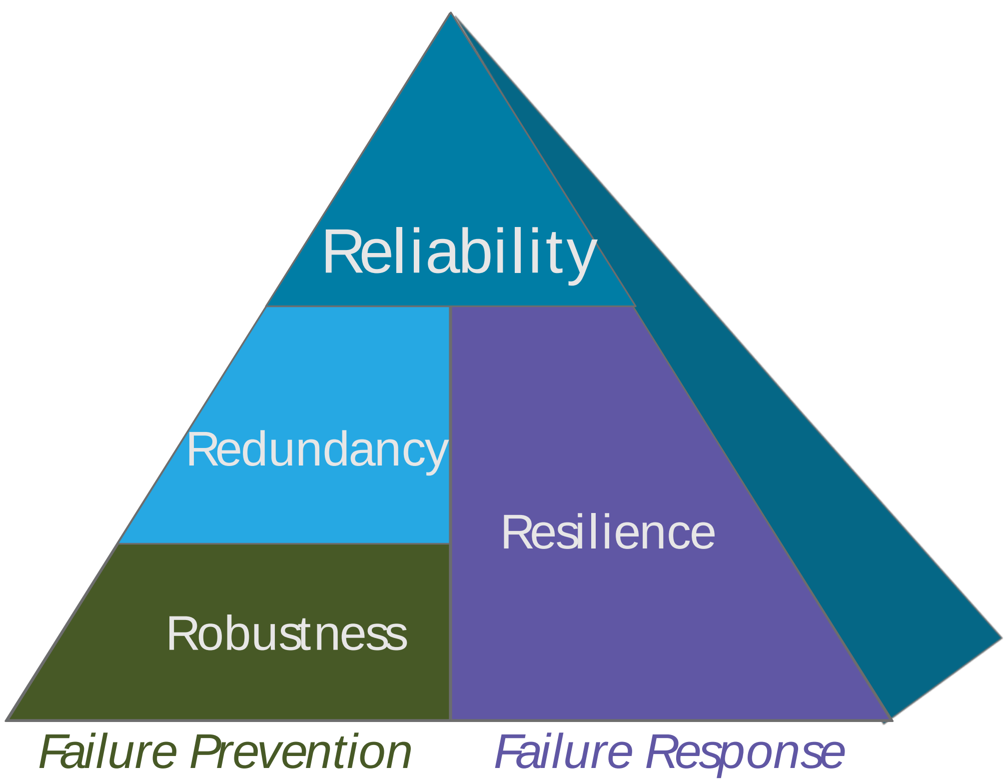


Figure 13-1: Four "Rs" of Potable Reuse Safety

Because they both help to achieve the ultimate goal of reliability, failure prevention and failure response can be balanced in different combinations while maintaining equivalent degrees of public health protection. This viewpoint has been supported by numerous examples, including the California State Expert Panel who stated:

> *"Two major options have been proposed to fulfill the core functions of the environmental buffer in DPR systems, either by providing additional treatment redundancy and/or by adding engineered storage with a defined holding time prior to release into the drinking water supply distribution system."* (Olivieri et al., 2016)

The Expert Panel concludes safety can be achieved through failure prevention (additional treatment redundancy) or failure response (storage of treated waters that allows time to detect and respond to any failures that occur). DDW expressed similar views, stating that potable reuse systems will need either treatment redundancy (failure prevention) or "infallible monitoring" (failure response) to ensure consistent control of pathogens (Hultquist, 2012).

The balancing of elements is also evident in the groundwater recharge regulations and SWA regulations. In both cases, higher degrees of treatment (failure prevention) compensate for lower degrees of time and dilution (failure response), both of which can be used to respond to or mitigate off-spec water, as illustrated on Figure 13-2.

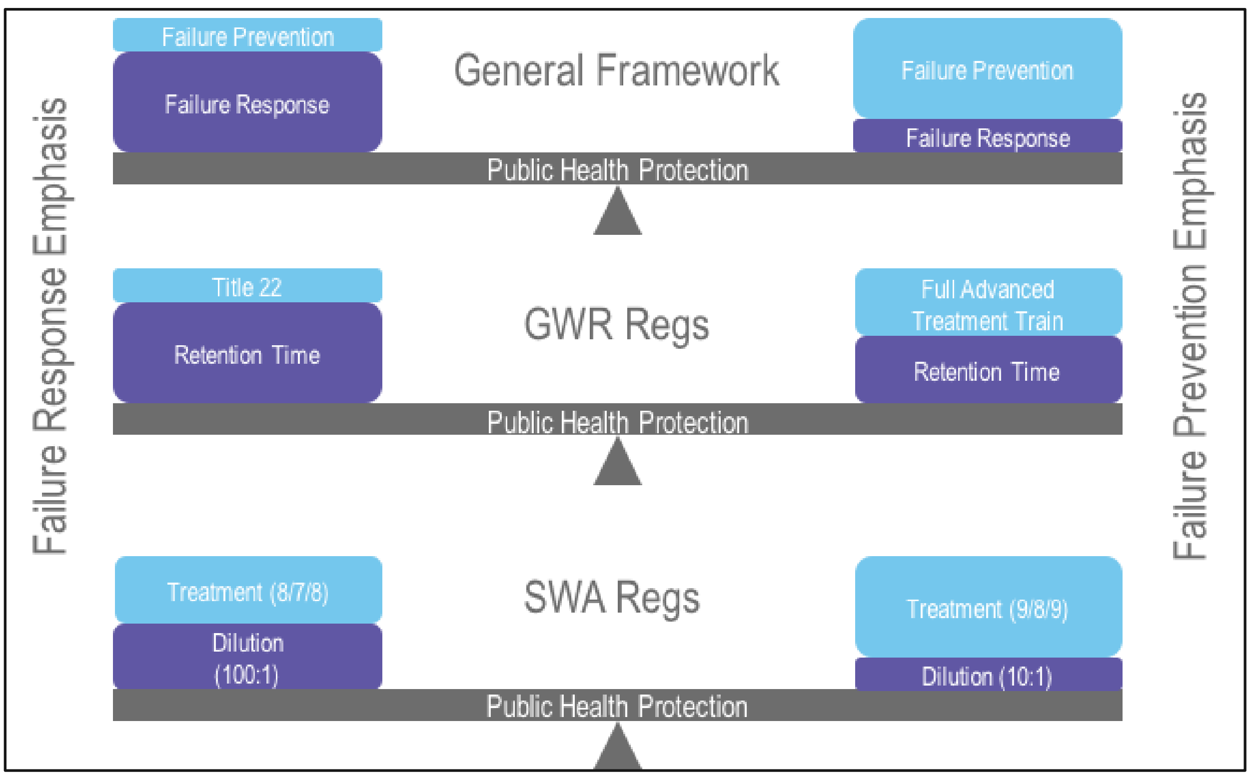


Figure 13-2: Balancing Failure Prevention and Response in California's Potable Reuse Regulations

The Project will incorporate multiple elements to achieve reliability. This section discusses how the reliability through failure prevention and failure response will be implemented to provide consistent protection against the CECs, including both pathogens and chemicals.

The word "failure" can be used to describe multiple events, including unit process treatment excursions, monitoring malfunctions, and operator error. To reduce the ambiguity associated with the word "failure," other terms will be employed in this Engineering Report. For example, off-spec water is defined as any final effluent leaving the NCPWF that does not meet the regulatory requirements for discharge to Miramar Reservoir. Water quality will also be evaluated through each unit process (or critical control point), but the designation of off-spec water will only be applied to the final effluent.

To determine the acceptability of the water leaving any given unit process, on-line process monitoring data will be collected and evaluated. Acceptable bounds, or “control limits,” will be established for each treatment process by characterizing the variability of the process under periods of stable operation. Using the performance data, statistical analysis will identify the upper control limit and lower control limit, (i.e., the range of acceptable performance values). These control limits will also account for any regulatory limits, (e.g., the 0.5 mg/L TOC limit in RO permeate). For the purposes of this Engineering Report, unit processes that fail to perform within these designated ranges will be characterized as “exceeding control limits.”

13.2 Failure Prevention: Redundancy and Robustness

Redundancy is defined as “the use of measures beyond the minimum requirements to ensure that treatment goals are more reliably met or performance can be more reliably demonstrated” (Pecson et al., 2016). The benefits of redundancy are multiple:

- ***Excursions and Failures Do Not Jeopardize Public Health***. By providing treatment beyond the minimum requirements, the system has a buffer against excursions or failures in treatment and monitoring;
- ***Treatment Redundancy is Protective against Multiple Types of Failure.*** Failures in treatment, monitoring, and operation can all lead to the production of off-spec water. Treatment redundancy can help mitigate the impact of all of these types of failure; and
- ***Treatment Redundancy Provides a High Degree of Operational Flexibility.*** In the absence of treatment redundancy, reliability is dependent on the detection and rapid response to any failures that occur. Treatment redundancy provides a buffer against excursions and failures, thereby reducing the reliance on rapid failure response.

Robustness is defined as “the use of multiple and diverse barriers to control a broad variety of constituents and resist catastrophic failures.” Many unit processes are effective at the control of one pathogen, but are less effective at others; therefore, a diverse combination of processes is employed to ensure that effective removal and inactivation mechanisms are provided for the various pathogen types. For example, free chlorine provides excellent control of viruses, but provides essentially no protection against *Cryptosporidium*. When coupled with MF, which provides a strong barrier against the larger protozoan pathogens such as *Cryptosporidium*, the train increases in robustness and the control of diverse constituents.

The other benefit of robustness is its ability to reduce the risk of complete failures. In brief, the higher the number of barriers, the lower the probability that all of the barriers fail simultaneously, resulting in a catastrophic failure. Take for example the case of two different treatment trains, each providing 10-logs of pathogen protection. Train 1 utilizes a single 10-log barrier to achieve the goal while Train 2 uses two 5-log barriers. Assume that each barrier has a 1 percent probability of failure. Over the course of a year, Train 1 will meet the goal 99 percent of the time (>361 days per year), but will also experience a complete failure 3.7 days per year. Train 2, however, will only experience a complete failure when both its 5-log barriers fail. At a 1 percent failure rate, Train 2 experiences failure at a rate of 0.01 x 0.01 x 365 days, or 0.037 days per year (~53 minutes per year). Thus, robustness contributes to failure prevention by reducing the risk that all barriers will fail simultaneously and result in a catastrophic failure.

This section details the redundancy and robustness features of the Project for both pathogens and chemicals. The strategies to protect against these two contaminant groups, however, are not identical. Contaminants that cause health effects after short exposure periods must be guarded against with highest priority since even brief periods of off-spec water production can lead to public health impacts. Of the contaminant groups, pathogens pose the most acute threat with infections occurring after as little as a single exposure. More flexibility can be permitted for chronic constituents because their effects are manifested over longer periods, often over a lifetime, of exposure. For such constituents, the instantaneous exposure is less meaningful than the average lifetime exposure. Thus, short periods of off-spec water production can be tolerated if the average concentration meets the health thresholds. The following discussion will differentiate between the strategies used to protect against these two groups: pathogens and chronic constituents.

13.2.1 Failure Prevention for Pathogens

13.2.1.1 Redundancy

Given the acute nature of pathogen infections, a premium is placed on providing consistent and continuous protection against them. One of the main strategies to achieve this is through the use of redundant treatment. Redundancy in the overall train provides a buffer so that an excursion or failure in one unit process does not cause the system as a whole to fail to meet specifications. The NCWRP and NCPWF will provide redundancy in treatment beyond the minimum SWA requirements. The LRV credits that are being sought for the Project are described in detail in Section 10 and presented in Table 13-1.

The minimum pathogen reduction required by the SWA regulations is 8/7/8 for V/G/C prior to discharge to the reservoir. This requirement assumes that the DWTP downstream of the Project achieves the minimum pathogen reduction requirements of the Surface Water Treatment Rules, namely, 4/3/2 for V/G/C. The sum of these reductions provides a total level of protection of 12/10/10 for V/G/C. This degree of treatment has been deemed to be sufficient for public health protection, and is the specific pathogen requirement of the groundwater recharge regulations. In SWA, a project providing 8/7/8 must also achieve a minimum 100:1 dilution in the reservoir providing additional protection in the event of a short-term discharge of off-spec water.

For a project providing dilution less than 100:1 but at least 10:1, an additional log of pathogen reduction is required prior to discharge to the reservoir, bringing the total pathogen reduction prior to discharge to 9/8/9. This reduction of 9/8/9, in addition to the assumed 4/3/2 provided by the DWTP brings the total pathogen protection to 13/11/11. In this way, the treatment requirements are dependent on the degree of dilution.

The final factor impacting treatment requirements is the retention time within the reservoir. While all projects must begin with a 180-day minimum theoretical retention time, the regulations allow projects to propose alternatives as low as 60 days. Any project that propose a minimum theoretical retention time less than 120 days will be required to provide no less than 1-log of additional pathogen protection. Through discussions with DDW, the total pathogen reduction required for the Project prior to discharge to Miramar Reservoir is 10/9/10 for V/G/C. This is based on (a) the 9/8/9 pathogen requirements for a project with dilution of less than 100:1, plus (b) 1-log of additional protection for V/G/C due to a reservoir retention time less than 4 months. The total pathogen reduction of 10/9/10 prior to discharge, in addition to the 4/3/2 provided by the DWTP, brings the total credited pathogen protection for the Project to 14/12/12.

Table 13-1: Proposed LRV Credits for NCWRP, NCPWF, and Disinfection in Pipeline

Pathogen	NCWRP[a]	Ozone/ BAC	MF	RO[b]	UV/ AOP	Pipeline Cl_2	Total Prior to Discharge to Reservoir	Required Prior to Discharge to Reservoir
Virus	0.7	6	0	2.5	6	6	21.2	10
Giardia	3.2	6	4	2.5	6	1	22.7	9
Cryptosporidium	0.9	1	4	2.5	6	0	14.4	10

[a] Subject to change upon additional pathogen monitoring
[b] RO credits based on Tier 1 and may exceed this value.

13.2.1.2 Robustness

The NCPWF builds upon the diversity of the full advanced treatment train by adding additional removal mechanisms in the form of Ozone/BAC pre-treatment and free chlorine disinfection, as illustrated on Figure 13-3. By employing multiple and different barriers, the treatment train effectively controls the three regulated pathogens (virus, *Giardia*, and *Cryptosporidium),* and should be equally or more effective against other known pathogens, such as pathogenic bacteria, and UV- and free chlorine-resistant adenovirus and coxsackievirus. The same strategy should also provide protection against new and emerging pathogens.

The use of five distinct pathogen barriers at the NCPWF serves to reduce the risk of catastrophic failure significantly. The probability of multiple barriers failing simultaneously drops to fractions of a second per year, further enhancing the strength of the failure prevention strategy. The reliability analysis that provides insight into failure rates is presented below in Section 13.2.1.4.

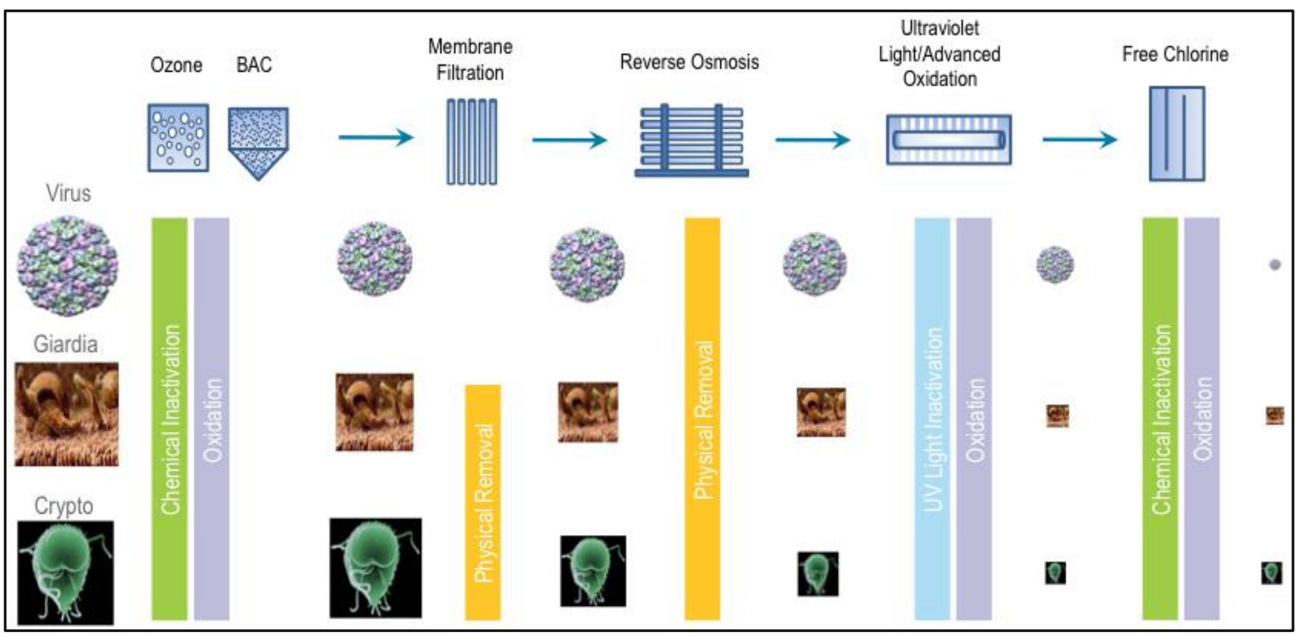


Figure 13-3: Robustness to Protect Against a Diversity of Pathogens at NCPWF

13.2.1.3 Monitoring

As described in Section 10, each of the pathogen barriers is considered a critical control point and will be monitored continuously through the use of on-line metering. Monitoring provides demonstration of the effectiveness of each critical control point and provides proof of the failure prevention approach effectiveness. The high temporal sensitivity of pathogen monitoring is required given their acute nature; a constant threat requires constant vigilance.

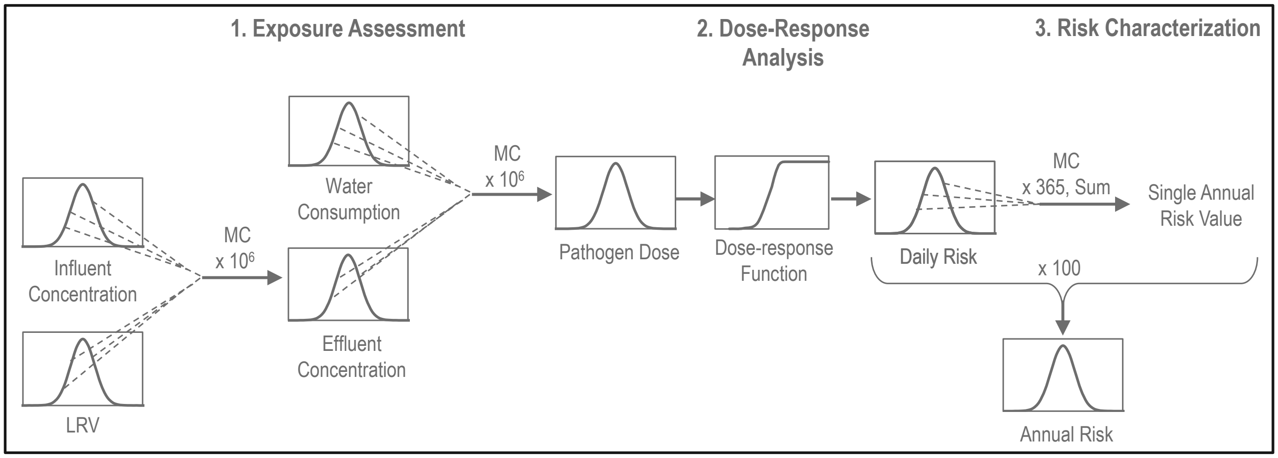
The use of multiple and redundant monitoring also minimizes the time when the system is unverified or "goes black." This is important because, in the absence of demonstrable performance, a unit process must be assumed to be providing minimal or no protection. The failure of a monitor could be compensated with manual measurements of the relevant parameter, such as is done in drinking water applications; however, the use of redundant on-line monitors provides greater flexibility and will be included in this system. The ozone and RO systems provide good examples of the benefits of monitoring redundancy. The failure of one of the three ozone monitors will reduce the CT (product of the concentration of a disinfectant and the contact time) credit earned by the process, but will not drop the credit to zero. Likewise, the RO utilizes a three-tiered monitoring approach with the use of three different surrogates to determine pathogen credit. The failure of the Tier 1 monitoring will not cause the RO to receive 0-log credit, assuming the Tiers 2 and 3 monitors provide a constant redundant back-up.

13.2.1.4 Pathogen Reliability

The degree of failure prevention provided by the NCPWF treatment train may alone be sufficient to ensure the reliability of the Project. Nevertheless, additional failure response features will be included that are not captured through failure prevention, in order to help ensure a safe reaction to failures. Recently, the reliability of the treatment train has been assessed through two independent efforts. In the first, the State Expert Panel evaluated the performance data collected over a yearlong period at the NCPWF during the WRRF14-12 Study. Through this evaluation, the State Expert Panel concluded:

> *"The example treatment train (i.e., O3/BAC/UF/RO/UV-AOP) demonstrated ample additional protection over the broadly accepted risk-based treatment performance goal for Cryptosporidium in a conventional drinking water supply. It also is above the accepted risk-based performance criteria (i.e., 12/10/10) for current IPR projects in California."* (Olivieri et al., 2016).

Simultaneously, the WRRF 14-12 Study has undertaken a complementary effort to characterize the reliability of the treatment train through quantitative microbial risk assessment. The analysis utilized the three pathogen groups previously mentioned (virus, *Giardia*, and *Cryptosporidium*) and assessed the risk associated with the consumption of final effluents. The steps of the quantitative microbial risk assessment are illustrated on Figure 13-4. The analysis utilized a number of data sources, including information on pathogen concentrations in raw wastewater, performance data of the unit processes collected through the WRRF 14-12 testing (WRRF, 2017), and assumptions about water consumption. These data were described as distributions to reflect the variability inherent in all of these parameters. Using the data, a quantitative microbial risk assessment was performed to assess both the range of exposures and the resulting distribution of risk associated with the consumption of the final effluent.



MC = Monte Carlo Analysis

Figure 13-4: Steps Used in the Quantitative Microbial Risk Assessment Evaluation of Potable Reuse Safety

Results from this analysis demonstrate the high degree of protection provided by the treatment train, both under normal and failure conditions. The failure prevention strategy reduces the risk of failing to meet the health-based goal of 10^{-4} infections per person per year essentially to zero (Pecson et al., 2017b). Through this analysis, the authors made the following conclusions:

- Potable reuse reliability can be achieved through a failure prevention approach that emphasizes redundancy and robustness; the effectiveness of this approach was verified both through research and an independent assessment by a State Expert Panel;
- Treatment redundancy allows the system to continue to produce water that meets public health specifications, even when individual unit processes are exceeding control limits from excursions or failures;
- The use of multiple barriers and stand-by units reduces the probability that multiple processes will suffer simultaneous failures to very low levels, essentially eliminating the probability of catastrophic failure; and
- The high degree of reliability achieved by the failure prevention approach reduces the reliance on failure response measures.

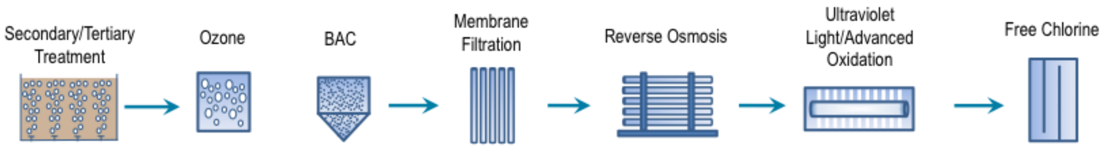
13.2.2 Failure Prevention for Chemicals

As discussed previously, most of the chemicals that are found in wastewaters are at concentrations that do not pose acute threats to human health. These low-level concentrations can exert health effects, but only after repeated and prolonged exposure. Chemicals mostly fall into the category of chronic constituents whose effects are evaluated on the basis of a lifetime of exposure. As a result, there is less need to provide continuous and unwavering protection against these constituents compared to pathogens; therefore, the use of redundancy to ensure continuous pathogen protection, is less critical for chemical control.

One of the main differences between chemicals and pathogens is the diversity of constituents that exist in the chemical universe. Chemicals span a wide range of physicochemical characteristics, including compounds that are small and large, charged and uncharged, polar and non-polar, UV-sensitive and UV-resistant, and biodegradable and refractory. Accordingly, the main challenge with chemical control is to provide barriers against this diversity to ensure that all constituents can be adequately controlled. While redundancy was the key concept for pathogen control, a higher emphasis is placed on robustness for chemical control.

13.2.2.1 Robustness

Robustness is the key to effective chemical control. Because no single process effectively controls the wide diversity of chemical constituents, the NCPWF is designed with a number of distinct barriers operating by different mechanisms. While some unit processes provide a high degree of protection against this diversity, the combined effect of the overall treatment train provides excellent protection against all of the known constituents as illustrated on Figure 13-5.



	Secondary/Tertiary Treatment	Ozone / BAC	Membrane Filtration	Reverse Osmosis	Ultraviolet Light/Advanced Oxidation	Free Chlorine
17β-estradiol	Excellent	Excellent	Poor	Excellent	Excellent	Excellent
Carbamazepine	Poor	Excellent	Poor	Excellent	Excellent	Poor
NDMA	Fair	Good	Poor	Fair	Excellent	Poor
1,4-dioxane	Poor	Good	Poor	Good	Good	Poor

Figure 13-5: Effectiveness of Unit Process Barriers in the Control of Chemical Diversity

The effectiveness of the Project's treatment train has been borne out in the results of the yearlong testing undertaken in the WRRF 14-12 Study. The main factor providing these benefits is the diversity of removal mechanisms provided in the train as illustrated on Figure 13-6.

In addition to routine sampling for an extensive set of chemical parameters, the WRRF 14-12 Study undertook several challenge tests of the NCDPWF system, upon which the Project is based. These tests showed the enhanced protection provided by the Ozone/BAC pre-treatment, which provides another barrier to complement the organics protection of the RO and UV/AOP processes (Trussell et al., 2016). The inclusion of additional removal mechanisms not only helps to control known constituents, but it also provides greater mitigation and control against new and future emerging constituents as well.

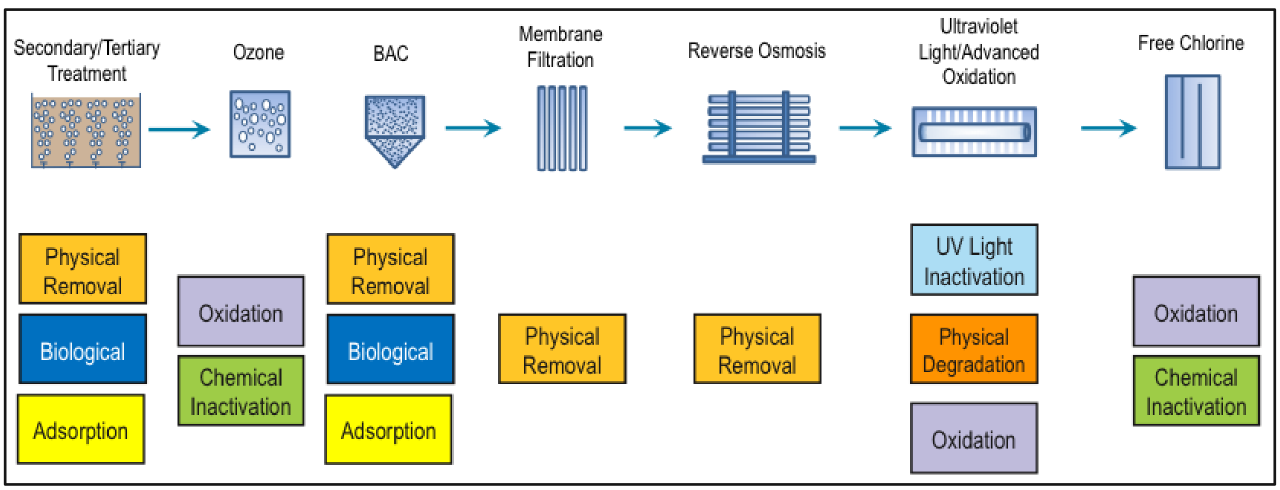


Figure 13-6: Robustness of Treatment Provided Through the Use of Multiple Attenuation Mechanisms at NCPWF

13.2.2.2 Redundancy

While most chemicals pose chronic risks, there is a subset that may be present at concentrations high enough to pose acute risks. These acute chemicals include nitrate and nitrite, as well as perchlorate. While they are categorized as acute risks, it is important to stress that the degree of acuteness is different from that of pathogens. Whereas pathogens can lead to adverse health outcomes after a single exposure, a compound like perchlorate is acute, but still requires multiple days or weeks of exposure to exert an effect. Thus, the stringency with which we need to control these two subsets, pathogens and chemicals, should be in accord with their degree of acuteness.

As discussed in Section 13.2.1.1, redundancy should be prioritized toward the constituents that pose the most acute threats. In the case of acute chemicals, multiple barriers will be used to control perchlorate, nitrite, and nitrate, with more than one barrier in place to control the discharge of these constituents in the final effluent, as illustrated on Figure 13-7. In the case of perchlorate, two barriers can be used: source control and RO. The perchlorate levels have been measured in the tertiary treated water (tertiary effluent) of the NCWRP and have shown levels that are above the MCL (6 µg/L). Treatment through the RO provides a 2-log barrier that consistently reduces the perchlorate concentration below the MCL. Based on the historical feed water levels, the RO alone should provide effective control of perchlorate. Nevertheless, perchlorate may also be added to the Source Control Program depending on the results of the City's local limits study.

Nitrite and nitrate will also be controlled at multiple steps in the treatment process. Control begins in the secondary process that provides both nitrification and partial denitrification. The effectiveness of the biological control will be monitored continuously through the use of an on-line nitrate/nitrite monitor in the secondary process. Ozone provides the next barrier, leading to the chemical oxidation of nitrite to nitrate. Finally, RO provides an additional 1-log removal of any remaining nitrate to be below the health limit of 10 mg/L of total nitrogen consistently, as established in the SWA regulations. The multiple barriers: (1) nitrification-partial denitrification in secondary treatment, (2) ozonation, and (3) RO will reduce concentrations of nitrite and nitrate to levels below the MCLs, 1 mg/L and 10 mg/L as nitrogen, respectively.

Through source control, secondary treatment, Ozone/BAC, RO, and UV/AOP, it is expected that a wide swath of chemicals will also be removed through the multiple unit processes. Thus, redundancy will also play an important role in the control of both acute and chronic chemical constituents.

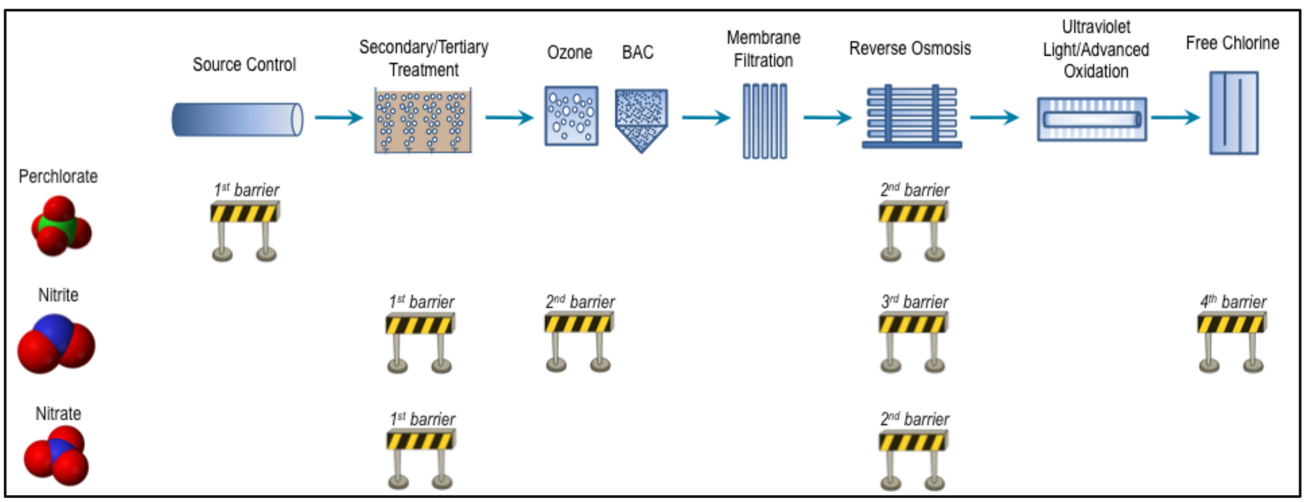


Figure 13-7: Redundant Removal Mechanisms Provided by the Project to Control Acute Chemical Contaminants

13.2.2.3 Monitoring

The monitoring schedule for the various unit processes' ability to reduce pathogens is described in detail in Section 10. As described in the previous section, the chemical removal performance of many of the unit processes can be determined through the use of on-line instrumentation, (e.g., nitrate/nitrite monitors for secondary process and strontium, TOC, and EC removal for RO). In addition to the surrogate monitoring, the chronic chemicals will also be targeted for periodic, direct measurement using laboratory analyses. The frequency and extent of the chemical monitoring is described in Section 15.

One chemical constituent for which there are not effective treatment removal processes is the radionuclide tritium. Source control will be the most important form of protection against this compound, though radionuclide discharges are regulated differently from many of the other toxic chemicals, with the Nuclear Regulatory Commission overseeing and the California Department of Public Health, Radiologic Health Branch, coordinating these efforts. Laboratories, x-ray facilities, and other nuclear medical technology sites that possess sources of radioactive materials must be licensed. Monitoring for tritium should be coupled with efforts to identify potential dischargers and modify their discharge patterns so that slug inputs are distributed over longer periods of time, and do not cause high concentration spikes over a short duration.

13.2.2.4 Summary

Like pathogens, multiple strategies will be implemented to prevent the passage of toxic chemicals through the Project treatment system. The key chemical control approach is robustness. The Project includes an enhanced set of removal mechanisms that has proven effective at the control of all known compounds sampled to date. The use of diverse removal mechanisms also confers increased protection against emerging and unknown chemicals. Redundancy is also provided to ensure multiple barriers are in place to control acute chemicals.

13.3 Failure Response: Resilience

Within the 4Rs framework, reliability can be achieved in multiple ways; greater reliance can be placed on either failure prevention or failure response. In general, as the degree of failure prevention increases, the need for failure response measures decreases. The Project provides a high degree of resilience through multiple strategies, including source control and treatment at the NCWRP and NCPWF, access to the PLWTP outfall, and alternate raw water sources (imported water) available to the Miramar DWTP. Given the high degree of redundancy provided for pathogen control, even significant treatment excursions could be absorbed without leading to the production of off-spec water. In short, the high degree of failure prevention may eliminate the need to ever implement failure response protocols. The quantitative microbial risk assessment results help drive this point home. The NCPWF alone should protect the public against any unacceptable health risks over more than 100 years of operation (Pecson et al., 2017b).

Nevertheless, multiple failure response features will be included in the Project for the control of both pathogens and toxic chemicals. This section describes the resilience features of the system. As with the failure prevention discussion, the degree of acuteness is important in understanding the requirements for failure response features. Because pathogenic infections can occur from a single exposure, response features for pathogens must be implemented rapidly to deal with failures that can lead to off-spec water production.

13.3.1 Resilience at the NCPWF and NCPW Pipeline

The first step in failure response is identifying that a failure has occurred. The more frequently a process is monitored, the more quickly a corrective action can be implemented. In the case of pathogens, each critical control point will be measured continuously through the use of multiple surrogate parameters (see Section 10). Any failure in treatment will normally be detected within 15 minutes (i.e., the minimum monitoring interval required for a continuous on-line monitoring process).

Once a failure is detected, a number of responses can be implemented. These responses should be commensurate with the degree of failure that is observed, as will be discussed in Section 13.3.4. Within the NCPWF, diversions will allow water that exceeds control limits to be rerouted back to the headworks of the NCWRP or discharged to the sewer. The diversion points will be both in between processes and at the end of the treatment train at the NCPW Pump Station. Given the continuous on-line monitoring provided, failures in treatment should be detected rapidly, such that nearly all diversions can take place prior to discharge to the NCPW Pipeline. There will also be facilities to allow diversions from the NCPW Pipeline if needed in the very rare case that off-spec water may enter the pipeline.

While emphasis is placed on rapid response against failures in pathogen control, these same responses will also ensure effective chemical control. This is due to the fact that many of the surrogates used to define pathogen removal performance also serve as surrogates of chemical control. Examples include monitoring of ozone dose, RO integrity, and UV dose. Thus, a failure in ozone dosing will prompt a corrective action to ensure control of pathogens. This same action, however, will also ensure effective oxidation of chemical constituents. The benefits of failure responses to pathogens also apply to chemicals. Because of the possibility of discharges of uncharged, low molecular weight organic chemicals that might pass through the RO process (e.g., acetone), continuous TOC monitoring of the NCPWF influent, RO feed, and UV/AOP effluent will be performed. SOPs will be developed in the North City Project's OP to ensure that water is discarded whenever these processes exceed their control limits.

13.3.2 Resilience at Miramar Reservoir

The defining feature of SWA projects is the reservoir, which serves as an environmental buffer and provides numerous reliability features and distinguishes SWA as indirect potable reuse. Most of the reliability provided by the reservoir falls under the category of failure response. The three main Project benefits of Miramar Reservoir are: (1) dilution, (2) decoupling, and (3) time to respond to off-spec water.

13.3.2.1 Dilution

Certain failures in treatment may lead to increases in contaminant concentrations in the treated effluent. Dilution in the reservoir helps to overcome the impact of these failures by reducing the concentration of all constituents in a proportion equivalent to the degree of dilution provided. Because dilution is not formally credited as treatment in the SWA regulations, no LRV credits are assigned to this benefit provided by Miramar Reservoir. Nevertheless, it serves as an important resilience feature of the reservoir.

13.3.2.2 Decoupling

The production of off-spec water at the NCPWF can only impact the quality of water produced at the Miramar DWTP if the Miramar DWTP utilizes Miramar Reservoir water as a portion of its source water. By introducing an environmental barrier in between the NCPWF and Miramar DWTP, the reservoir allows the Miramar DWTP to be decoupled from the NCPWF. The Miramar DWTP has the ability to switch its source water over to imported water only via the SDCWA system for long periods, if necessary. In fact, imported water is supplied directly to the Miramar DWTP based on current operating practices; therefore, the impact of the

NCPWF treatment failures can be contained within the NCPWF and Miramar Reservoir when the Miramar DWTP is decoupled from the reservoir and utilizes only imported water an alternative source of supply.

13.3.2.3 Response to Off-spec Water

As previously discussed, both failure prevention and failure response strategies can be used to achieve the primary project goal, which is reliability in public health protection. The Project utilizes both strategies, but with particular emphasis on providing a high degree of failure prevention. Multiple system elements have been included to minimize the probability that a failure event would lead to the production of off-spec water:

- Rigorous source control;
- Redundancy in treatment;
- Enhanced monitoring; and
- High level of process control.

In concert, these elements minimize the constituents entering the system, reduce them to levels beyond what is needed to protect public health, and monitor and control the processes continuously to ensure they perform as designed and within their control limits. These failure prevention strategies are further buttressed by an operational plan that will cease the use of treated effluents before the water becomes off-spec. As illustrated on Figure 13-8, the Miramar DWTP will stop extracting from Miramar Reservoir if the water quality even begins to approach the regulatory limit in terms of LRVs, (i.e., when the water is still fully compliant).

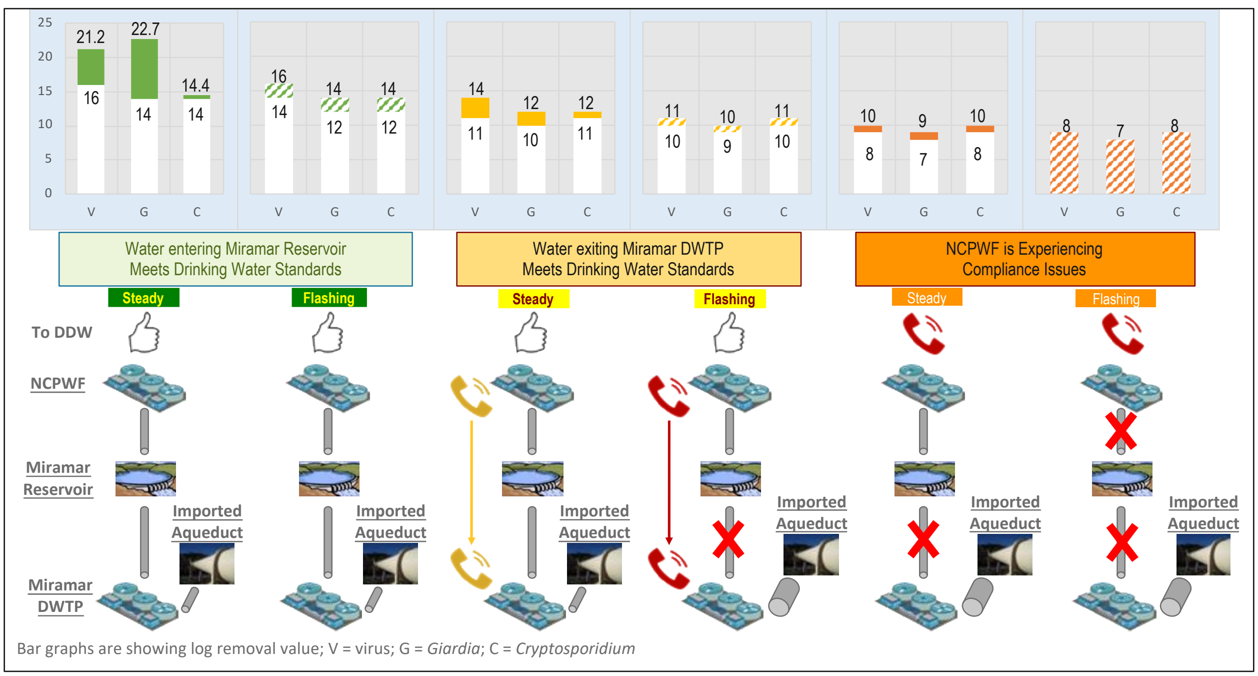


Figure 13-8: Graded Response Plan with Alarms and Responses

It should be noted that the possibility of a scenario involving purified water beginning to approach the minimum LRV levels is exceedingly low because the Project has been designed with such high degrees of redundancy. The performance evaluation and quantitative microbial risk assessment of this process train (undertaken through the WRRF 14-12 Study) showed that even high rates of assumed unit process failure would not impact the ability of the system to meet specifications and protect public health (Pecson et al., 2017b). In other words, the reliability achieved through treatment redundancy renders the Project essentially impervious to unit process failures. The State Expert Panel independently evaluated the WRRF 14-12 Study findings and endorsed this conclusion, stating that a failure prevention approach based on redundancy was the correct path to reliability.

The Project will offer additional reliability features beyond those in the WRRF 14-12 Study, particularly with regard to treatment redundancy and process performance control. Note that while the NCPWF alone provides reliable public health protection, the Project will be further supported by the additional 4/3/2 LRV redundancy provided at the Miramar DWTP. The performance monitoring data will be evaluated with control chart theory, a data-driven methodology used to characterize the normal variability of process performance using control limits. Performance monitoring is then continuously evaluated relative to the control limits. The benefit of such vigilance is that it can provide significant advanced warning that process performance is trending downward before the process experiences an actual excursion or an overt failure (i.e., exceeding control limits). Control charts provide benefits analogous to preventive maintenance in that implementing this strategy further reduces the probability of a failure ever occurring (failure prevention).

In light of these failure prevention elements, the need for failure response is greatly reduced. Were this system to achieve exactly the minimum 10/9/10 LRVs needed to comply with the SWA regulations (i.e., in the absence of any treatment redundancy), any excursion that caused a unit process LRV to drop would necessarily lead to off-spec water production below 10/9/10. In this case, immediate failure responses would be needed to ensure the system maintained its reliability. Such a system represents the alternative approach to the one presented here, namely, a reliability strategy built upon failure response. Clearly, the need for such rigorous response strategies diminishes as redundancy and other failure prevention strategies are increased. It stands to reason that failure response would cease to be needed at some high level of failure prevention. Proof of the effectiveness of a failure-prevention strategy can be seen in our existing drinking water systems. Conventional DWTPs are designed to achieve a consistently high-quality product so that events in which unsafe water is produced are virtually non-existent. Options to deal with drinking water failures do exist (e.g., boil-water orders), but are so rarely invoked that there is essentially no reliance on failure response. The NCPWF has been developed utilizing this same philosophy.

Despite the reduced need for failure response, the Project will provide a number of response features, including the reservoir itself. Miramar Reservoir will provide more than two months of mean theoretical hydraulic retention time for the North City Project as indicated in Section 11.9. The long theoretical hydraulic detention time of at least two months in the reservoir (measured as V/Q) provides time for environmental processes to further reduce contaminant levels. Dilution provides an additional “barrier” to reduce the impacts of any off-spec event by ensuring that a minimum level of contaminant attenuation is continuously provided. Reservoir modeling has been performed and tracer tests will be used to verify that this dilution is sufficient to protect against any 24-hour pulse of off-spec water to the reservoir.

Per the SWA regulation, the project must be protective of any 24-hour pulse, a requirement that implies that an off-spec event would be detected and addressed within a 24-hour time period. This 24-hour response time should be easily met for a system providing continuous monitoring and rigorous control of unit process performance. While a 24-hour response time is what is required, the larger question remains: How much time is actually needed? Building off of the previous discussion, it is clear that this question cannot be answered in a vacuum, but needs to reflect the degree of other system elements that have been provided. In other words, the answer will vary depending on the balance of failure prevention and failure response that is provided. Based on the demonstrated reliability of this Project’s treatment train, the need for response time has been reduced to levels equivalent with existing drinking water systems; in short, the provision of response time will not be critical for Project reliability. Nevertheless, numerous failure response features will be provided, including an ability to respond to off-spec water within 24 hours.

13.3.3 Resilience in Operational Responses

Operations is the final critical element of the failure response strategy. A North City Project OP will be developed that includes defined protocols and procedures to engage in the event of excursions or failure. Section 16 of this report highlights some of the elements to be included in that document. The North City Project OP will identify failure conditions and provide a graded response based on the severity of the excursion or failure type. The responses will be standardized to allow for rapid operational actions that control the impact of treatment challenges. The specifics of these responses will be included in the draft North City Project OP that will be submitted for review by DDW prior to Project start-up.

13.3.4 Graded System-wide Alarms and Responses

To facilitate the effective operation of the Project, an operator-friendly, graded response plan will be used. The corrective actions will be graded based on the severity of the treatment excursion or failure. An overview of the plan is illustrated on Figure 13-8. The plan is based on the use of three different colored lights signifying normal operating conditions (green), compromised operating conditions (yellow), and failing operating conditions (orange). Each color is further subdivided into steady and flashing light scenarios, with flashing implemented as treatment performance begins to near the next color level down in operation.

When the NCWRP and NCPWF are operating at design LRV conditions, as described in Section 10, and presented in Table 13-1, the two facilities alone will provide protection in excess of 14/12/12 for V/G/C. Under these conditions, the NCWRP and NCPWF alone meet the full extent of the SWA regulations, which require a minimum treatment of 14/12/12 (10/9/10 + 4/3/2 provided by the Miramar DWTP) for this project with 10:1 dilution in the reservoir and retention time less than 4 months as discussed in Section 13.2.1.1.

13.3.4.1 Green Light - Normal Operating Conditions

The first operational mode, signified by a steady green light, is defined by periods when the NCPWF is providing treatment at least 2-logs above the 14/12/12 minimum. The operational mode switches to a flashing green light when the NCPWF moves between 16/14/14 and 14/12/12. A flashing green mode will initiate a response at the NCPWF to implement actions more urgently to improve treatment performance. Nevertheless, the facility remains in excess of the minimum 10/9/10 requirement; therefore, it still provides a significant buffer warranting the “green light” operational condition.

13.3.4.2 Yellow Light - Compromised Operating Conditions

If the NCPWF treatment drops below 14/12/12, the warning light will switch from flashing green to steady yellow. In the steady yellow light scenario, the treatment provided by the NCPWF coupled with treatment at the Miramar DWTP is above the 14/12/12 minimum (assuming 4/3/2 at Miramar DWTP). When the light switches from flashing green to steady yellow, the NCPWF will communicate to the Miramar DWTP that the NCPWF is running below design; however, the treated drinking water exiting the Miramar DWTP meets drinking water standards and should continue distribution.

If the NCPWF LRV treatment drops between 10/9/10 and 11/10/11, the warning light will begin to flash yellow. This indicates that the treatment provided by the Project and the Miramar DWTP are just meeting the required LRVs of 14/12/12 (10/9/10 + 4/3/2 = 14/12/12). At this point, the NCPWF will notify the Miramar DWTP to switch to an alternative source of water (imported water). The overall treatment at the NCPWF and Miramar DWTP is still compliant, however, with SWA requirements.

13.3.4.3 Orange Light – Failing Operating Conditions

If the NCPWF drops between 10/9/10 and 8/7/8, the warning light will switch from flashing yellow to steady orange. If the NCPWF drops to this level, DDW must be alerted. The SWA regulations do, however, allow for the NCPWF to discharge water of this quality to Miramar Reservoir for a period of up to four hours continuously and up to eight hours total in a seven-day period. At this stage, the NCPWF is running significantly below design and is in preparation to cease discharge to Miramar Reservoir. If the NCPWF drops to 8/7/8 or below, the warning light will switch from steady orange to flashing orange. In this scenario, the NCPWF must contact DDW and discontinue the pumping of purified water to Miramar Reservoir.

13.4 Overview of Reliability Features

The Project's overall reliability is based on the features encompassing both the failure prevention and failure response strategies that are illustrated on Figure 13-9. Through the enhanced source control, treatment, and monitoring provided through the NCPWF, it is anticipated that the failure prevention features alone will suffice to ensure a high degree of system reliability. The rigor of the failure prevention approach should minimize the need for additional failure response. Nevertheless, the Project will be implemented with significant failure response features, including multiple diversion points for off-spec water, as well as response time, dilution, and decoupling of Miramar Reservoir. The ability to rapidly switch to an alternative supply source (i.e., 100 percent imported water), provides additional failure response that also ensures the continued availability of the Miramar DWTP. Along with effective and defined operational strategies, these features ensure a high degree of potable reuse reliability.

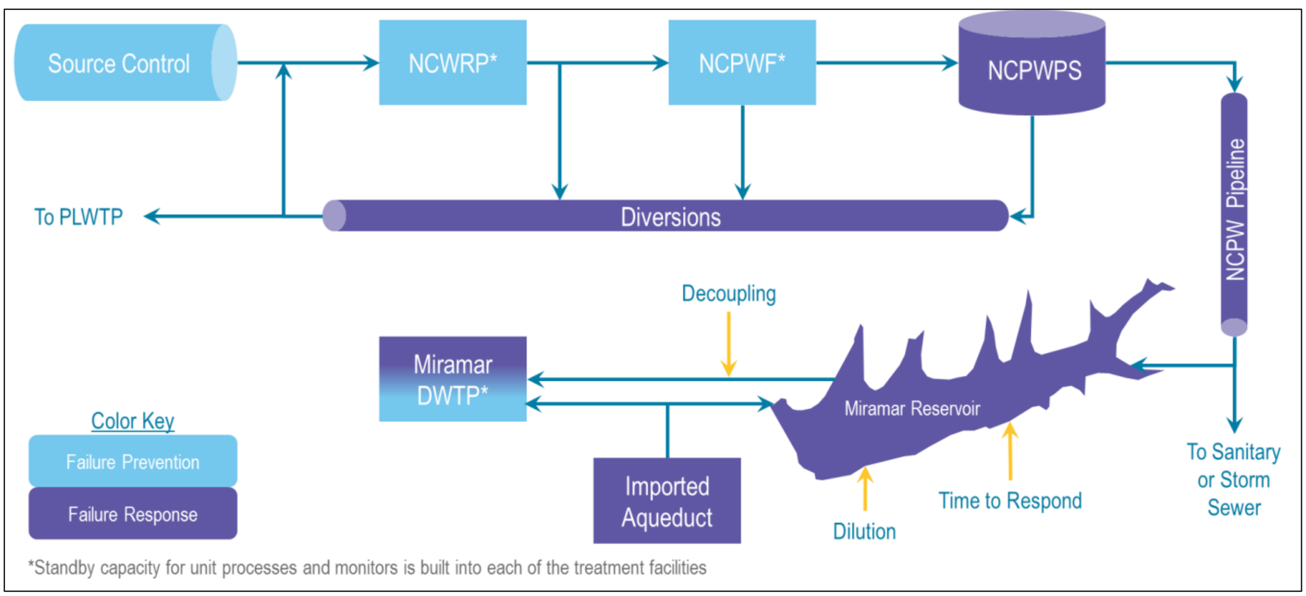


Figure 13-9: Reliability Features of the North City Project

14. Response and Notification Plan and Contingency Plan

To produce a water supply that is reliably protective of public health and the environment, the Project facilities will be equipped with state-of-the-art control and monitoring equipment that are operated by highly trained operations staff. Standby equipment will be included, as needed, to facilitate both planned and unplanned service of equipment. A North City Project OP will be developed that details SOPs for the facilities. See Section 16 for an overview of the OP to be submitted to DDW prior to Project start-up.

As discussed in previous sections, if the purified water does not meet permit requirements, pathogen reduction performance, or advanced treatment criteria based on on-line monitoring parameters (e.g., conductivity removal through RO, UV dose, etc.) and other critical control points limits, the purified water can be:

- Redirected to the PLWTP;
- Returned to the head of the NCWRP;
- Diverted within the NCPW Pipeline to drain to a nearby sewer or storm drain rather than discharging to Miramar Reservoir;
- Isolated within Miramar Reservoir; or
- Miramar DWTP can be decoupled from Miramar Reservoir so that the SDCWA aqueduct water is its only source water.

This section describes the responses and notifications that will be implemented if the operating conditions were to transition from normal to challenging conditions. This section also describes the contingency plan that will be implemented to ensure that a suitable raw water source is continuously available for the Miramar DWTP. The section is divided into the following subsections that describe the Project's response, notification, and contingency plans to protect public health:

- ***Enterprise Control Strategy.*** Description of the control strategy that will be implemented during both normal and challenging/emergency conditions;
- ***Interface with Water and Wastewater Operations.*** Description of the coordination and communication between the various operations groups, including both the level and means of communication between these groups;
- ***Response and Notification Plan.*** Description of the three operating conditions and the actions to be taken when operating under various scenarios of challenging excursions or failure. Additionally, the section describes the responses of the NCWRP, NCPWF and Miramar DWTP, and notification procedures between the operations groups and with DDW and the RWQCB; and
- ***Contingency Plan.*** Description of the actions to be taken to ensure the availability of an alternative raw water source in the event of a system failure or production of water that is non-compliant with permit requirements.

14.1 Enterprise Control Strategy

To produce and convey purified water to Miramar Reservoir for SWA reliably, a linear system comprising of multiple treatment and conveyance facilities is required. The interconnected nature of these facilities requires that the system be operated as a holistic enterprise. The Enterprise Level Control Strategy was developed as an overarching strategy to control Project facilities in a cohesive way. The Enterprise Level Control Strategy serves as a roadmap for the development of more detailed control plans and designs at the facility, process, and device levels. This approach will ensure that the controls associated with all the processes and devices (all the way down to sensors, input or output points, and control interlocks) of the various Project facilities are properly coordinated and consistent with the overarching strategy. The schematic on Figure 14-1 illustrates the control strategy hierarchy established for the North City Project.

A summary of facilities was developed to establish how the system will operate under standard and normal conditions, and how the system will react in response to an unplanned supply or quality event (e.g., production of off-spec water, loss of power, and unscheduled shutdown). A full assessment of the interconnection between the various elements of the system was performed to develop a detailed Enterprise Level Control Strategy Matrix. The matrix identifies facility instruments and devices, required monitoring signals, control interlocks needed between facilities, and resulting actions initiated by control signals. A general schematic of these interconnections is illustrated on Figure 14-2.

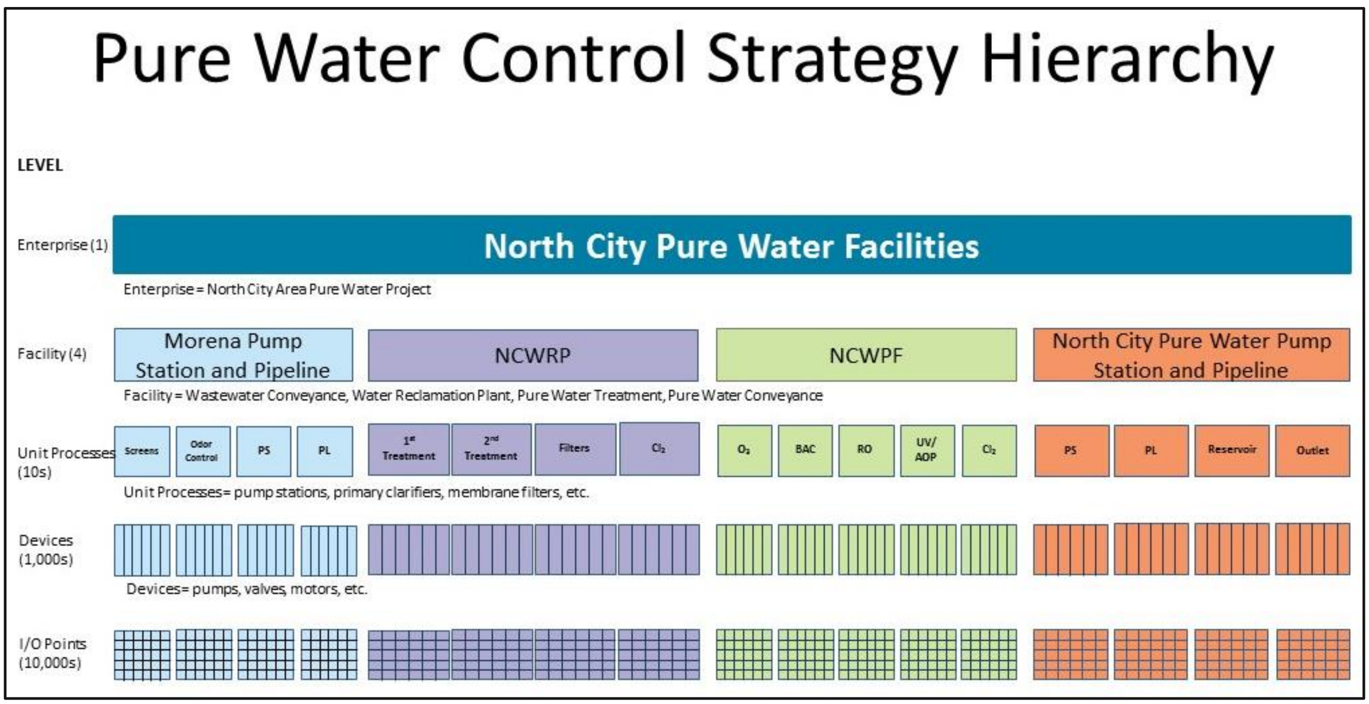
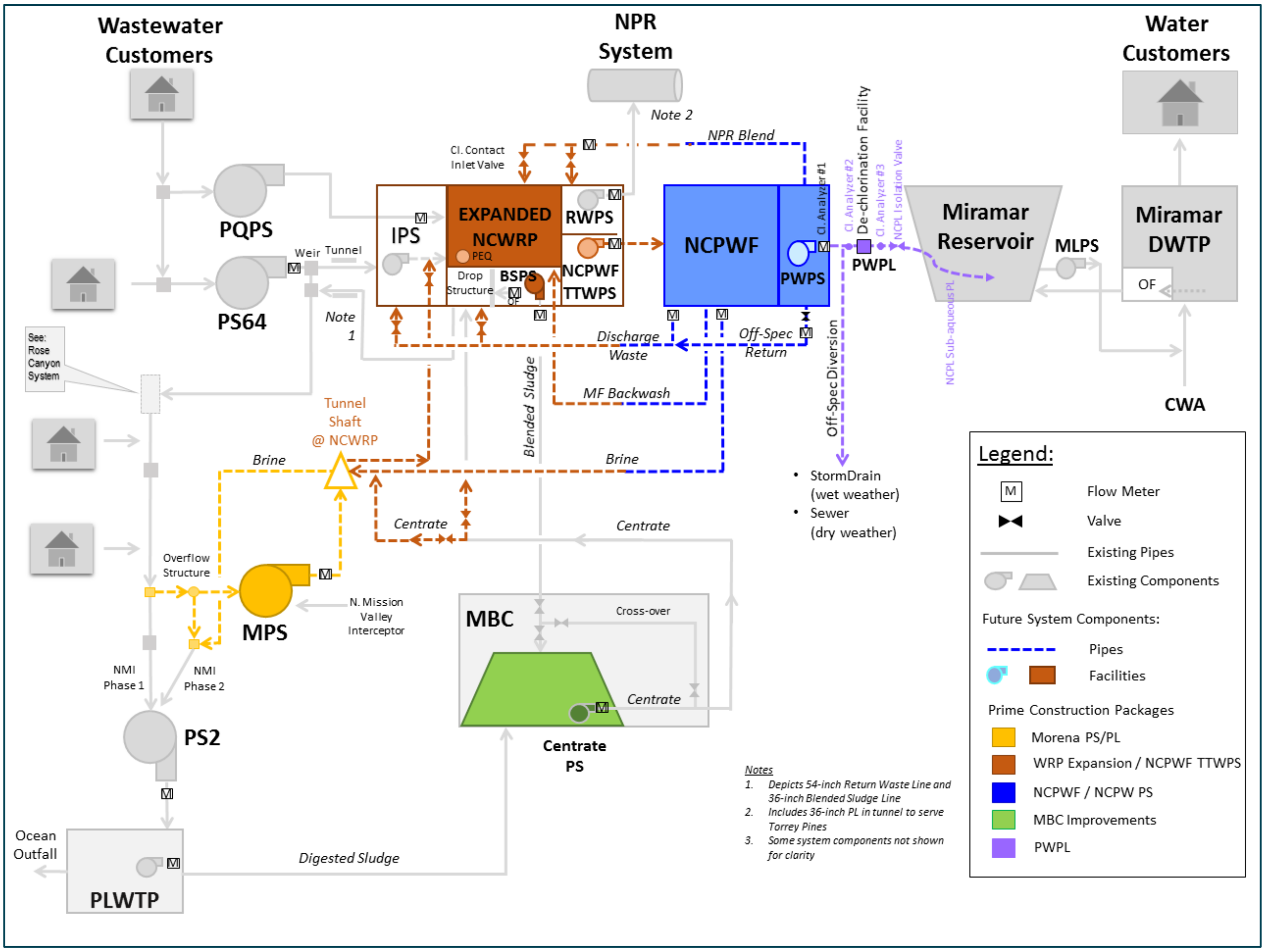


Figure 14-1: Pure Water Control Strategy Hierarchy



BSPS = Blended Sludge Pump Station; CL = Chlorine; CWA = County Water Authority (same as SDCWA); IPS = NCWRP Influent Pump Station (same as NCWRP Raw Wastewater Pump Station); MLPS = Miramar Lake Pump Station (same as Miramar Reservoir Pump Station); MPS = Morena Pump Station; NCPWF TTWPS = North City Pure Water Facility Tertiary Treated Water Pump Station; NMI = North Metro Interceptor; NPR = Non-Potable Reuse; OF = Overflow; PQPS = Penasquitos Pump Station; PWPL = Pure Water Pipeline; PWPS = Pure Water Pump Station; RWPS = Recycled Water Pump Station

Figure 14-2: Enterprise Level Infrastructure Overview

The Enterprise Level Control Strategy Matrix is being utilized by each of the facility design teams to ensure required devices, monitoring signals, and control interlocks are implemented consistent with the overarching control strategy. The operational scheme associated with the Enterprise Level Control Strategy will be described in detail in the North City Project OP.

14.2 Interface with Water and Wastewater Operations

The overall Pure Water Program organizational structure is presented on Figure 14-3. The Wastewater Treatment and Disposal Division within the System Management and Operations Branch of the PUD will be responsible for the O&M of all the Pure Water Program facilities. For the North City Project, this includes the Morena Pump Station and Pipeline, NCWRP, NCPWF, NCPW Pump Station and Pipeline, and NCPW Dechlorination Facility. The existing Pump Station 64 and the Penasquitos Pump Station convey raw wastewater to the NCWRP. The Wastewater Treatment and Disposal Division staff currently operate and maintain these two pump stations and will continue to do so when the new Project facilities are on-line. Water Operations staff currently operate the Miramar Reservoir Pump Station and the Miramar DWTP and will continue to do so after the new Project facilities are on-line.

As illustrated on Figure 14-3, both the Wastewater Treatment and Disposal Division and the Water Operations Division report to the same Assistant Director. Section 17 provides more details on how the City's PUD plans to incorporate the new Pure Water organization into its existing structure.

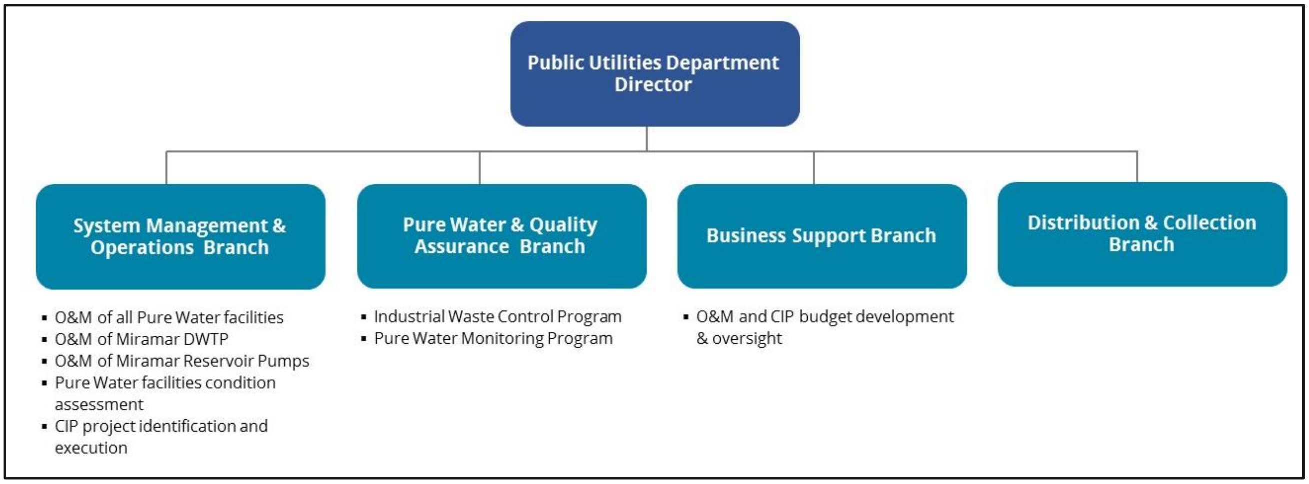


Figure 14-3: Pure Water Functions with the PUD Organization

The O&M of the new Project facilities will be coordinated through various standing weekly meetings. The typical objectives of these meetings are described below:

- Weekly Wastewater Treatment and Disposal Senior Staff Meetings
  - Coordinate and plan O&M activities among the wastewater and Pure Water facilities
  - Discuss and establish Pure Water Program and North City Project policies and procedures
  - Identify and implement system optimization studies
  - Identify and address cross-training needs
- Weekly NCWRP and NCPWF Staff Meetings
  - Review treatment performance at both treatment facilities
  - Plan upcoming O&M activities at both treatment facilities
- Monthly CIP meetings between the Wastewater Treatment and Disposal and the Engineering and Program Management Divisions
  - Monitor progress of ongoing CIP projects
  - Identify the need for new CIP projects
  - Program new CIP projects

The COMNET system is currently utilized by the Wastewater Treatment and Disposal Division to monitor and control all Metropolitan Sewerage System facilities. The Project facilities will be integrated into this system. Water Operations staff that operate and maintain the Miramar Reservoir Pump Station and the Miramar DWTP use a different monitoring and control system. Water Operations staff will continue to use their same supervisory control and data acquisition system, but a new communications link will be established for these facilities to receive all signals from COMNET. Thus, Water Operations staff will be able to see what is taking place at all the Project facilities.

On a day-to-day basis, coordination between the control rooms will be via telephone and email. Notifications via phone, with a follow-up email will be required to address operational changes or events that are expected to occur within 24 hours or less. Additional notification and communication may be necessary depending on the type of event. For planned operational changes or events that are anticipated to occur in 24 hours or more, notification via email will be required with a follow-up telephone call prior to the operational change or event. An example of typical, normal events requiring these notifications may include significant variations in flow rates.

It is envisioned that SOPs will be prepared as part of the North City Project OP to instruct operators on communications with other related facilities during normal operating conditions, as well as notification procedures in the event of alarm warning or emergency/shutdown conditions. Close operational coordination will be essential between the facilities because the flows, water quality, and permit requirements are interrelated. Perhaps one of the most significant SOPs will address the ability of the Miramar DWTP to decouple from Miramar Reservoir.

Other significant examples relate to handling off-spec water and start-up or restart procedures to bridge the interface and coordinate among all facilities, including the Morena Pump Station, NCWRP, Tertiary Treated Water Pump Station, NCPWF, NCPW Pump Station, NCPW Dechlorination Facility, Miramar Reservoir, and Miramar DWTP. It will be important to review the SOPs on a regular basis to make improvements based on "lessons learned." The interface with Water and Wastewater Operations for the Project will be described in more detail in SOPs and the North City Project OP that will be submitted for review and approval prior to the Project start-up.

The Pure Water and Quality Assurance Branch, as well as the Business Support Branch, will provide Project-related support functions outside of the realm of O&M. The IWCP will be enhanced to address additional constituents relevant to the Project (refer to Section 5 for these source control enhancements). The Pure Water and Quality Assurance Branch already provides laboratory support to both Wastewater and Water Operations and will take on the additional monitoring responsibilities, described in Section 15. The Program's CIP and O&M budgeting will be coordinated among the Operations, Pure Water and Quality Assurance, and Business Support Branches.

14.3 Response and Notification Plan

City staff will follow the SOPs, O&M manuals, and North City Project OP for operation of the NCWRP and NCPWF. The SOPs, O&M manuals, and OP will include plans and procedures for normal operation, preventive maintenance (e.g., membrane cleanings), equipment failures, power outages, source water quality excursions, NCWRP upsets or changes in performance, NCPWF upsets or changes in performance, and challenges with conveyance and the operations of Miramar Reservoir and the Miramar DWTP.

Section 13 presented an overview of the three operational scenarios for the system based on a green, yellow, and orange color system. These scenarios indicate normal operating conditions (green), compromised operating conditions (yellow), and failing operating conditions (orange). Each operational scenario is further subdivided into either a steady or flashing color category, indicating the level of urgency of the responses required. Within each of the resultant six categories, a series of notifications and responses will be enacted.

The response and notification plan corresponding to the various operational conditions is presented in Table 14-1. These responses will be modified and optimized (as needed and based on actual operating experience) to ensure compliance with the requirements of the SWA regulations and Project permit.

Table 14-1: Response and Notification Plan for the NCPWF

Condition	NCPWF Response	Miramar DWTP Notification	Miramar DWTP Response	DDW and the RWQCB Notification	Contingency
Green Steady	Standard operator response to address any treatment performance issues	N/A[a]	N/A	N/A	N/A
Green Flashing	Enhanced operator response to improve treatment performance	N/A	N/A	N/A	N/A
Yellow Steady	Enhanced operator response to improve treatment performance	NCPWF alerts Miramar DWTP of reduced, but acceptable level of treatment	N/A	N/A	N/A
Yellow Flashing	Further enhanced operator response to improve treatment performance	NCPWF alerts Miramar DWTP to use alternative source water	Miramar DWTP discontinues using water from Miramar Reservoir	N/A	Miramar DWTP uses only imported water
Orange Steady	Urgent operator response to improve treatment performance	NCPWF alerts Miramar DWTP to use alternative source water	Miramar DWTP discontinues using water from Miramar Reservoir	City notifies DDW and RWQCB that permit limits are jeopardized and alternative source water is in use	Miramar DWTP uses only imported water
Orange Flashing	Discontinue purified water flow to Miramar Reservoir	NCPWF alerts Miramar DWTP to use alternative source water	Miramar DWTP discontinues using water from Miramar Reservoir	City notifies DDW and RWQCB notified that purified water discharge to Miramar Reservoir has been discontinued and alternative source water is in use	Miramar DWTP uses only imported water

[a] Not applicable, meaning no response or notification is needed.

In summary, the responses and notifications increase in urgency and magnitude as the system moves from the green to the orange end of the spectrum. Given the high degree of treatment redundancy, treatment unit failures can be sustained without impacting the overall system's ability to meet overall treatment requirements (i.e., if a single unit in a system fails, the standby unit will operate in its place, providing the level of redundancy needed to maintain treatment performance). Thus, notifications between the NCPWF and the Miramar DWTP are not required until entering the yellow flashing operational mode. Because public health requirements are still met within the yellow mode, communications with DDW are not required. As the NCPWF enters the orange mode, communication with DDW and the RWQCB are required, along with more significant responses, including switching to imported water as the alternative raw water source and discontinuing purified water flow to Miramar Reservoir.

In addition to the system-wide responses to treatment issues, specific performance requirements for the NCWRP and each of its unit processes were discussed in Section 10. The performance of these barriers is measured continuously through on-line monitoring; operational responses are specified based on the measured treatment performance. Given the high degree of redundancy provided by the treatment system, reduced performance of any given unit treatment process will likely not impact the system's ability to comply with the minimum pathogen removal requirements. Nevertheless, opportunities exist within the NCPWF to divert off-spec water between unit processes and at the NCPW Pump Station. Details of these responses will be further developed in the SOPs, O&M manuals, and North City Project OP to ensure reliable operation of the various facilities.

14.4 Contingency Plan

An extensive Contingency Plan will be developed as part of the development of the North City Project OP. Under normal Project operating conditions, the Miramar DWTP will receive a blend of purified water stored in Miramar Reservoir and imported water from the SDCWA aqueduct system. The Contingency Plan will include measures taken to ensure the availability of an alternative raw water source (100 percent imported water from the SDCWA aqueduct system) for the Miramar DWTP in the event of process and control upsets that are triggered by failures in equipment or loss of power.

In the event the NCPWF purified water does not meet the permit requirements so that Miramar Reservoir can no longer be used as a source of water supply to the Miramar DWTP, the NCPWF will alert the Miramar DWTP to use an alternative water source, imported water, from SDCWA's raw water aqueduct system. This alternative will ensure the continued delivery of an acceptable raw water for treatment at the Miramar DWTP and distribution in the plant's service area.

Miramar DWTP currently receives imported water via connections to SDCWA's raw water aqueduct (Second Aqueduct). Those same connections between the Miramar DWTP and the aqueduct system will be used in the future if there is a need to entirely switch to an imported water source. The connections between the SDCWA aqueduct and the Miramar DWTP are completely independent of Miramar Reservoir connections; therefore, they would not be impacted by potential quality issues within the reservoir. In other words, imported water can be sent directly to the Miramar DWTP, bypassing Miramar Reservoir. Refer to Figure 6-40 for an illustration of the interconnections to the Miramar DWTP.

15. Monitoring and Reporting Program

Please note that this section is based on SWA regulations released by DDW in July 2017 and the information contained within this section may need to be revisited and updated based on the specific monitoring and reporting requirements included in the final SWA regulations. Please also note that the City is aware of the anticipated amendment to the State's Recycled Water Policy regarding CEC monitoring requirements and will comply with the requirements upon finalization of the Recycled Water Policy.

The proposed compliance MRP presented in this section is designed to satisfy the monitoring and reporting requirements specified in the SWA regulations. It is assumed that the City's existing MRP will suffice for the projected NPR demand. The MRP presented herein also includes anticipated purified water and receiving water monitoring likely to be required by the RWQCB for assessing compliance with state and federal water quality plans, policies, and standards. A laboratory with Environmental Laboratory Accreditation Program accreditation will be used for water quality compliance. This accreditation ensures the quality of analytical data used for regulatory purposes. The compliance sampling locations are illustrated on Figure 15-1 and Figure 15-2. The compliance sampling locations and the requirements, which are summarized below, are based on SWA regulations, the Water Quality Control Plan for the San Diego Basin, EPA's CTR requirements, and EPA's National recommendations.

- CCR Section 60320.302. Advanced Treatment Criteria:
    - Recycled municipal wastewater (Compliance Point 1c)
    - RO performance (Compliance Point 2e)
    - AOP performance
        - Demonstration testing
        - Routine monitoring (Compliance Points 2e & 2f)
- CCR Section 60320.308. Pathogenic Microorganism Reduction:
    - Verification that each treatment process is achieving credited LVRs
        - NCWRP Treatment (Compliance points 1a and 1c)
        - Ozone treatment (Compliance Point 2a)
        - MF treatment (Compliance Point 2b)
        - RO treatment (Compliance Point 2c, 2d, & 2e)
        - AOP treatment (Compliance Points 2e & 2f)
        - Pipeline chlorination treatment (Compliance Points 2g & 3a)
- CCR Section 60320.312. Regulated Contaminants and Physical Characteristics Control and Section 60320.320. Additional Chemical and Contaminant Monitoring:
    - Purified water quality at the NCPW Pump Station (Compliance Point 2g)
        - DDW SWA requirements
            - pMCLs and Action Levels
            - sMCLs
            - Notification Levels

        - Priority Toxic Pollutants
        - Chemicals Specified by DDW
        - Indicator Compounds specified by DDW and RWQCB
- Basin Plan:
    - Purified water quality at the NCPW Pump Station (Compliance Point 2g)
        - pMCLs (note: overlaps with SWA requirements)
        - sMCLs (note: overlaps with SWA requirements)
        - Mineral constituents
        - Biostimulatory substances (nutrients)
        - Physical parameters
- CFR Title 40, Section 131.38. Establishment of numeric criteria for priority toxic pollutants for the State of California:
    - Purified water quality at the NCPW Pump Station (Compliance Point 2g)
        - CTR constituents
- EPA National Recommendations:
    - NCPW Dechlorination Facility effluent – discharge into Miramar Reservoir (Compliance Point 3b)
        - Chlorine
- CCR Section 60320.326. Augmented Reservoir Monitoring and Section 64668.30. Surface Water Source Augmentation Project Augmented Reservoir Requirements:
    - Initial – prior to Project implementation (Compliance Points 4a-4c)
    - Routine (Compliance Point 4a-4c)

Operational parameters for alarms and response plans that are beyond the monitoring required by the promulgated regulations, such as additional monitoring of the NCWRP tertiary effluent, alternative reservoir water supply(ies), Miramar DWTP supply, Miramar DWTP finished drinking water, and process performance (critical control point and critical control limit), are discussed in Section 14 and Section 16. The MRP that will be conducted at the expanded NCWRP for NPR water direct uses will remain essentially unchanged from the existing NCWRP MRP. A description of the monitoring and reporting of the Miramar DWTP, which includes water withdrawn from Miramar Reservoir, plant influent, plant effluent, and key points in between, is detailed in Appendix G.

This section has the following layout and focuses on the proposed MRP for the production of purified water and its release into Miramar Reservoir:

- Advanced Treatment Criteria;
- Pathogenic Microorganism Reduction;
- Purified Water Quality Characteristics for Compliance;
- Discharge Characteristics for Compliance; and
- Augmented Reservoir Characteristics for Compliance.

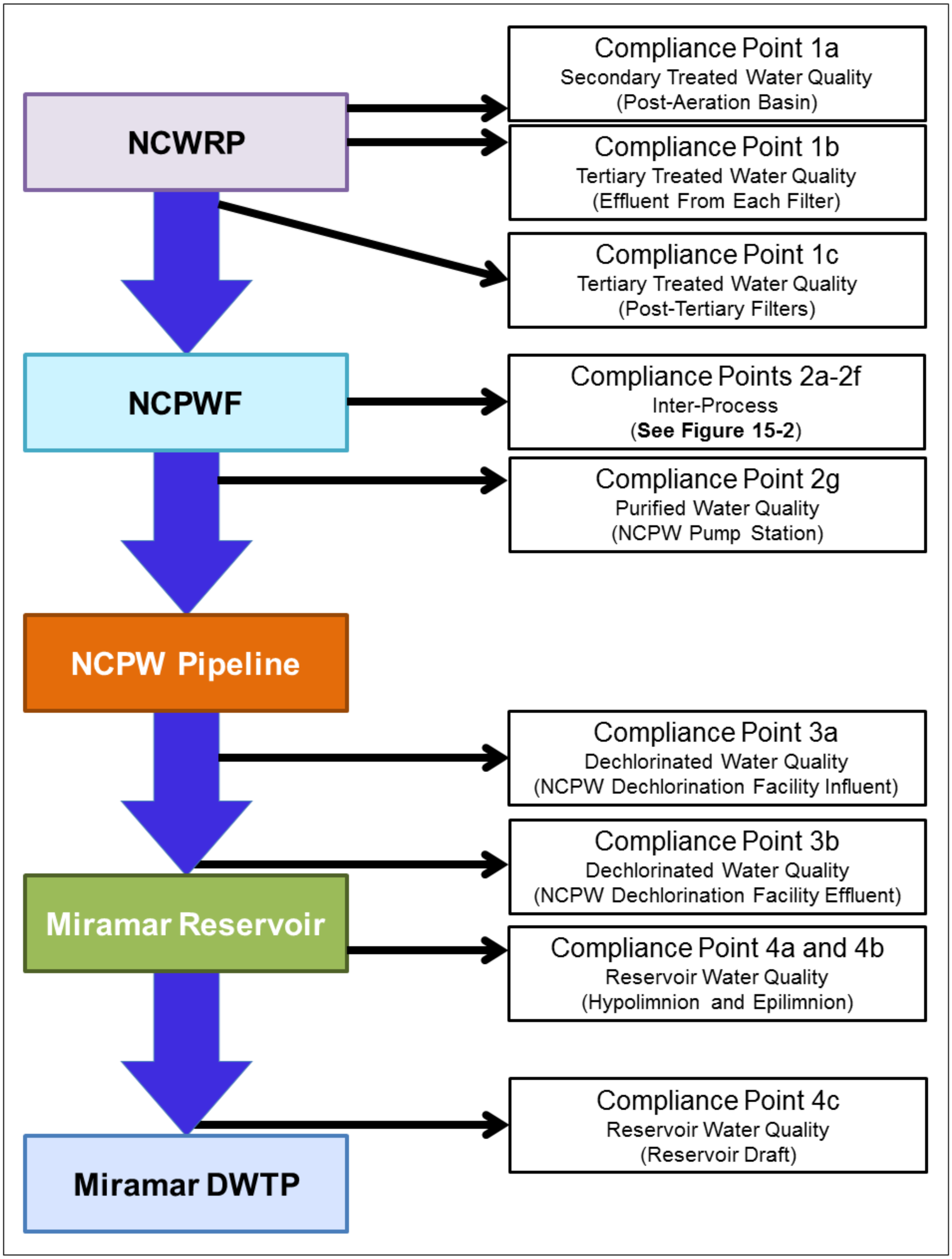


Figure 15-1: Locations of Compliance Points for the Purposes of the MRP

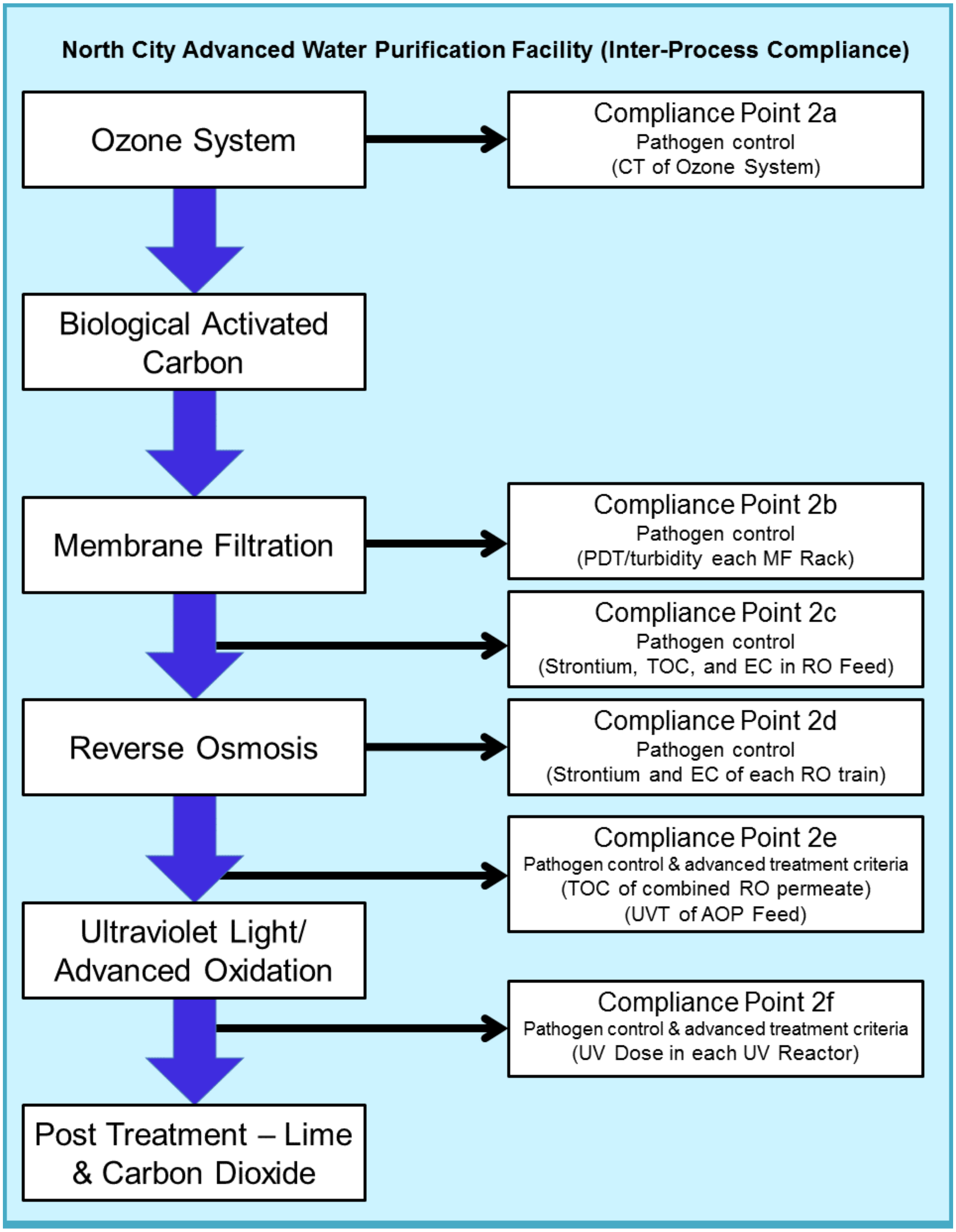


Figure 15-2: Locations of MRP Compliance Points – NCPWF Inter-Facility Compliance

15.1 Advanced Treatment Criteria

The sampling and reporting requirements within Section 60320.302 (Advanced Treatment Criteria) are provided in this subsection. For the RO and AOP systems, this section only addresses system monitoring requirements to demonstrate full advanced treatment. RO and AOP system requirements for microorganism control is discussed in Section 15.2, Section 10.2.3, and Section 10.2.4.

15.1.1 Recycled Municipal Wastewater

The City will use well-oxidized recycled municipal wastewater source from the NCWRP, which is tertiary treated as defined in Section 60301.650 (CCR, 2014). This requirement is satisfied through compliance with Discharge Specification IV.B.1 of RWQCB Order No. R9-2015-0091[1] that establishes the following effluent limitations for BOD:

- 30-day arithmetic average of the results from daily composite samples collected during any 30 consecutive calendar day period is less than 30 mg/L; and
- All daily composite samples are less than 45 mg/L.

The sampling location will be the combined effluent flow from the tertiary filters (Compliance Point 1c as illustrated on Figure 15-1).

15.1.2 Reverse Osmosis Performance

In accordance with Section 60320.302, at least one continuous surrogate or operational parameter for the RO must be monitored to demonstrate proper on-going full advanced treatment. This is different than the requirements related to pathogenic microorganism control, which are discussed in Section 15.2 and Section 10.2.3.

In accordance with Section 60320.302(b), ongoing performance monitoring will either use continuous conductivity or TOC (i.e., at least 15-min data) as a surrogate to indicate process integrity. The sampling location will be the combined RO permeate (Compliance Point 2e as illustrated on Figure 15-2). At least one of these forms of continuous monitoring will be proposed in the North City Project OP, along with operational targets and alarm settings to ensure integrity is maintained.

In accordance with Section 60320.302(g), the City will calculate the percent of results from the quarter's monitoring that did not meet the surrogate performance limits defined in the North City Project OP. If greater than 10 percent of the values fall outside the performance limit (using daily averages of 15-minute data for computation), the City will submit a report identifying reason(s) for failure, if known; describe corrective actions planned or taken; and consult with the RWQCB and SWRCB.

15.1.3 Advanced Oxidation Performance

In accordance with Section 60320.302, at least one continuous surrogate or operational parameter for the AOP must be monitored to demonstrate proper on-going full advanced treatment. This is different than the requirements related to pathogenic microorganism control, which are discussed in Section 15.2 and Section 10.2.4.

In accordance with Section 60320.302(c), demonstration testing will be conducted to validate 0.5-log reduction of 1.4-dioxane using a DDW-approved testing protocol. Additionally, UV dose for each reactor and

[1] RWQCB Order No. R9-2015-0091, *Master Recycling Permit for the City of San Diego NCWRP*, adopted by the RWQCB on December 16, 2016 (RWQCB, 2015).

UV/AOP influent UV transmittance will be evaluated as operational parameters to reflect that 0.5-log reduction of 1,4-dioxane has been achieved.

In accordance with Section 60320.302(d), during full-scale operations the following surrogate and operational parameters will be continuously monitored to demonstrate proper on-going AOP performance:

- Continuous (15-min data) on-line UV AOP influent UV transmittance (Compliance Point 2d as illustrated on Figure 15-2); and
- Continuous (15-min data) UV dose for each reactor (using continuous UV intensity sensors and continuous flowrate (Compliance Point 2e as illustrated on Figure 15-2).

In accordance with Section 60320.302(g), the City will calculate the percent of results from the quarter's monitoring that did not meet the following surrogate and operational parameter performance limits:

- Daily average UV AOP influent UV transmittance of 95 percent; and
- Daily average dose of 850 mJ/cm^2.

If greater than 10 percent of the values fall outside of performance limit (using daily averages of 15-minute data for computation), the City will submit a report identifying reason(s) for failure, if known; describe corrective actions planned or taken; and consult with the RWQCB and SWRCB.

15.2 Pathogenic Microorganism Control

To satisfy Section 60320.308(a)(3), on-going demonstration of at least 10-log virus, 9-log *Giardia* cysts, and 10-log *Cryptosporidium* oocysts reductions are required by the Project. To satisfy Section 60320.308(b), on-going monitoring can be conducted using the pathogenic microorganism of concern or a microbial, chemical, or physical surrogate parameter(s). The City will monitor each treatment process's ability to achieve its credited pathogen log reduction, as detailed in Section 10. Overall pathogenic microorganism credits will be achieved through the following treatment processes and demonstrated using the following corresponding surrogate parameters (also presented in Table 10-15):

- ***NCWRP Treatment.*** Pathogen LRV credits through the NCWRP that are determined from the NCWRP Pathogen Study will be met if the primary, secondary, and tertiary processes are properly functioning and if the following conditions are achieved (Compliance Points 1a and 1c[2] as illustrated on Figure 15-1):
  - Daily average ammonia secondary effluent ammonia-N must not exceed1 mg/L (Compliance Point 1a as illustrated on Figure 15-1)
  - The 30-day running average SRT must be greater than 9 days (Compliance Point 1a as illustrated on Figure 15-1)
  - Daily average combined filter effluent TOC does not exceed 11 mg/L. (Compliance Point 1c as illustrated on Figure 15-1):
    - An average of 1.5 NTU within a 24-hour period
    - 2.5 NTU more than 5 percent of the time within a 24-hour period
    - No exceedance over 5 NTU at any time

[2] It is anticipated that Compliance Point 1b may be required for pathogen crediting upon further pathogen monitoring at the NCWRP for determining filter loading rate compliance, but is not currently required.

   - Daily average combined filter effluent TOC does not exceed 11 mg/L. (Compliance Point 1c as illustrated on Figure 15-1)

- ***NCPWF Ozone Treatment.*** V/G/C LVR will be determined based on calculated ozone CT using temperature corrected truncated extended integration (Compliance Point 2a as illustrated on Figure 15-2).
- ***NCPWF MF Treatment.*** The LRV for the MF system will be calculated daily based on the PDT.
   - The indirect integrity testing using continuous turbidity measurements will ensure proper functioning of the MF system (Compliance Point 2b as illustrated on Figure 15-2).
- ***NCPWF RO Treatment.*** The LRV for the RO system will be calculated using a tiered approach (Compliance Points 2c, 2d, & 2e as illustrated on Figure 15-2):
   - Tier 1: Daily calculated strontium reduction of each RO train (lowest RO train LRV will be used for LRV reporting)
   - Tier 2: Continuous calculated TOC reduction of overall RO system
   - Tier 3: Continuous calculated EC reduction of each RO train (lowest RO train LRV will be used for LRV reporting)
- ***NCPWF AOP Treatment.*** The LRVs of 6/6/6 for V/G/C are expected if the following conditions are met:
   - Feed UV Transmittance ≥ 95 percent (Compliance Point 2e as illustrated on Figure 15-2)
   - UV Dose ≥ 300 mJ/cm2 (Compliance Point 2f as illustrated on Figure 15-2)
- ***NCPW Pipeline Chlorination Treatment.*** Chlorine residual, temperature, and pH will be continuously measured at the point of compliance to calculate a CT (Compliance Points 2g & 3a as illustrated on Figure 15-1):
   - *Giardia* LRV credit will be calculated using Appendix E of the EPA Disinfection Profiling and Benchmarking Guidance Manual (EPA 1999).
   - Virus LRV credit of 6-log will be achieved if the calculated CT is greater than 10 mg-min/L. If the calculated CT is less than 10 mg-min/L, virus LRV credit will be determine using Table C-7 from Appendix C of the EPA Disinfection Profiling and Benchmarking Guidance Manual (EPA 1999)

The criteria used to determine pathogen removal credit is presented in Table 10-15 in Section 10.3. In accordance with Section 60320.308(c), if the overall calculated pathogen reduction fails to meet the criteria longer than four consecutive hours or more than a total of eight hours during any seven-day period, the City will notify the RWQCB and SWRCB within 24 hours of the knowledge of the failure. Additionally, City staff at the NCPWF will coordinate and notify City staff at the Miramar DWTP, as discussed in Sections 14.2 and 14.4. Failures of shorter duration will be reported to the RWQCB no later than ten days after the month in which the failure occurred. In accordance with Section 60320.308(d), if pathogen reduction is reduced to less than 8-log enteric virus, 7-log *Giardia* cysts, and 8-log *Cryptosporidium* oocysts, the City will notify the RWQCB and SWRCB within 24 hours of the knowledge of the failure, unless directed otherwise, and follow the notification procedures outlined in Section 14.3.

15.3 Purified Water Quality Characteristics for Compliance

Purified water will be monitored as it leaves the NCPWF at the NCPW Pump Station (Compliance Point 2g as illustrated on Figure 15-1 to satisfy requirements in place to protect public health as discussed in this section. A summary of the proposed monitoring details of the purified water are presented in Table 15-1 and further discussed below. The discussion involves the following groups of constituents to be satisfied in the purified water quality at the NCPW Pump Station (Compliance Point 2g):

- CCR Section 60320.312. Regulated Contaminants and Physical Characteristics Control and Section 60320.320. Additional Chemical and Contaminant Monitoring:
    - Constituents with pMCLs and Action Levels (Section 60320.302(h) and Section 60320.312(a))
    - Constituents with NLs (Section 60320.302(h))
    - Constituents with sMCLs (Section 60320.312(b))
    - Priority Toxic Pollutants (Section 60320.320(a))
    - SWRCB-specified chemicals based on a review of the Engineering Report, augmented reservoir, and results of the City's Source Control Program (Section 60320.320(a))
    - RWQCB and SWRCB-specified indicator compounds (Section 60320.320(d))
- Basin Plan:
    - Purified water quality at NCPW Pump Station:
        - pMCLs (overlaps with SWA requirements)
        - sMCLs (overlaps with SWA requirements)
        - Mineral constituents
        - Biostimulatory substances (nutrients)
        - Physical parameters
- CFR Title 40, Section 131.38. Establishment of numeric criteria for priority toxic pollutants for the State of California:
    - Purified water quality at NCPW Pump Station
        - CTR constituents

Monitoring related to pathogenic microorganism control is summarized earlier in Section 15.2 and detailed in Section 10.

Table 15-1: Compliance Monitoring of Purified Water Quality Leaving NCPWF

Category	Subcategory	Initial Monitoring Frequency	Potential Reduced Monitoring Frequency	Sample Type
pMCLs and Action Levels (See Section 15.3.1)	Inorganic chemicals Radionuclides Organic chemicals Disinfection byproducts Lead and copper	Monthly	Quarterly[a]	Grab or 24-hour composite
sMCLs (See Section 15.3.2)	n/a	Annually	n/a	Grab or 24-hour composite
Notification Levels (See Section 15.3.3)	n/a	Monthly	Quarterly	Grab or 24-hour composite
Priority Toxic Pollutants (See Section 15.3.4)	n/a	Quarterly	Annually	Grab or 24-hour composite
DDW-Specified Chemicals (See Section 15.3.5)	n/a	Quarterly	Annually	Grab or 24-hour composite
DDW and RWQCB-Specified Indicator Compounds (See Section 15.3.6)	n/a	Annually	n/a	Grab or 24-hour composite
Basin Plan- and CTR-Specified Requirements (See Sections 15.3.7 and 15.3.8)	Basin Plan: Minerals MCLs Nutrients Physical characteristics EPA CTR Rule: CTR constituents	Monthly[b] Monthly[c] Weekly[d] Daily[e] Quarterly[f]	Not applicable[g]	Grab or 24-hour composite

[a] For asbestos, if four consecutive quarterly results are below the detection limit, the City may request reduced monitoring, one sample every three years.

[b] The City will implement purified water monitoring per monitoring requirements established by the RWQCB within the North City Project NPDES permit. It is anticipated that the NPDES permit will specify monthly monitoring of TDS and mineral constituents.

[c] The North City Project NPDES permit will incorporate monitoring for pMCL and sMCL parameters as directed by DDW.

[d] It is anticipated that the North City Project NPDES permit will specify weekly or monthly monitoring of nitrogen compounds and total phosphorus.

[e] It is anticipated that the North City Project NPDES permit will specify daily, five samples per week, or weekly monitoring of BOD and TSS, and continuous monitoring of temperature and pH.

[f] It is anticipated that the NPDES permit will specify quarterly monitoring of constituents regulated by the CTR.

[g] The RWQCB typically establishes monitoring requirements that apply throughout the five-year NPDES permit period. While precedent exists for the RWQCB reducing monitoring requirements after one or two years, it is anticipated that RWQCB monitoring provisions will apply throughout the entire five-year NPDES permit period. Monitoring requirements in future five-year NPDES renewals may include increased or decreased monitoring at the discretion of the RWQCB.

15.3.1 Primary Maximum Contaminant Levels and Action Levels

To satisfy Section 60320.302(h), the City will assess purified water on a monthly basis for all constituents with pMCLs and Action Levels, which are presented in Table 15-2 through Table 15-7. These analyses will be performed by a laboratory that has accreditation or certification pursuant to Section 100825 of the Health and Safety Code, utilizing drinking water methods approved by the SWRCB. After 12 consecutive months with no results exceeding a pMCL, the City may apply to the RWQCB and SWRCB for reduced monitoring frequency (no less than quarterly). For asbestos, if four consecutive quarterly results are below the detection limit, the City will request reduced monitoring of one sample every three years, but will resume quarterly monitoring if asbestos is detected.

If any values presented in Table 15-2 through Table 15-7 are exceeded, the City will collect a confirmation sample within 72 hours of being notified for analyses of the contaminants in question. For nitrate, nitrite, perchlorate, asbestos, lead, or copper, if the average of the initial and confirmation samples exceeds the contaminant's MCL or Action Level, or the confirmation sample is not collected and analyzed pursuant to this subsection, the City will notify the RWQCB and SWRCB within 24 hours and initiate weekly monitoring. This weekly monitoring will continue until results are below the contaminant's MCL or Action Level for four consecutive weeks. If the running four-week average exceeds the contaminant's MCL or Action Level, the City will notify the RWQCB and SWRCB within 24 hours and, if directed by the RWQCB or SWRCB, suspend delivery of the purified water to Miramar Reservoir. For all other contaminants, if the average of the initial and confirmation sample exceeds the contaminant's MCL, or a confirmation sample is not collected and analyzed pursuant to this subsection, the City will initiate weekly monitoring for the contaminant until the running four-week average no longer exceeds the contaminant's MCL.

If the running four-week average exceeds the contaminant's MCL, the City will describe the reason(s) for the exceedance and provide a schedule for completion of corrective actions in a report submitted to the RWQCB and SWRCB within 45 days following the quarter in which the exceedance occurred. If the running four-week average exceeds the contaminant's MCL for 16 consecutive weeks, the City will notify the RWQCB and SWRCB within 48 hours of knowledge of the exceedance and, if directed by the RWQCB or SWRCB, suspend delivery of the purified water to Miramar Reservoir.

Table 15-2: Primary Maximum Contaminant Levels / Inorganic Chemicals

Analyte	Units	Primary MCL	Method
Aluminum	mg/L	1	EPA 200.8
Antimony	mg/L	0.006	EPA 200.8
Arsenic	mg/L	0.010	EPA 200.8
Asbestos	millions of fibers per liter for fibers exceeding 10 microns in length	7	EPA 100.2
Barium	mg/L	1	EPA 200.8
Beryllium	mg/L	0.004	EPA 200.8
Cadmium	mg/L	0.005	EPA 200.8
Chromium	mg/L	0.05	EPA 200.8
Cyanide	mg/L	0.15	EPA 335.4
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Analyte	Units	Primary MCL	Method
Fluoride	mg/L	2.0	SM 4500F C
Hexavalent chromium	mg/L	0.010	EPA 218.6
Mercury	mg/L	0.002	EPA 245.1
Nickel	mg/L	0.1	EPA 200.8
Nitrate (as N)	mg/L	10	EPA 300.0
Nitrate+Nitrite (sum as N)	mg/L	10	EPA 300.0 Calculated
Nitrite (as N)	mg/L	1	EPA 300.0
Perchlorate	mg/L	0.006	EPA 314.0
Selenium	mg/L	0.05	EPA 200.8
Thallium	mg/L	0.002	EPA 200.8

Source: Title 22, Division 4, Environmental Health Chapter 15, Article 4, Section 64431

Table 15-3: Primary Maximum Contaminant Levels / Radionuclides

Analyte	Unit	MCL	Method
Radium-226 and Radium-228	pCi/L	5	GA Method
Gross Alpha Particle Activity (excluding radon and uranium)	pCi/L	15	EPA 900.0
Uranium	pCi/L	20	EPA 200.8
Beta/photon Emitters	millirem/year	4	EPA 900.0
Strontium-90	pCi/L	8	EPA 905.0
Tritium	pCi/L	20,000	EPA 906.0

Source: Title 22, Division 4, Environmental Health Chapter 15, Article 5, Sections 64442 and 64443

Table 15-4: Primary Maximum Contaminant Levels / Organic Chemicals / Volatile Organic Chemicals

Analyte	Units	Primary MCL	Method
Benzene	mg/L	0.001	EPA 524.2
Carbon Tetrachloride	mg/L	0.0005	EPA 524.2
1,2-Dichlorobenzene	mg/L	0.6	EPA 524.2
1,4-Dichlorobenzene	mg/L	0.005	EPA 524.2
1,1-Dichloroethane	mg/L	0.005	EPA 524.2
1,2-Dichloroethane	mg/L	0.0005	EPA 524.2
1,1-Dichloroethylene	mg/L	0.006	EPA 524.2
cis-1,2-Dichloroethylene	mg/L	0.006	EPA 524.2
trans-1,2-Dichloroethylene	mg/L	0.01	EPA 524.2
Continues on next page...			

Analyte	Units	Primary MCL	Method
Dichloromethane	mg/L	0.005	EPA 524.2
1,2-Dichloropropane	mg/L	0.005	EPA 524.2
1,3-Dichloropropene	mg/L	0.0005	EPA 524.2
Ethylbenzene	mg/L	0.3	EPA 524.2
MTBE	mg/L	0.013	EPA 524.2
Monochlorobenzene	mg/L	0.07	EPA 524.2
Styrene	mg/L	0.1	EPA 524.2
1,1,2,2-Tetrachloroethane	mg/L	0.001	EPA 524.2
Tetrachloroethylene	mg/L	0.005	EPA 524.2
Toluene	mg/L	0.15	EPA 524.2
1,2,4-Trichlorobenzene	mg/L	0.005	EPA 524.2
1,1,1-Trichloroethane	mg/L	0.200	EPA 524.2
1,1,2-Trichloroethane	mg/L	0.005	EPA 524.2
Trichloroethylene	mg/L	0.005	EPA 524.2
Trichlorofluoromethane	mg/L	0.15	EPA 524.2
1,1,2-Trichloro-1,2,2-Trifluoroethane	mg/L	1.2	EPA 524.2
Vinyl Chloride	mg/L	0.0005	EPA 524.2
Xylenes (single isomer or sum of isomers)	mg/L	1.750	EPA 524.2

Source: Title 22, Division 4, Environmental Health Chapter 15, Article 5.5, Section 64444

Table 15-5: Primary Maximum Contaminant Levels / Organic Chemicals / Non-Volatile Synthetic Organic Chemicals

Analyte	Units	Primary MCL	Method
Alachlor	mg/L	0.002	EPA 505
Atrazine	mg/L	0.001	EPA 525.2
Bentazon	mg/L	0.018	EPA 515.4
Benzo(a)pyrene	mg/L	0.0002	EPA 525.2
Carbofuran	mg/L	0.018	EPA 531.2
Chlordane	mg/L	0.0001	EPA 505
2,4-D	mg/L	0.07	EPA 515.4
Dalapon	mg/L	0.2	EPA 515.4
Dibromochloropropane	mg/L	0.0002	EPA 551.1
Di(2-ethylhexyl)adipate	mg/L	0.4	EPA 525.2
Di(2-ethylhexyl)phthalate	mg/L	0.004	EPA 525.2
Continues on next page...			

Analyte	Units	Primary MCL	Method
Dinoseb	mg/L	0.007	EPA 515.4
Diquat	mg/L	0.02	EPA 549.2
Endothall	mg/L	0.1	EPA 548.1
Endrin	mg/L	0.002	EPA 525.2
Ethylene Dibromide	mg/L	0.00005	EPA 551.1
Glyphosate	mg/L	0.7	EPA 547
Heptachlor	mg/L	0.00001	EPA 505
Heptachlor Epoxide	mg/L	0.00001	EPA 505
Hexachlorobenzene	mg/L	0.001	EPA 505
Hexachlorocyclopentadiene	mg/L	0.05	EPA 505
Lindane	mg/L	0.0002	EPA 505
Methoxychlor	mg/L	0.03	EPA 505
Molinate	mg/L	0.02	EPA 525.2
Oxamyl	mg/L	0.05	EPA 531.2
Pentachlorophenol	mg/L	0.001	EPA 515.4
Picloram	mg/L	0.5	EPA 515.4
Polychlorinated Biphenyls	mg/L	0.0005	EPA 505
Simazine	mg/L	0.004	EPA 525.2
Thiobencarb	mg/L	0.07	EPA 525.2
Toxaphene	mg/L	0.003	EPA 505
1,2,3-TCP	mg/L	0.000005	EPA 524.2m
2,3,7,8-TCDD (Dioxin)	mg/L	$3x10^{-8}$	EPA 1613B
2,4,5-TP (Silvex)	mg/L	0.05	EPA 515.4

Table 15-6: Primary Maximum Contaminant Levels / Disinfection ByProducts

Analyte	Units	MCL	Method
TTHM Bromodichloromethane Bromoform Chloroform Dibromochloromethane	mg/L	0.080	EPA 551.1
HAA5 Monochloroacetic Acid Dichloroacetic Acid Trichloroacetic Acid Monobromoacetic Acid Dibromoacetic Acid	mg/L	0.060	SM 6251B
Bromate	mg/L	0.010	EPA 317.0
Chlorite	mg/L	1.0	EPA 300.0

Source: Title 22, Division 4, Environmental Health Chapter 15.5, Article 2, Section 64533

Table 15-7: Primary Action Levels / Lead and Copper Chemicals

Analyte	Unit	Action Level	Method
Lead	mg/L	0.015	EPA 200.8
Copper	mg/L	1.3	EPA 200.8

Source: Title 22, Division 4, Environmental Health Chapter 17.5, Article 3, Section 64678

15.3.2 Secondary Maximum Contaminant Levels

To satisfy Section 60320.312(d), the City will assess purified water each year for the secondary drinking water contaminants presented in Table 15-8 and Table 15-9. These analyses will be performed by a laboratory that has accreditation or certification pursuant to Section 100825 of the Health and Safety Code utilizing drinking water methods approved by the SWRCB.

If the results of the yearly monitoring exceed a contaminant's sMCL in Table 15-8 or the upper limit in Table 15-9, the City will initiate quarterly monitoring for the contaminant. If the running annual average of quarterly-averaged results exceeds a contaminant's sMCL or upper limit, the City will describe the reason(s) for the exceedance and provide a schedule for completion of corrective actions in a report submitted to the RWQCB within 45 days following the quarter in which the exceedance occurred. The annual monitoring will be resumed if the running annual average of quarterly results does not exceed the contaminant's sMCL or upper limit.

Table 15-8: Secondary Maximum Contaminant Levels

Analyte	Units	MCL/Upper Limit	Method
Aluminum	mg/L	0.2	EPA 200.8
Color	Units	15	SM 2120B
Copper	mg/L	1.0	EPA 200.8
Foaming Agents, MBAS	mg/L	0.5	SM 5540C
Iron	mg/L	0.3	EPA 200.7
Manganese	mg/L	0.05	EPA 200.8
MTBE	mg/L	0.005	EPA 524.2
Odor - Threshold	Units	3	SM 2150B
Silver	mg/L	0.1	EPA 200.8
Thiobencarb	mg/L	0.001	EPA 525.2
Turbidity	NTU	5	EPA 180.1
Zinc	mg/L	5.0	EPA 200.8

Source: Title 22, Division 4, Environmental Health Chapter 15, Article 16, Section 64449

Table 15-9: Secondary Maximum Contaminant Levels / Upper Limits for Consumer Acceptance

Analyte	Units	MCL/Upper Limit	Method
TDS	mg/L	1,000	EPA 160.1
Specific Conductance	µS/cm	1,600	SM 2510B
Chloride	mg/L	500	EPA 300.0
Sulfate	mg/L	500	EPA 300.0

15.3.3 Notification Levels

To satisfy Section 60320.302(h) and Section 60320.320(b), the City will assess purified water monthly for all constituents with Notification Levels, which are presented in Table 15-10 for reference. After 12 consecutive months with no results exceeding a Notification Level, the City may apply to the RWQCB and SWRCB for a reduced monitoring frequency.

In accordance with Section 60320.320(e), if any values presented in Table 15-10 are exceeded, the City will collect a confirmation sample within 72 hours of being notified of the results. If the average of the initial and confirmation sample exceeds the contaminant's Notification Level, or a confirmation sample is not collected and analyzed pursuant to this subsection, the City will initiate weekly monitoring for the contaminant until the running four-week average no longer exceeds the Notification Levels. If the running four-week average exceeds the contaminant's Notification Level, the City will describe the reason(s) for the exceedance and provide a schedule for completion of corrective actions in a report submitted to the RWQCB, with a copy concurrently provided to the SWRCB, within 45 days following the quarter in which the exceedance occurred. If the running four-week average exceeds the contaminant's Notification Level for 16 consecutive weeks, the City will notify the RWQCB and SWRCB within 48 hours of knowledge of the exceedance. A chemical or contaminant detected as a result of monitoring conducted pursuant to this section will be reported to the RWQCB and SWRCB no later than the quarter following the quarter in which the results are received by the City.

Table 15-10: Notification Levels (Last Updated February 4, 2015)

Analyte	Units	Notification Level	Method
Boron	mg/L	1	EPA 200.7
n-Butylbenzene	mg/L	0.26	EPA 524.2
sec-Butylbenzene	mg/L	0.26	EPA 524.2
tert-Butylbenzene	mg/L	0.26	EPA 524.2
Carbon disulfide	mg/L	0.16	EPA 624
Chlorate	mg/L	0.8	EPA 300.0
2-Chlorotoluene	mg/L	0.14	EPA 524.2
4-Chlorotoluene	mg/L	0.14	EPA 524.2
Diazinon	mg/L	0.0012	EPA 525.2
Freon 12	mg/L	1	EPA 524.2
1,4-Dioxane	mg/L	0.001	EPA 522
Ethylene glycol	mg/L	14	EPA 8270C
Formaldehyde	mg/L	0.1	EPA 556
Continues on next page...			

HMX	mg/L	0.35	LC-MS-MS
Isopropylbenzene	mg/L	0.77	EPA 524.2
Manganese	mg/L	0.5	EPA 200.8
MIBK	mg/L	0.12	EPA 524.2
Naphthalene	mg/L	0.017	EPA 525.2
NDEA	mg/L	0.00001	EPA 521
NDMA	mg/L	0.00001	EPA 521
NDPA	mg/L	0.00001	EPA 521
Propachlor	mg/L	0.09	EPA 525.2
n-Propylbenzene	mg/L	0.26	EPA 524.2
RDX	mg/L	0.0003	LC-MS-MS
TBA	mg/L	0.012	EPA 524.2
1,2,4-Trimethylbenzene	mg/L	0.33	EPA 524.2
1,3,5-Trimethylbenzene	mg/L	0.33	EPA 524.2
TNT	mg/L	0.001	LC-MS-MS
Vanadium	mg/L	0.05	EPA 200.8

Source: DDW 2015

15.3.4 Priority Toxic Pollutants

In accordance with Section 60320.320(a)(1), the City will sample for Priority Toxic Pollutants on a quarterly basis, as specified by DDW based on review of this Engineering Report. The City may request reduced monitoring (to at least annually) after two years of data are available. Detected Priority Toxic Pollutants will be reported to DDW and the RWQCB no later than the quarter following the quarter in which the results were obtained. Some of the constituents in the list of Priority Toxic Pollutants are already monitored as part of the MCL monitoring effort. DDW may require the quarterly monitoring of purified water for some or all of the remaining Priority Toxic Pollutants presented in Table 15-11 through Table 15-14.

Table 15-11: Remaining Priority Toxic Pollutants[a] / Pesticides

Analyte	Method
Aldrin	EPA 505
Dieldrin	EPA 505
4,4’-DDT	EPA 8081A
4,4’-DDE	EPA 8081A
4,4’-DDD	EPA 525.2
Alpha-endosulfan	EPA 525.2
Beta-endosulfan	EPA 525.2
Endosulfan sulfate	EPA 8081A
Endrin aldehyde	EPA 8081A
Alpha-BHC	EPA 525.2
Beta-BHC	EPA 8081A
Delta-BHC	EPA 8081A

[a] Source EPA, 2000. Remaining priority toxic pollutants that are not MCLs.

Table 15-12: Remaining Priority Toxic Pollutants[a] / Volatile Organics

Analyte	Method
Acrolein	EPA 624
Acrylonitrile	EPA 624
Chlorobenzene	EPA 524.2
Chloroethane	EPA 524.2
1,1-dichloroethylene	EPA 524.2
Methyl chloride	EPA 524.2
Methyl bromide	EPA 524.2
2-chloroethyl vinyl ether	EPA 524.2

[a] Source EPA, 2000. Remaining priority toxic pollutants that are not MCLs.

Table 15-13: Remaining Priority Toxic Pollutants[a] / Acid Extractables

Analyte	Method
2,4,6-trichlorophenol	EPA 625
P-chloro-m-cresol	EPA 625
2-chlorophenol	EPA 625
2,4-dichlorophenol	EPA 625
2,4-dimethylphenol	EPA 625
2-nitrophenol	EPA 625
4-nitrophenol	EPA 625
2,4-dinitrophenol	EPA 625
4,6-dinitro-o-cresol	EPA 625
Phenol	EPA 625

[a] Source EPA, 2000. Remaining priority toxic pollutants that are not MCLs.

Table 15-14: Remaining Priority Toxic Pollutants[a] / Base/Neutral Extractables

Analyte	Method
Acenaphthene	EPA 525.2
Benzidine	EPA 625
Hexachloroethane	EPA 625
Bis(2-chloroethyl)ether	EPA 625
2-chloronaphthalene	EPA 625
1,3-dichlorobenzene	EPA 524.2
3,3'-dichlorobenzidine	EPA 625
Continues on next page...	

Analyte	Method
2,4-dinitrotoluene	EPA 525.2
2,6-dinitrotoluene	EPA 525.2
1,2-diphenylhydrazine	EPA 625
Fluoranthene	EPA 525.2
4-chlorophenyl phenyl ether	EPA 625
4-bromophenyl phenyl ether	EPA 625
Bis(2-chloroisopropyl)ether	EPA 625
Bis(2-chloroethoxyl)methane	EPA 625
Hexachlorobutadiene	EPA 524.2
Isophorone	EPA 525.2
Nitrobenzene	EPA 625
NDPA	EPA 521
N-nitrosodiphenylamine	EPA 625
Bis(2-ethylhexyl)phthalate	EPA 525.2
Butyl benzyl phthalate	EPA 525.2
Di-n-butyl phthalate	EPA 525.2
Di-n-octyl phthalate	EPA 625
Diethyl phthalate	EPA 525.2
Dimethyl phthalate	EPA 525.2
Benzo(a)anthracene	EPA 625
Benzo(a)fluoranthene	EPA 525.2
Benzo(k)fluoranthene	EPA 525.2
Chrysene	EPA 525.2
Acenaphthylene	EPA 525.2
Anthracene	EPA 525.2
1,12-benzoperylene	EPA 525.2
Fluorene	EPA 525.2
Phenanthrene	EPA 525.2
1,2,5,6-dibenzanthracene	EPA 525.2
Indeno(1,2,3-cd)pyrene	EPA 525.2
Pyrene	EPA 525.2

[a] Source EPA, 2000. Remaining priority toxic pollutants that are not MCLs

15.3.5 DDW-Specified Chemicals

In accordance with Section 60320.320(a)(2), the City will monitor for chemicals that DDW specifies based on its review of this Engineering Report, Miramar Reservoir, and results of the Source Control Program assessment. The City may request reduced monitoring (to at least annually) after two years of data are available. Detected chemicals will be reported to DDW and the RWQCB no later than the quarter following the quarter in which the results were obtained.

15.3.6 DDW- and RWQCB-Specified Indicator Compounds

In accordance with Section 60320.320(d), DDW and the RWQCB may specify Indicator Compounds that are monitored annually. The Indicator Compounds are selected based on the following:

- Review of the Title 22 Engineering Report;
- Review of the inventory developed as a part of the City's Source Control Program;
- Ability of Indicator Compound to characterize the performance of the AWT processes for the removal of chemical; and
- Availability of analytical methodologies.

If any specified Indicators Compounds are detected as a part of this additional monitoring, the City will notify DDW and the RWQCB no later than the quarter following the quarter in which results were obtained.

15.3.7 Basin Plan Specified Water Quality Objectives

As discussed in Section 4, the RWQCB-issued NPDES permit will include provisions to maintain the water quality necessary for the designated uses described in the Basin Plan for Miramar Reservoir. To protect the designated beneficial uses of Miramar Reservoir, the Basin Plan establishes water quality standards for the following:

- Mineral constituents such as TDS, chloride, sulfate, manganese, iron, boron, and fluoride;
- Constituents for which state and federal primary drinking water standards have been established; and
- Nutrient constituents (total nitrogen and total phosphorus).

The water quality standards are presented in Table 15-15.

Monthly, quarterly, and annual monitoring reports submitted to DDW and the RWQCB will document concentrations of the monitored chemicals or contaminants presented in Table 15-15.

Table 15-15: Basin Plan Surface Water Objectives for Purified Water Discharged to Miramar Reservoir

Parameter[a]	Concentration[b] (mg/l, unless otherwise noted)
TDS	500
Chloride	250
Sulfate	250
Percent sodium	60%
Iron	0.3
Continues on next page...	

Manganese	0.05
Boron	0.75
Fluoride	1.0
Biostimulatory substances[c]	Total phosphorus: 0.025 mg/L as P Total nitrogen 2.0 mg/L as N
pMCLs, sMCLs, and Action Levels[d]	Detailed list presented in Tables 15-2, 15-3, 15-4, 15-5, 15-6 and 15-7

[a] The following non-mineral constituents are duplicated in the Basin Plan and Title 22 Secondary MCLs lists: MBAS, odor, turbidity, and color. To avoid duplication and confusion, they are not individually presented in this table, because they are governed by requirements to meet secondary MCLs, since secondary MCLs are either the same or more stringent than the Basin Plan limits. Additionally, other physical characteristics, such as temperature, pH, and dissolved oxygen, are not presented in this table.

[b] Basin Plan surface water quality objectives not to be exceeded more than 10 percent of the time. Basin Plan surface water quality objectives have been adopted by EPA as federal surface water standards subject to the protection of the federal Clean Water Act.

[c] See Section 4.3.1.3 for details.

[d] This is a redundant requirement imposed by the RWQCB's NPDES permit on the purified water being discharged into Miramar Reservoir and does not differ from CCR Title 22.

15.3.8 California Toxics Rule

As discussed in Section 4.3, the RWQCB-issued NPDES permit will include statewide standards for inland surface waters that have been imposed by EPA within the CTR. CTR[3] standards are presented in Table 15-16 through Table 15-21. Monthly, quarterly, and annual monitoring reports submitted to DDW and the RWQCB will report concentrations of the monitored chemicals or contaminants. The methods shown in the tables were provided by an Environmental Laboratory Accreditation Program certified laboratory, represent the lowest detection limits for reporting purposes, and approved methods with these detection limits will be used to satisfy CTR for the Project.

Table 15-16: CTR Standards for Purified Water Discharged to Miramar Reservoir / Metals

Constituent	Criteria for the Protection of Aquatic Habitat[a]		Criteria for the Protection of Human Health - Consumption Plus Organisms[a]	Units	Method
	Criteria Maximum Concentration[b]	Criteria Continuous Concentration[c]			
Antimony, Total Recoverable	-	-	14	µg/L	EPA 200.8
Arsenic, Total Recoverable	340	150	-	µg/L	EPA 200.8
Beryllium, Total Recoverable	-	-	**	µg/L	EPA 200.8
Cadmium, Total Recoverable	4.3	2.2	**	µg/L	EPA 200.8
Chromium (III)	550	180	**	µg/L	Calculated (EPA 200.8)
Chromium (VI)	16	11	**	µg/L	EPA 218.6
Copper, Total Recoverable	13	9	1300	µg/L	EPA 200.8
Lead, Total Recoverable	65	2.5	**	µg/L	EPA 200.8
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3 The CTR (40 CFR 131.38) was established in 2000. The California Toxics Rule incorporates provisions of the 1992 National Toxics Rule (40 CFR 131.36).

Constituent	Criteria for the Protection of Aquatic Habitat[a]		Criteria for the Protection of Human Health - Consumption Plus Organisms[a]	Units	Method
	Criteria Maximum Concentration[b]	Criteria Continuous Concentration[c]			
Mercury, Total Recoverable	[Reserved]	[Reserved]	0.05	µg/L	EPA 245.1
Nickel, Total Recoverable	470	52	610	µg/L	EPA 200.8
Selenium, Total Recoverable	[Reserved]	5	**	µg/L	EPA 200.8
Silver, Total Recoverable	3.4	-	-	µg/L	EPA 200.8
Thallium, Total Recoverable	-	-	1.7	µg/L	EPA 200.8
Zinc, Total Recoverable	120	120	-	µg/L	EPA 200.8

[a] CTR (40 CFR 131) per EPA (2000). CTR numeric criteria for protection of human health are for consumption of water plus organisms. All values rounded to two significant figures.

[b] Criteria maximum concentration is the highest concentration to which aquatic life can be exposed for a short period of time without deleterious effect.

[c] Criteria continuous concentration is the highest concentration to which aquatic life can be exposed for four days without deleterious effect.

** EPA is not promulgating human health criteria for these contaminants; however, permit authorities should address these contaminants in NPDES permit actions using the State's existing narrative criteria for toxics.

- Indicates no standard is established.

Table 15-17: CTR Standards for Purified Water Discharged to Miramar Reservoir / Miscellaneous

Constituent	Criteria for the Protection of Aquatic Habitat[a]		Criteria for the Protection of Human Health - Consumption Plus Organisms[a]	Units	Method
	Criteria Maximum Concentration[b]	Criteria Continuous Concentration[c]			
Cyanide, Total (as CN)	22	5.2	700	µg/L	EPA 335.4
Asbestos	-	-	7.00E+06	Fibers/L	EPA 100.2
2,3,7,8-TCDD (Dioxin)	-	-	1.30E-08	µg/L	EPA 1613B

[a] CTR (40 CFR 131) per EPA (2000). CTR numeric criteria for protection of human health are for consumption of water plus organisms. All values rounded to two significant figures.

[b] Criteria maximum concentration is the highest concentration to which aquatic life can be exposed for a short period of time without deleterious effect.

[c] Criteria continuous concentration is the highest concentration to which aquatic life can be exposed for four days without deleterious effect.

- Indicates no standard is established.

Table 15-18: CTR Standards for Purified Water Discharged to Miramar Reservoir / Volatile Organics

Constituent	Criteria for the Protection of Aquatic Habitat[a]		Criteria for the Protection of Human Health - Consumption Plus Organisms[a]	Units	Method
	Criteria Maximum Concentration[b]	Criteria Continuous Concentration[c]			
Acrolein	-	-	320	µg/L	EPA 624
Acrylonitrile	-	-	0.059	µg/L	EPA 624
Benzene	-	-	1.2	µg/L	EPA 524.2
Bromoform	-	-	4.3	µg/L	EPA 524.2
Carbon Tetrachloride	-	-	0.25	µg/L	EPA 524.2
Chlorobenzene	-	-	680	µg/L	EPA 524.2
Dibromochloromethane	-	-	0.401	µg/L	EPA 551.1
Chloroethane	-	-	-	µg/L	EPA 524.2
2-Chloroethylvinyl Ether	-	-	-	µg/L	EPA 524.2
Chloroform	-	-	[Reserved]	µg/L	EPA 551.1
Dichlorobromomethane	-	-	0.56	µg/L	EPA 524.2
1,1-Dichloroethane	-	-	-	µg/L	EPA 524.2
1,2-Dichloroethane	-	-	0.38	µg/L	EPA 524.2
1,1-Dichloroethylene	-	-	0.057	µg/L	EPA 524.2
1,2-Dichloropropane	-	-	0.52	µg/L	EPA 524.2
1,3-Dichloropropylenes, Sum	-	-	10	µg/L	EPA 524.2
Ethylbenzene	-	-	3100	µg/L	EPA 524.2
Bromomethane	-	-	48	µg/L	EPA 524.2
Methyl Chloride	-	-	**	µg/L	EPA 524.2
Methylene Chloride	-	-	4.7	µg/L	EPA 524.2
1,1,2,2-Tetrachloroethane	-	-	0.17	µg/L	EPA 524.2
Tetrachloroethene	-	-	0.8	µg/L	EPA 524.2
Toluene	-	-	6800	µg/L	EPA 524.2
trans-1,2-Dichloroethene	-	-	700	µg/L	EPA 524.2
1,1,1-Trichloroethane	-	-	**	µg/L	EPA 524.2
1,1,2-Trichloroethane	-	-	0.6	µg/L	EPA 524.2
Trichloroethene	-	-	2.7	µg/L	EPA 524.2
Vinyl Chloride	-	-	2	µg/L	EPA 524.2

[a] CTR (40 CFR 131) per EPA (2000). CTR numeric criteria for protection of human health are for consumption of water plus organisms. All values rounded to two significant figures.

[b] Criteria maximum concentration is the highest concentration to which aquatic life can be exposed for a short period of time without deleterious effect.

[c] Criteria continuous concentration is the highest concentration to which aquatic life can be exposed for four days without deleterious effect.

** EPA is not promulgating human health criteria for these contaminants; however, permit authorities should address these contaminants in NPDES permit actions using the State's existing narrative criteria for toxics.

- Indicates no standard is established.

Table 15-19: CTR Standards for Purified Water Discharged to Miramar Reservoir / Acid Extractables

Constituent	Criteria for the Protection of Aquatic Habitat[a]		Criteria for the Protection of Human Health - Consumption Plus Organisms[a]	Units	Method
	Criteria Maximum Concentration[b]	Criteria Continuous Concentration[c]			
2-Chlorophenol	-	-	120	µg/L	EPA 625
2,4-Dichlorophenol	-	-	93	µg/L	EPA 625
2,4-Dimethylphenol	-	-	540	µg/L	EPA 625
4,6-Dinitro-2-methylphenol	-	-	13.4	µg/L	EPA 625
2,4-Dinitrophenol	-	-	70	µg/L	EPA 625
2-Nitrophenol	-	-	-	µg/L	EPA 625
4-Nitrophenol	-	-	-	µg/L	EPA 625
4-Chloro-3-methylphenol	-	-	-	µg/L	EPA 625
Pentachlorophenol	19	15	0.28	µg/L	EPA 515.4
Phenol, Single Compound	-	-	21000	µg/L	EPA 625
2,4,6-Trichlorophenol	-	-	2.1	µg/L	EPA 625

[a] CTR (40 CFR 131) per EPA (2000). CTR numeric criteria for protection of human health are for consumption of water plus organisms. All values rounded to two significant figures.

[b] Criteria maximum concentration is the highest concentration to which aquatic life can be exposed for a short period of time without deleterious effect.

[c] Criteria continuous concentration is the highest concentration to which aquatic life can be exposed for four days without deleterious effect.

- Indicates no standard is established.

Table 15-20: CTR Standards for Purified Water Discharged to Miramar Reservoir / Base/Neutral Extractables

Constituent	Criteria for the Protection of Aquatic Habitat[a]		Criteria for the Protection of Human Health - Consumption Plus Organisms[a]	Units	Method
	Criteria Maximum Concentration[b]	Criteria Continuous Concentration[c]			
Acenaphthene	-	-	1200	µg/L	EPA 525.2
Acenaphthylene	-	-	-	µg/L	EPA 525.2
Anthracene	-	-	9600	µg/L	EPA 525.2
Benzidine	-	-	0.00012	µg/L	EPA 625
Benzo(a)anthracene	-	-	0.0044	µg/L	EPA 625

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Constituent	Criteria for the Protection of Aquatic Habitat[a]		Criteria for the Protection of Human Health - Consumption Plus Organisms[a]	Units	Method
	Criteria Maximum Concentration[b]	Criteria Continuous Concentration[c]			
Benzo(a)pyrene	-	-	0.0044	µg/L	EPA 525.2
Benzo(b)fluoranthene	-	-	0.0044	µg/L	EPA 525.2
Benzo(ghi)perylene	-	-	-	µg/L	EPA 525.2
Benzo(k)fluoranthene	-	-	0.0044	µg/L	EPA 525.2
Bis (2-Chloroethoxy) Methane	-	-	-	µg/L	EPA 625
Bis (2-Chloroethyl) Ether	-	-	0.031	µg/L	EPA 625
Bis (2-Chloroisopropyl) Ether	-	-	1400	µg/L	EPA 625
Bis (2-Ethylhexyl) Phthalate	-	-	1.8	µg/L	EPA 525.2
4-Bromophenyl Phenyl Ether	-	-	-	µg/L	EPA 625
Butylbenzyl Phthalate	-	-	3000	µg/L	EPA 525.2
2-Chloronaphthalene	-	-	1700	µg/L	EPA 625
4-Chlorophenyl Phenyl Ether	-	-	-	µg/L	EPA 625
Chrysene	-	-	0.0044	µg/L	EPA 525.2
Dibenzo(a,h)anthracene	-	-	0.0044	µg/L	EPA 525.2
1,2-Dichlorobenzene	-	-	2700	µg/L	EPA 524.2
1,3-Dichlorobenzene	-	-	400	µg/L	EPA 524.2
1,4-Dichlorobenzene	-	-	400	µg/L	EPA 524.2
3,3-Dichlorobenzidine	-	-	0.04	µg/L	EPA 625
Diethyl Phthalate	-	-	23000	µg/L	EPA 525.2
Dimethyl Phthalate	-	-	313000	µg/L	EPA 525.2
Di-n-butyl Phthalate	-	-	2700	µg/L	EPA 525.2
2,4-Dinitrotoluene	-	-	0.11	µg/L	EPA 525.2
2,6-Dinitrotoluene	-	-	-	µg/L	EPA 525.2
Di-n-octyl Phthalate	-	-	-	µg/L	EPA 625
1,2-Diphenylhydrazine	-	-	0.04	µg/L	EPA 625
Fluoranthene	-	-	300	µg/L	EPA 525.2
Fluorene	-	-	1300	µg/L	EPA 525.2
Hexachlorobenzene	-	-	0.00075	µg/L	EPA 505
Hexachlorobutadiene	-	-	0.44	µg/L	EPA 524.2
Hexachlorocyclopentadiene	-	-	240	µg/L	EPA 505

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Constituent	Criteria for the Protection of Aquatic Habitat[a]		Criteria for the Protection of Human Health - Consumption Plus Organisms[a]	Units	Method
	Criteria Maximum Concentration[b]	Criteria Continuous Concentration[c]			
Hexachloroethane	-	-	1.9	µg/L	EPA 625
Indeno (1,2,3-cd) Pyrene	-	-	0.0044	µg/L	EPA 525.2
Isophorone	-	-	8.4	µg/L	EPA 525.2
Naphthalene	-	-	-	µg/L	EPA 525.2
Nitrobenzene	-	-	17	µg/L	EPA 625
NDMA	-	-	0.00069	µg/L	EPA 521
NDPA	-	-	0.005	µg/L	EPA 521
N-Nitrosodiphenylamine	-	-	5	µg/L	EPA 521
Phenanthrene	-	-	-	µg/L	EPA 525.2
Pyrene	-	-	960	µg/L	EPA 525.2
1,2,4-Trichlorobenzene	-	-	-	µg/L	EPA 524.2

[a] CTR (40 CFR 131) per EPA (2000). CTR numeric criteria for protection of human health are for consumption of water plus organisms. All values rounded to two significant figures.

[b] Criteria maximum concentration is the highest concentration to which aquatic life can be exposed for a short period of time without deleterious effect.

[c] Criteria continuous concentration is the highest concentration to which aquatic life can be exposed for four days without deleterious effect.

- Indicates no standard is established.

Table 15-21: CTR Standards for Purified Water Discharged to Miramar Reservoir / Pesticides & PCBs

Constituent	Criteria for the Protection of Aquatic Habitat[a]		Criteria for the Protection of Human Health - Consumption Plus Organisms[a]	Units	Method
	Criteria Maximum Concentration[b]	Criteria Continuous Concentration[c]			
Aldrin	3	-	0.00013	µg/L	EPA 505
alpha-BHC	-	-	0.0039	µg/L	EPA 525.2
beta-BHC	-	-	0.014	µg/L	EPA 525.2
gamma-BHC	0.95	-	0.019	µg/L	EPA 505
delta-BHC	-	-	-	µg/L	EPA 8081A
Chlordane	2.4	0.0043	0.00057	µg/L	EPA 505
4,4-DDT	1.1	0.001	0.00059	µg/L	EPA 8081A
4,4-DDE	-	-	0.00059	µg/L	EPA 8081A
4,4-DDD	-	-	0.00083	µg/L	EPA 525.2
Dieldrin	0.24	0.056	0.00014	µg/L	EPA 505
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Constituent	Criteria for the Protection of Aquatic Habitat[a]		Criteria for the Protection of Human Health - Consumption Plus Organisms[a]	Units	Method
	Criteria Maximum Concentration[b]	Criteria Continuous Concentration[c]			
Endosulfan I	0.22	0.056	110	µg/L	EPA 525.2
Endosulfan II	0.22	0.056	110	µg/L	EPA 525.2
Endosulfan Sulfate	-	-	110	µg/L	EPA 8081A
Endrin	0.086	0.036	0.76	µg/L	EPA 525.2
Endrin Aldehyde	-	-	0.76	µg/L	EPA 8081A
Heptachlor	0.52	0.0038	0.00021	µg/L	EPA 505
Heptachlor Epoxide	0.52	0.0038	0.0001	µg/L	EPA 505
Polychlorinated Bisphenyls	-	0.014	0.00017	µg/L	EPA 505
Toxaphene	0.73	0.0002	0.00073	µg/L	EPA 505

[a] CTR (40 CFR 131) per EPA (2000). CTR numeric criteria for protection of human health are for consumption of water plus organisms. All values rounded to two significant figures.

[b] Criteria maximum concentration is the highest concentration to which aquatic life can be exposed for a short period of time without deleterious effect.

[c] Criteria continuous concentration is the highest concentration to which aquatic life can be exposed for four days without deleterious effect.

- Indicates no standard is established.

15.4 Discharge Characteristics for Compliance

As discussed in Section 4, the RWQCB-issued NPDES permit will include a statewide policy established by the SWRCB for chlorine residual, which is based on the EPA-established national criteria for chlorine residual concentrations to protect freshwater aquatic life (EPA, 2014). These discharge characteristics will be monitored in the effluent from the NCPW Dechlorination Facility, immediately downstream of the dechlorination station along the NCPW Pipeline and prior to discharge to Miramar Reservoir (Compliance Point 3b as illustrated on Figure 15-1). The allowable chlorine levels are: four-day averages of 11 µg/L and instantaneous maximums of 19 µg/L. The monthly, quarterly, and annual monitoring reports submitted to DDW and the RWQCB will report these values.

15.5 Augmented Reservoir Characteristics for Compliance

Purified water discharged into Miramar Reservoir will be continuously metered and recorded daily using an on-line flow meter and recorder. Compliance will be based on the average daily volume over a monthly period with an annual maximum (i.e., 30 mgd x 365 day/year = 10,950 mgd/year = 33,600 AFY) based on 100 percent on-line factor as the maximum in the permit.

At a point nearest to Miramar Reservoir outlet, three locations will be sampled to monitor the quality of the augmented reservoir: (1) hypolimnion (Compliance Point 4a as illustrated on Figure 15-1), (2) epilimnion (Compliance Point 4b as illustrated on Figure 15-1), and (3) pump station at outlet that serves as a source water for the Miramar DWTP (Compliance Point 4c as illustrated on Figure 15-1). In accordance with Section 60320.326(b) these locations will be characterized monthly for 24 months prior to augmentation of the reservoir, and in accordance with Section 60320.326(c) this monthly monitoring will continue for at least 24 months following the start of delivery of purified water to Miramar Reservoir for the following parameters:

- sMCLs and Upper Limit (expanded list in Table 15-8);
- TOC;
- Total nitrogen;
- Bacteriology: Total coliform, E coli, and Enterococcus;
- Temperature;
- Dissolved oxygen;
- Chlorophyll α;
- Total phosphorus;
- Dissolved phosphorus; and
- Other SWRCB-specified parameters based on a review of the Engineering Report and City Source Control Program.

The City may request reduced monitoring frequencies from DDW after 24 months of monthly monitoring (Section 60320.326(d)). If approved by DDW, the reduced monitoring frequency shall be at least annually. In addition to reservoir monitoring for assessing drinking water-related conditions in Miramar Reservoir, it is probable that the RWQCB will establish receiving water monitoring requirements that assess conformance with Basin Plan objectives (discussed in Section 15.3.7) and evaluate effects on beneficial uses. It is anticipated that the RWQCB monitoring will focus on biostimulation, and at a minimum would include monthly or quarterly monitoring for nitrogen compounds, phosphorus compounds, chlorophyll α, temperature, dissolved oxygen, and water clarity. At the RWQCB's discretion, depth-dependent reservoir monitoring may be required at the aforementioned reservoir sampling stations.

15.6 Reporting

Monthly reports will be submitted to the RWQCB and SWRCB in compliance with the permit.

Routine reporting requirements are provided in Section 60320.328, which include annual and five-year reports. On an annual basis, no later than six months after the end of each calendar year, the City will provide a report to the RWQCB and SWRCB that is prepared by an engineer licensed in California and experienced in the fields of wastewater treatment and public water supply. The report, at a minimum, will include the following:

- Summary of compliance status with the monitoring requirements and criteria;
- Summary of any violations, including the date, duration, nature of the violation, any corrective actions or suspensions of delivery of purified water to Miramar Reservoir resulting from a violation, and if uncorrected, a schedule for and summary of all remedial actions;
- Summary of monitored chemicals or contaminants detected in Miramar Reservoir, and any observed trends;
- Description of any changes in the operation of any unit processes or facilities;
- Description of any anticipated changes, along with an evaluation of the expected impact of the changes on subsequent unit processes;
- Estimated quantity and quality of the purified water to be delivered for the next calendar year, as well as the quantity delivered for the previous three years; and

- Summary of the effectiveness and measures taken to comply with wastewater source control requirements.

Every five years from the date of the initial approval of this Title 22 Engineering Report, the City will update the Engineering Report to address any changes and submit the report to the RWQCB and SWRCB. The update will include, at a minimum, the anticipated increases in delivery of purified water and a description of the expected impact the increase will have on the City's ability to meet the regulatory requirements.

16. North City Project Operation Plan

This section presents the framework for the OP that will be prepared for the North City Project. While much is known about the elements comprising the OP for the Project, more detailed information about the actual facilities will become available after final designs are completed and construction nears completion. Technical specifications and process control descriptions from the construction contract documents and associated shop drawing submittals for the installed equipment will be used to develop the North City Project OP.

The framework for the North City Project OP is based primarily on the NCWRP 10% Engineering Design Report (MWH/BC, 2016b) and the NCPWF 30% Engineering Design Report (MWH/BC et al., 2016). Final designs are underway for these facilities, the Morena Pump Station and Pipeline, and NCPW Pump Station and Pipeline. Operation of these facilities will be paired with the operation of Miramar Reservoir and the Miramar DWTP to complete the North City Project OP.

This section presents the:

- Summary of the North City Project OP elements that will serve as the preliminary framework for the North City Project OP that will be submitted for review prior to beginning operation;
- Brief description of coordinated commissioning efforts by City and construction contractors and of system-wide test to verify proper functioning of all interconnections and system-wide control functions;
- Definition of the proposed operational ramp-up plan that includes strategies for staging Project operation during the initial period; and
- Explanation of how the City intends to dispose of off-spec water.

16.1 Summary of North City Project OP

The North City Project OP will comply with the requirements set forth in the SWA regulations. The purpose of the OP is to support the goal of optimizing facility operations in order to produce purified water reliably, with exceptional quality and at the targeted volumes to supplement existing water supplies.

The North City Project OP will describe all Project components, including:

- Descriptions of the treatment processes along with their purpose and functions;
- Design criteria for each process;
- Process schematics;
- Descriptions of process control strategies, process and instrumentation diagrams, and instrumentation devices with sample process control system screenshots;
- Discussions about the modes of operation, routine and normal operating conditions, process control troubleshooting, SOPs, emergency operating procedures, and operations staffing responsible for each process;
- Descriptions of alarms, trigger points for alarms, alarm levels and responses, emphasizing corrective actions, and explaining emergency shutdown procedures with restarting instructions;
- Information about the equipment, including general mechanical checklists, schedules for routine maintenance, troubleshooting, and maintenance procedures with references to equipment manufacturers' O&M manuals;

- Safety procedures;
- Process performance monitoring with applicable critical control points and limits to support attainment of LRVs for microbial pathogens and chemical contaminants;
- Water quality monitoring and reporting requirements, including details about laboratory analyses and analytical methods for contaminants that have pMCLs and sMCLs, microbial constituents, lead and copper action levels, and other unregulated constituents, along with sample reporting forms to be filed in accordance with the permit requirements;
- Descriptions of Miramar Reservoir operations with dilution and blending criteria, storage volumes and water levels, inlet and withdrawal rates, water quality monitoring and reporting, and source water supply management procedures;
- Staffing plan, quality control and assurance, and contingency plans, with descriptions of operator duties, qualifications, certifications, work schedules, and training programs; and
- Communication procedures (enterprise level and facility level), organization charts, and communication and communication between the wastewater/water reclamation, purified water, and drinking water O&M staff.

Towards the end of construction, the testing, commissioning, and start-up phases will be implemented. Various hands-on training sessions will be conducted for operations staff by the design engineers and equipment suppliers. Equipment manufacturers that are responsible for treatment systems will provide O&M manuals with detailed descriptions, step-by-step procedures, figures, and photographs for their respective processes. These manuals will be part of the construction submittals and will be available electronically. By assembling these documents, an electronic O&M manual "library" of all Project facilities will assist operators in handling normal conditions, routine maintenance, and troubleshooting to correct problems before they become process failures. The manufacturers' electronic O&M manuals also assist with process operation during abnormal or emergency conditions by instructing the operators in troubleshooting or proper shutdown procedures. It is envisioned that the North City Project OP will refer to the electronic O&M manual for specific equipment and systems.

Because it is an existing facility, the NCWRP already has its own O&M manual which will be used as the basis for the expanded and upgraded NCWRP portion of the North City Project OP. Similarly, the Miramar DWTP O&M manual will be used and referenced in the North City Project OP. Operation of Miramar Reservoir and the City's coordination with SDCWA for the delivery of imported water will be discussed in the North City Project OP. This includes lines of communication, which will be clearly described in action plans, to be triggered in the event off-spec water is produced at the NCPWF and the Miramar DWTP needs to discontinue drawing water from Miramar Reservoir and use imported water exclusively. Off-spec water is defined as any final effluent leaving the NCPWF (as measured at the NCPW Pump Station or Compliance Point 2g on Figure 15-1) that does not meet the requirements for discharge to Miramar Reservoir. For additional discussion of off-spec water, refer to Section 13 and Section 16.4.

Due to its size, it is envisioned that the North City Project OP will feature separate volumes with multiple sections for the major components of the Project. Below is a preliminary breakdown of the North City Project OP:

- NCWRP (including the source wastewater control, Morena Pump Station and Pipeline, and all treatment processes, diversions, and biosolids discharges);
- NCPWF (including the Tertiary Treated Water Pump Station and Pipeline, and all treatment processes, waste/concentrate discharges, and diversions);

- NCPW Pump Station and Pipeline (including the NCPW Dechlorination Facility and diversions);
- Miramar Reservoir (including purified water and alternative water supply sources); and
- Miramar DWTP (including the drinking water distribution system).

The SWRCB, with assistance from the California-Nevada Section of American Water Works Association and California Water Environment Association, is currently developing a statewide operator certification program for potable reuse facilities. These same agencies are responsible for the certification and training of water and wastewater facilities operators. The potable reuse program will bridge the gap between water and wastewater programs, and it is anticipated that new or modified programs will offer supplemental certification and cross-training for operators. For example, supplemental certifications would be offered to train wastewater operators in membrane and AWT technology monitoring, regulatory requirements, and appropriate emergency responses to protect public health. Likewise, supplemental certifications would be offered to train water treatment operators in wastewater processes and source wastewater quality requirements to benefit the AWT processes.

As a member of the California Urban Water Agencies, the City participated in the preparation of a white paper on potable reuse operator training and certification frameworks. The City anticipates continuing this effort to help the State of California with the development of a potable reuse operator certification program. The City will require appropriate levels of training and certification for Project operations staff; the Project staffing plan and organization chart will be presented in the North City Project OP. Refer to Section 17 for more details on the planning efforts completed to date to build a North City Pure Water Organization comprising qualified O&M staff.

The North City Project OP will be updated as needed to be representative of current operation, maintenance, and monitoring practices as actual experience with the Project facilities provides “lessons learned” and supports changes in the documentation. Similarly, SOPs for specific processes and systems will be revised from time to time based on experience with the facilities. Updates of the North City Project OP will be submitted to DDW and the RWQCB for review in accordance with the SWA regulations.

16.2 Contractor Commissioning and System-wide Test

All Project facilities will go through a rigorous contractor commissioning process prior to the City issuing a Notice of Completion to individual construction contractors. Following completion of all contractor commissioning activities and prior to the start of regular operations (i.e., prior to treatment of purified water at the Miramar DWTP), a system-wide test involving the concurrent operation of all Project facilities will be completed.

16.2.1 Contractor Commissioning

Specific contractor commissioning requirements will be detailed in the final design and construction documents that are currently under development. In addition, construction management firms have been retained by the City to oversee the construction for the conveyance and treatment facilities. Those firms will also review commissioning plans and will oversee commissioning for each of the facilities. The final commissioning documents will be discussed with DDW as a separate item from this Engineering Report.

In general, contractor commissioning, which will be preceded by equipment testing and functional acceptance testing of process systems, will include the following criteria for all of the Project’s facilities:

- ***Mechanical.*** All mechanical components working as specified in construction contract documents;
- ***Electrical.*** All electrical components working as specified in construction contract documents;

- ***Instrumentation.*** All instrumentation, including critical control point monitors, functioning;
- ***Controls and Display.*** All controls components (including displays) working as specified in the contract documents for and display of LRV on the distributed control system;
- ***Process Train Objectives.*** Tertiary treated water turbidity in the combined filter effluent with an average of < 1.5 NTU , < 2.5 NTU not more than 5 percent of the time in a 24-hour period, and < 5 NTU at all times, TOC ten-day running average of ≤ 11 mg/L, ozone process achieving target residual, RO process demonstrating dissolved organic carbon ≤ 0.25 mg/L , UV/AOP process demonstrating chlorine reductions that correspond to UV dose, and all design LRVs met (see Section 10 for design LRV objectives); and
- ***Decoupling.*** Demonstrate that alarm functions are capable of automatically sending the signal that would take the Miramar Pump Station off-line in accordance with the graded, system-wide alarms and responses discussed in Section 13.3.4. The pumps withdrawing from Miramar Reservoir will not be running at this time.

16.2.2 System-wide Test

When completed, the North City Project will form a linear system of interconnected water reclamation, water purification, and drinking water facilities. Not only do all of these facilities need to operate as planned individually, they also need to operate properly as a holistic unit. Following contractor commissioning of all individual facilities, the City will perform a system-wide test to verify proper functioning of all interconnections and system-wide control functions. That test will involve sequentially:

1. Pumping wastewater from the Morena Pump Station to the expanded NCWRP via the Morena Pipeline;
2. Treatment of that wastewater at the expanded NCWRP;
3. Pumping of tertiary treated water to the NCPWF via the Tertiary Treated Pump Station and Pipeline;
4. Advanced treatment of the tertiary treated water at the NCPWF;
5. Pumping of purified water to Miramar Reservoir via the NCPW Pump Station and Pipeline;
6. Dechlorination of the purified water at the NCPW Dechlorination Facility; and
7. Distribution of the purified water into Miramar Reservoir via the subaqueous pipeline at the bottom of the reservoir.

The system-wide test will involve the operational ramp up of each facility sequentially (one to seven), providing adequate time for each facility to achieve necessary performance targets. It is anticipated that the biological process in the NCWRP will be one of the tests that will require the most time to stabilize and achieve all performance objectives, followed by the advanced treatment at the NCPWF. Once all steps have been completed, the entire system will continue to be operated for a period of time (yet to be established) to confirm system-wide operation can be sustained without any malfunctions.

16.2.3 Handling of Purified Water During Commissioning and System-wide Test

The water produced during contractor commissioning activities and during the first four steps of the system-wide test will be diverted and not allowed to enter the NCPW Pipeline. Once all facilities in steps one through four are fully functional, the full-scale test will require the engagement of remaining facilities (NCPW Pump Station and Pipeline and NCPW Dechlorination Facility). This, in turn, will require the delivery of purified water into Miramar Reservoir. There are two important aspects of the proposed delivery of purified water to Miramar Reservoir during the contractor commissioning and system-wide testing: (1) the City plans to communicate to

DDW when it intends to first deliver water to Miramar Reservoir and (2) the Miramar DWTP will be isolated from the reservoir, meaning that it will not withdraw water from Miramar Reservoir at that time.

During the contractor commissioning work and system-wide test, the Miramar DWTP will only treat imported water delivered via the SDCWA system. Miramar Reservoir will be drawn down prior to delivering purified water to the reservoir to ensure that adequate storage capacity is available for the duration of commissioning and system-wide testing activities with a safety factor to ensure that no water needs to be extracted from Miramar Reservoir. Once all required certifications and regulatory approvals have been secured, the City will meet with DDW to discuss the start of the operational ramp-up (refer to Section 16.3). At this point and with DDW oversight, the Miramar DWTP will begin treating water from Miramar Reservoir at the flow rates defined in this Engineering Report.

16.3 Operational Ramp-Up

Following successful completion of the contractor commissioning and system-wide testing activities described in Section 16.2, the operation of the North City Project, including pumping of purified water diluted in Miramar Reservoir to the Miramar DWTP, will be ramped up gradually. This section includes the proposed plan for the City's operational ramp-up of the North City Project. Operational ramp-up follows traditional contractor commissioning that occurs after the construction phase and the planned system-wide test (both described in Section 16.2), which will be performed prior to delivery of purified water to the Miramar DWTP. Operational ramp-up will comprise three staging steps with incremental increases in the purified water flowrate, building up to full design production flow. The three staging steps include designated performance criteria to elevate confidence in the overall operations prior to full-scale implementation.

The operational ramp-up period is temporary and will be in addition to the MRP requirements for the Project. The proposed flowrates and durations for each of the three stages are presented in Table 16-1. The initiation and completion of each stage will be based on pre-defined, DDW-approved checklists that validate proper Project operations. These detailed plans and the checklist will be submitted to DDW as part of the North City Project OP. A completed checklist with supporting operational performance and enhanced water quality monitoring data will be supplied to DDW on a monthly basis and at the successful conclusion of each stage. The enhanced water quality monitoring will be discontinued after the Project has been in routine operations with full flow for approximately three months, at which point the routine MRP will commence.

If targets are met for the duration of a stage, the City will submit the final monthly checklist with supporting data and, upon written authorization from DDW, will go to the next stage. If targets are not met for the duration of a stage, the City will submit the final monthly checklist with supporting data and meet with DDW to present corrective measures. The operation at that stage of the ramp-up will continue until the targets are achieved, and an updated submittal confirming compliance is provided to DDW. At the end of Stage 3, a full report summarizing the Project operation and monitoring results will be submitted to DDW. The RWQCB will receive copies of the stage checklists and full report and will be invited to participate in any meetings related to operational ramp-up.

Table 16-1: Operational Ramp-up Staging Flowrates and Durations

Operational Ramp-up Stage	Stage 1	Stage 2	Stage 3
Average Purified Water Flow to Miramar Reservoir	7.5 mgd	15 mgd	30 mgd
Duration[a]	90 days	90 days	90 days

[a] Durations are tentative. If targets are met, the City will submit a final monthly checklist with supporting data to DDW and go to next stage without meeting with DDW.

Operational ramp-up will involve enhanced monitoring and reporting beyond the Project permit requirements. The five proposed criteria categories are illustrated on Figure 16-1: (1) Water Quality Compliance, (2) Treatment Train Reliability, (3) Reservoir Functions, (4) Reservoir Decoupling, and (5) Finished Water Analysis.

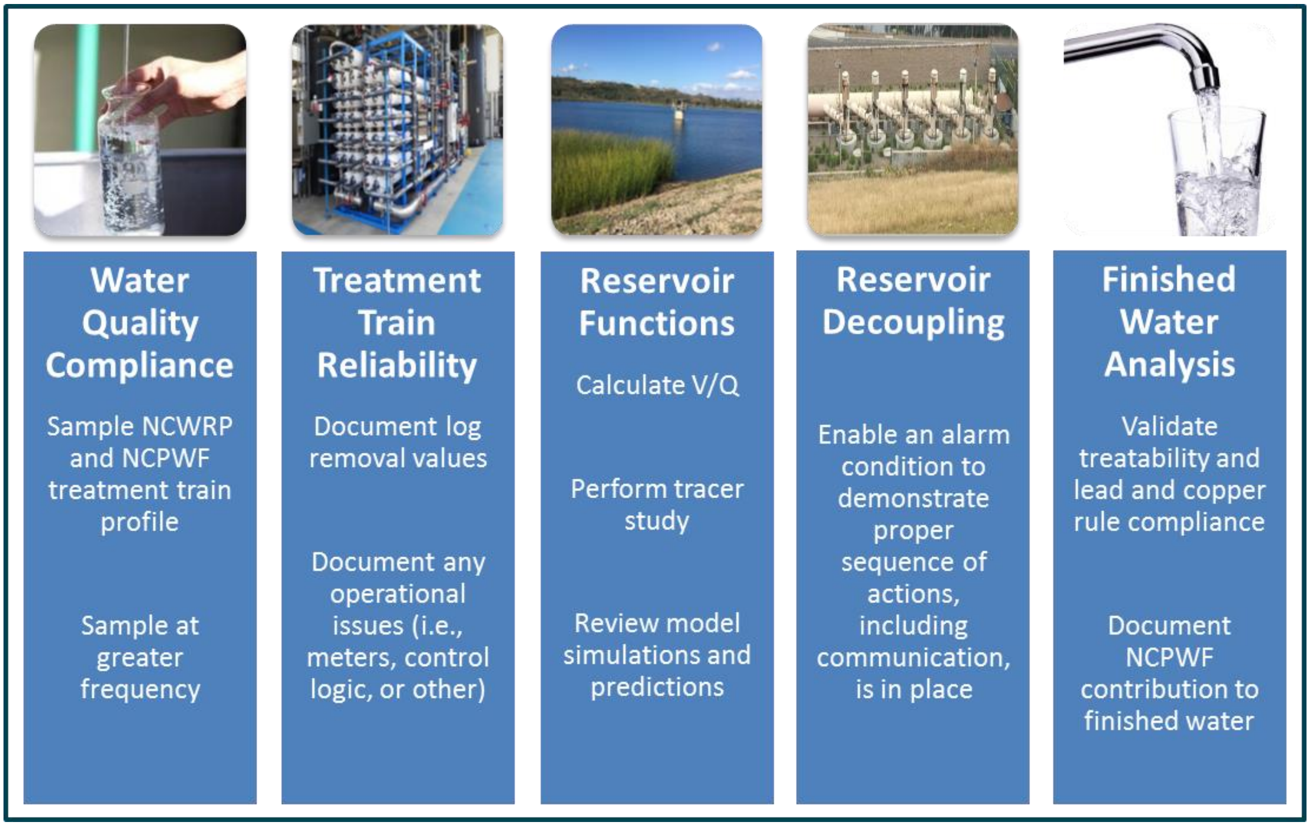

Figure 16-1: Proposed Criteria for Operational Ramp-up

The first criterion, Water Quality Compliance, includes the development of a water quality profile through the treatment train by monitoring multiple sampling locations, which are illustrated on Figure 16-2.

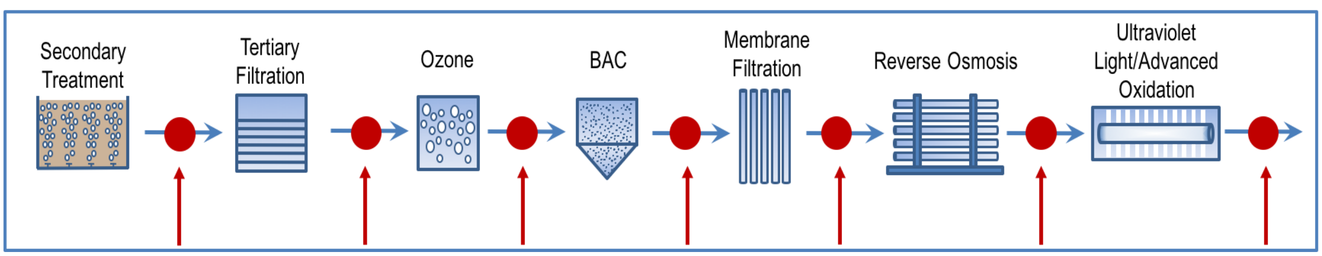

Figure 16-2: Multiple Sampling Locations to Develop Treatment Train Profiles

The monitored water quality parameters will include compliance monitors for constituents in the Project MRP to satisfy DDW and the RWQCB water quality objectives (further detailed in Section 15), as well as focused and enhanced monitoring for acute chemicals and parameters of concern at higher frequency, as presented in Table 16-2.

Table 16-2: Enhanced Monitoring During Operational Ramp-up

Constituent	Attenuation	Monitoring
Nitrate	Biological Nutrient Removal RO	Direct on-line (secondary) Continuous surrogate[a] (RO) Daily grabs (RO)
Nitrite	Biological Nutrient Removal Ozone RO	Direct on-line (secondary) Continuous surrogate[a] (Ozone/RO) Daily grabs (RO)
Perchlorate	Source Control RO	Weekly grabs (secondary) Continuous surrogate[a] (RO) Weekly grabs (RO)
1,4-dioxane and NDMA	Source Control Biological Nutrient Removal Ozone/BAC RO UV/AOP	Weekly grabs (secondary) Weekly grabs (RO and UV)

[a] Specific details on surrogate monitoring are provided in Section 10.

The second criterion, Treatment Train Reliability, includes assessment of each process using on-line, continuous monitoring techniques. The second criterion also includes demonstrating compliance with pathogen removal goals by using supervisory control and data acquisition outputs of LRVs for each unit process at 15-minute intervals, and automated calculations of the overall treatment train LRVs at 15-minute intervals to create distribution of pathogen performance. Pathogen removal performance will be reported and communicated frequently during operational ramp-up to demonstrate sufficient and acceptable pathogen removal is achieved. Figure 16-3 illustrates the pathogen reduction design goals and monitored parameters for each process that will be utilized during the operational ramp-up stages and beyond.

Multiple Barrier Treatment Train:

Pathogen	NCWRP	O_3/BAC	MF/UF	RO	UV/AOP	Pipeline Cl_2	Total
Virus	0.7	6	0	2.5	6	6	**21.2**
Giardia	3.2	6	4	2.5	6	1	**22.7**
Crypto	0.9	1	4	2.5	6	0	**14.4**
Monitoring[1]	SRT Ammonia Turbidity TOC	Ozone CT	Turbidity and PDT	Strontium TOC EC	UVT UV Dose	Free Chlorine CT Temperature pH	Sum of All Barriers

[1]Refer to Table 10-15 for a summary of the critical control point framework and pathogen LRV crediting strategy

Continuous Display of System Reliability:

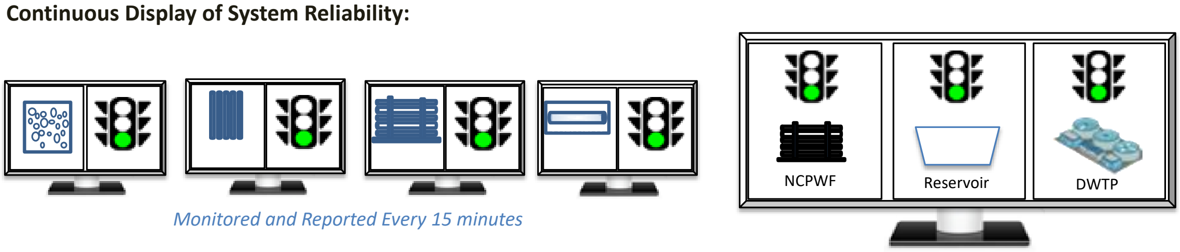

Figure 16-3: Pathogen Reliability Demonstration

The third criterion, Reservoir Functions, includes the development of methods to perform tracer studies in order to validate the hydrodynamic model, completion of tracer studies, execution of model under actual conditions experienced during each stage to determine dilutions achieved, and V/Q.

The fourth criterion, Reservoir Decoupling[1], includes demonstrating how the City responds to alarm conditions by executing the proper sequence of actions and lines of communication required to disengage the Miramar DWTP from Miramar Reservoir and switch to imported water as the sole source of water to ensure full protection of public health. During the decoupling step, DDW will have an opportunity to observe the procedures and complete plant inspections.

The fifth criterion, Finished Water Analysis, includes validation of finished water treatability, validation of appropriate corrosion control through lead and copper monitoring, and documentation of the NCPWF contribution to finished water. An example scenario, which used 2015 demands and assumed the Project begins delivering purified water in the winter season, was evaluated to predict the fraction of purified water in Miramar Reservoir and the fraction of purified water entering the Miramar DWTP. The results of this evaluation are illustrated on Figure 16-4.

[1] Decoupling of the six pumps that provide 100 mgd of withdrawal capacity provides time to evaluate upsets at the NCPWF. Miramar Reservoir is conducive to decoupling, because the Miramar DWTP can operate and typically does treat 100 percent imported water delivered through the SDCWA Second San Diego Aqueduct.

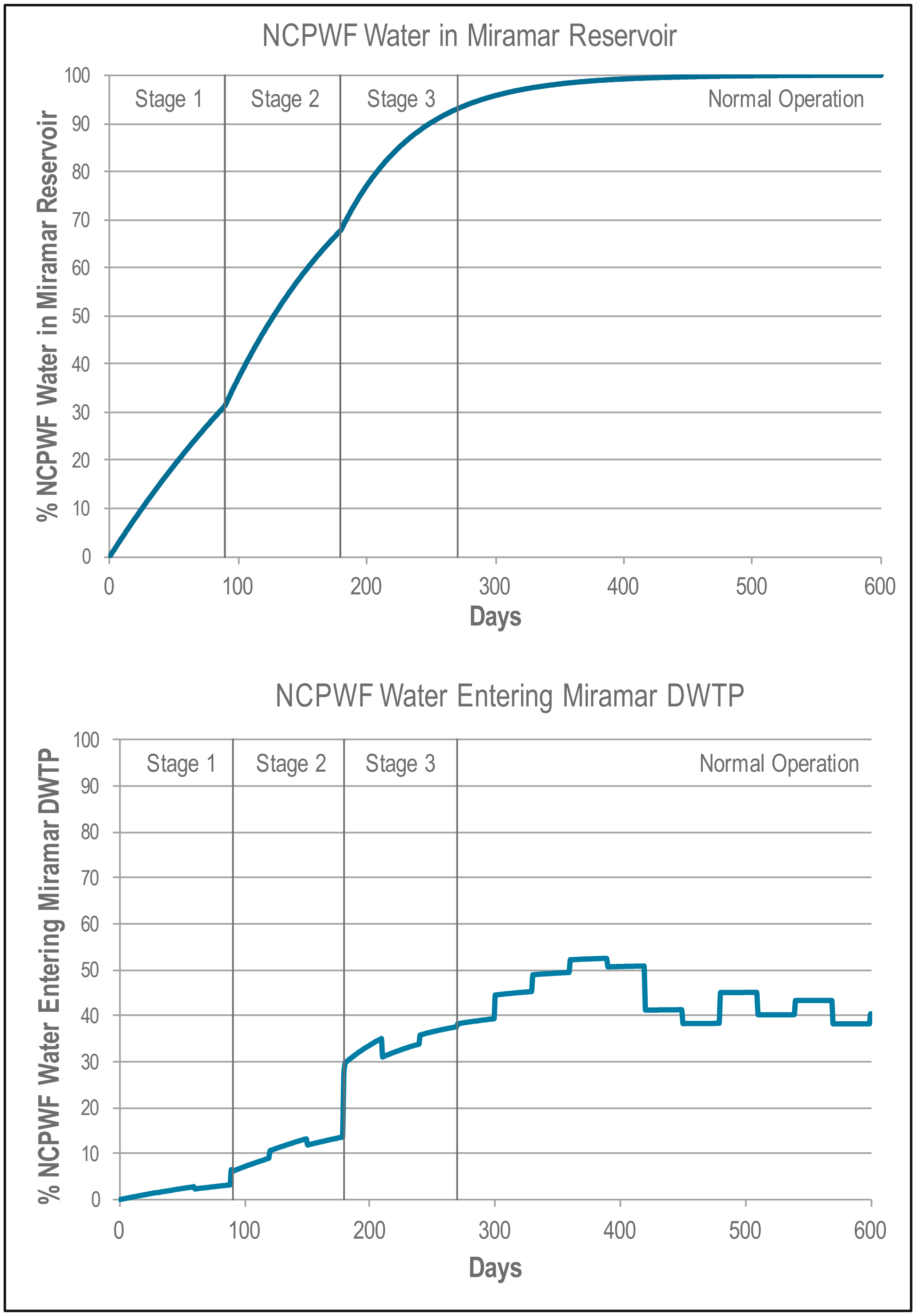

Figure 16-4: Depiction of Purified Water in Miramar Reservoir and Miramar DWTP During Each Ramping-Up Period

As discussed in Section 12.2.3, the ability of the treatment plant to demonstrate 80 percent turbidity removal through the Miramar DWTP processes may be uncertain when Miramar Reservoir contains virtually all purified water. Under these circumstances and depending upon the imported water blend, the source water turbidity may be at or below 0.25 NTU. This raw water turbidity level would requiring a consistent 0.05 NTU filtered water turbidity to demonstrate 80 percent turbidity removal. If this turbidity reduction cannot be measured, the plant must use other means to demonstrate that optimum coagulation is being achieved.

In 2015, a bench-scale study was conducted to assess potential impacts of the blended source water quality changes at the Miramar DWTP, and the City operators were trained regarding any operational changes identified during the study. The findings demonstrated that treatability was remarkably robust for all test conditions and purified water blended with imported water can be successfully coagulated and filtered.

The results of the bench and pilot testing demonstrated that maintaining filtered water turbidity is the key indicator of successful coagulation. Proper conditioning of the purified water to maintain sufficient alkalinity to avoid undesirable reductions in pH during coagulation will be important to maintain proper coagulation. Starting in 2013, the Miramar DWTP has received the President's Award from the Partnership for Safe Water for its filtered water quality performance. Therefore, filtered water turbidity will be used to gauge coagulation effectiveness when 80 percent removal of turbidity cannot be measured as a result of very low raw water turbidity, and alkalinity measurement will remain a part of regular monitoring to ensure that adequate buffering capacity is available to maintain coagulation pH in an optimal range.

In summary, the three purified water ramp-up staging steps, each approximately three months long, will demonstrate at a minimum, water quality compliance, treatment train reliability, reservoir benefits, and finished water conformance. Stage 1 serves as a practice round for decoupling, and Stage 2 allows DDW to participate as the City demonstrates its ability to decouple the reservoir. At the end of operational ramp-up, a final report will be generated for DDW's review and input. An example timeline and communication plan is illustrated on Figure 16-5.

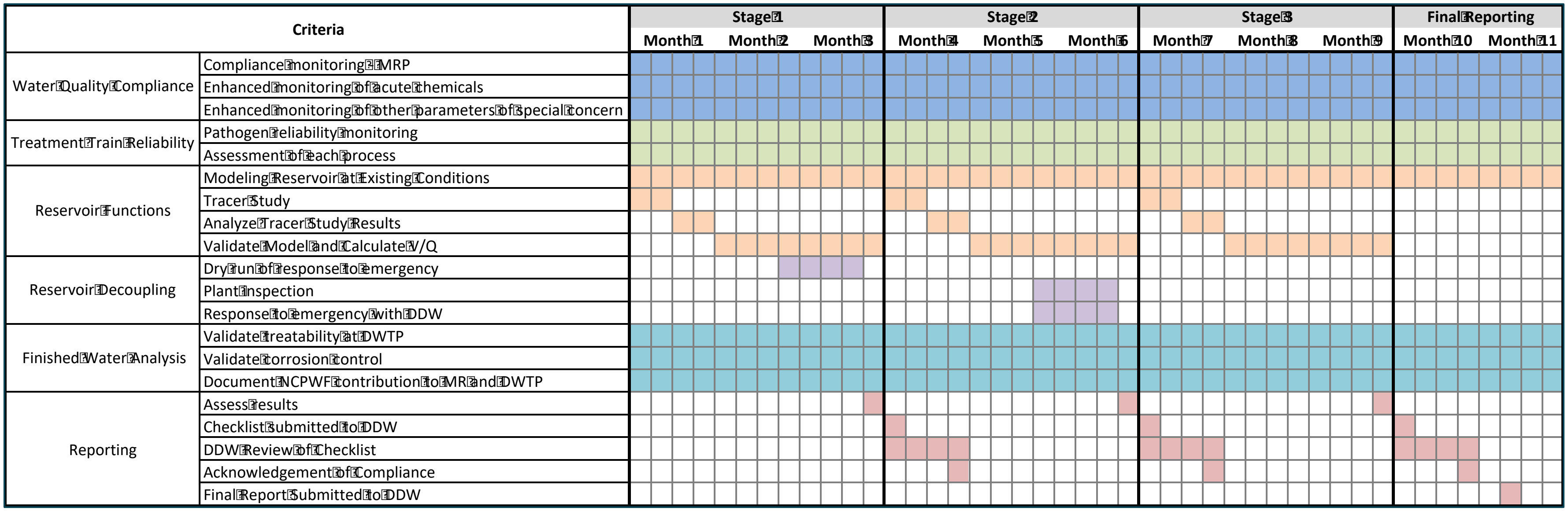

Figure 16-5: Example Timeline and Communication Plan

16.4 Handling of Off-spec Water

16.4.1 Handling Off-spec Water Prior to Reaching the Reservoir

As mentioned in previous sections of this Engineering Report, off-spec water is defined as any final effluent leaving the NCPWF that does not meet the requirements for discharge to Miramar Reservoir. In the very unlikely event that off-spec water requires the termination of discharge to Miramar Reservoir (refer to Figure 13-8 for conditions requiring shutdown of the NCPWF), the proposed strategies for off-spec water disposal were developed based on the following four goals:

1. Provide barriers to protect public health;
2. Limit scope of facilities required to dispose of off-spec water;
3. Minimize the conveyance system's out of service time before the NCPWF can come back on-line; and
4. Develop preferred disposal options based on a list of pre-selected criteria (e.g., reducing system down time, reducing water loss).

Three options for off-spec water disposal have been identified to provide operational flexibility and are described below. These options were developed as part of a thorough evaluation of various disposal strategies. That evaluation is documented in the Off-Spec Water Disposal Facilities Technical Memorandum (HDR, 2016b).

All three options utilize the closure of an isolation valve downstream of the NCPW Dechlorination Facility on the NCPW Pipeline to prevent off-spec water from entering Miramar Reservoir. This valve closure on the NCPW Pipeline will be performed immediately following the shutdown of the NCPW Pump Station, which will prevent any additional purified water from entering the NCPW Pipeline.

Option A: Disposal of Off-spec Water to the NCPWF Waste Discharge Pipeline. Option A involves draining the NCPW Pipeline back through the NCPW Pump Station discharge header controlled by a pressure control valve that is plumbed to a 24-inch pipeline. The 24-inch pipeline is connected to the 48-inch NCPWF Waste Discharge Pipeline, which has the capacity to drain 42 mgd. The NCPW Pipeline will drain back utilizing the elevation head in the pipeline. Water remaining in localized low points will have to be pumped out of the NCPW Pipeline and into adjacent sanitary sewers manually. This will require the temporary shutdown and closure of the NCPW Pump Station. Option A is best suited in a situation where disposing of off-spec water and the commencement of on-spec water production from the NCPWF will take more than a few hours. Draining the line back by gravity, using this disposal option, will take up to nine hours and an additional 37 hours will be needed to drain the multiple low points along the NCPW Pipeline manually.

Option B: Disposal of Off-spec Water to the Existing Carroll Canyon Trunk Sewer. Option B involves disposing of the volume of off-spec water that is in the NCPW Pipeline into the existing Carrol Canyon Trunk Sewer via an above-grade discharge pipe and into an existing sewer manhole. This option will require the re-start of the NCPW Pump Station at a lower flow rate to push the off-spec water out of the NCPW Pipeline into the Carrol Canyon Trunk Sewer. The capacity of the receiving trunk sewer will need to be monitored during that operation. In addition to the closure of the isolation valve downstream of the NCPW Dechlorination Facility, an additional closure of the isolation valve located at Via Pasar will be required to isolate the eastern portion of the NCPW Pipeline, downstream of the diversion point to the Carroll Canyon Trunk Sewer. Option B is not recommended during wet weather conditions. The travel time within the NCPW Pipeline from the NCPW Pump Station to the above-grade discharge pipe and into the Carrol Canyon Trunk Sewer is two hours when the NCPW Pump Station is operating at the maximum design flow (32.8 mgd). This option is suited for scenarios where on-spec water production is projected to be within a few hours and operators are looking to dispose of the off-spec water in the pipeline segment west of Via Pasar during dry weather conditions.

Option C: Disposal of Off-spec Water to the Existing Storm Drain System. Option C involves disposing of the volume of off-spec water that is in the NCPW Pipeline into an existing 18-inch storm drain located in Meanley Drive, just downstream of the NCPW Dechlorination Facility. Information gathered from the existing storm drain system as-builts and a hydraulic analysis indicated adequate capacity to accommodate the full flow of the NCPW Pump Station. Similarly to Option B, this option will require the re-start of the NCPW Pump Station at a lower flow rate to push the off-spec water out of the NCPW Pipeline into the storm drain system. The capacity of the receiving storm drain system and any potential erosion issues at the outlet located at the west end of Scripps Ranch Court will need to be monitored during that operation. Operators will also need to coordinate with the City's Transportation and Storm Water Department, particularly during a rain event. This option involves the following requirements:

- A NPDES permit;
- Water quality compliance monitoring; and
- Compliance with applicable surface water quality standards.

Furthermore, the following may be required:

- Energy dissipation/erosion controls or flow throttling facilities; and
- A U.S. Army Corps of Engineers streambed alteration permit.

The travel time within the NCPW Pipeline from the NCPW Pump Station to the storm drain diversion point is two hours and 30 minutes when the NCPW Pump Station is operating at the maximum design flow (32.8 mgd). Figure 16-6 illustrates a preliminary decision matrix that has been developed to assist operations staff in the very unlikely event that off-spec water is produced at the NCPWF. The disposal options and associated procedures will be refined and documented in the North City Project OP.

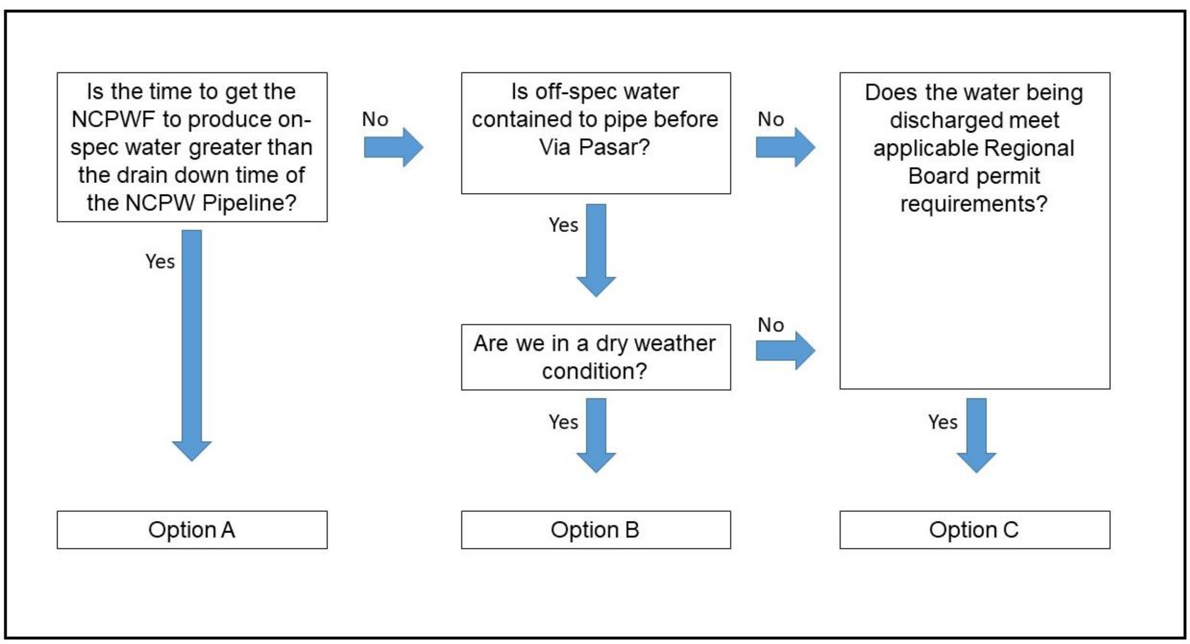

Figure 16-6: Decision Diagram for Disposal of Off-spec Waters

In addition to the above-mentioned proposed configurations for the temporary offloading or disposal of off-spec water in the NCPW Pipeline, the City continues to explore other possible engineering solutions to assist with permanent offloading of the PLWTP.

16.4.2 Handling Off-spec Water Should it Reach the Reservoir

In the unlikely event that off-spec water is produced by the NCPWF, the immediate response is to terminate the flow in the conveyance pipeline to Miramar Reservoir. Section 16.4.1 describes the procedures to dispose of off-spec water from the conveyance pipeline.

In the even more unlikely event that off-spec water reaches the reservoir, a generalized procedure will guide the response. Measurements made at the NCPWF provide indications that the water being produced is off-spec; thus the nature of what caused the water to be off-spec will be known. Plant operators will be aware of the reason for the off-spec condition, and this will guide the response (e.g., a faulty EC sensor, e.g., a lab measurement of a specific chemical compound that is out-of-tolerance).

The response to off-spec water reaching the reservoir has five objectives and is designed to: 1) protect public health, 2) avoid disruption of the Miramar DWTP normal operations and deliveries to the potable distribution system, 3) demonstrate that the reservoir is an acceptable drinking source water before returning to normal reservoir operations, 4) minimize the time the reservoir is off-line as a source of supply to the Miramar DWTP, and 5) minimize water loss.

The generalized response procedure, as presented in Table 16-3 on the following page, will follow these 5 steps:

1. Shut-off purified water inflow to the reservoir;
2. Shut-off draft (outflow);
3. Document relevant information;
4. React to off-spec condition alarm; and
5. Resume the draft from Miramar Reservoir.

Table 16-3: Response Procedure to Off-spec Condition

Step	Action	Comment/Note
Step 1	Shut-off purified water inflow to the reservoir	The purified water inflow to the reservoir will have previously been shut off
Step 2	Shut-off draft (outflow) from the reservoir to the Miramar DWTP	The DWTP will switch to 100% imported water from the 2nd SD Aqueduct or from San Vicente Reservoir. There is no urgency to return to drafting from Miramar Reservoir because: • inflow to the reservoir is off; there is no need to balance reservoir volume • operating the DWTP on 100% imported water is routine operations
Step 3	Document Relevant Information	Documented information will include: • duration and volume of off-spec inflow to the reservoir • nature of the off-spec condition • current reservoir conditions
Step 4	React to off-spec condition	• Report off-spec condition to DDW. • Establish specific actions in consultation with DDW that are required to demonstrate that the water in the reservoir is, or has returned to, an acceptable drinking source water to include: ✓ identify the specific water quality parameter(s) that lead to the off-spec determination ✓ identify threshold concentrations for specific parameter(s) in the reservoir that can be successfully treated at the DWTP to meet drinking water standards ✓ monitor the reservoir for the above specific water quality parameter(s) to include a.) monitoring at established locations and depths, and b.) monitor at frequency that aligns with the expected rates of loss, decay or degradation of the off-spec parameters
Step 5	Resume the draft from the reservoir when the monitored parameter(s) achieve the established threshold	• Possibility that this may happen with the first round of sampling, because of the dilution of the off-spec parameter(s) in the reservoir results in the parameter(s) being below the threshold • the draft from the reservoir may resume before inflow of purified water starts up again

17. Operations & Maintenance Readiness Plan

17.1 Background

The City developed the North City Pure Water Operations and Maintenance Readiness Master Plan ("O&M Readiness Plan"), which involved a thorough assessment of the O&M resources that will be required to operate and maintain the various facilities associated with the North City Project. The O&M Readiness Plan:

- Describes the positions and associated responsibilities and qualifications required to operate and maintain the new North City Project facilities (excluding support staff such as administrative or engineering staff);
- Defines how the new North City Pure Water O&M Organization will be structured and integrated within the City's existing City water and wastewater O&M organization;
- Outlines the number of full-time equivalents required for each position to fully staff the Pure Water Project facilities;
- Includes a staff hiring plan specifying when each position should be filled; and
- Establishes the level of certification, type of training, and new class specifications that will be required for O&M staff.

The O&M Readiness Plan focuses on the O&M of the North City Pure Water Project and comprises the following facilities, referred to in this section as the North City Project facilities:

- Morena Pump Station and Pipeline;
- NCWRP;
- NCPWF;
- NCPW Pump Station and Pipeline (including the NCPW Dechlorination Facility); and
- Laboratories (NCPWF Laboratory and other laboratories providing services in support of the operations of the Project facilities).

O&M Working Group. To spearhead the completion of the O&M Readiness Plan, the City created a Working Group comprising key O&M staff from the PUD wastewater, water, and laboratory organizations. The Working Group's role was to develop key recommendations for the O&M of North City Project facilities in order to help ensure safe, reliable operation. Working Group members were selected based on experience and background to ensure that diverse perspectives were represented.

Workshop Members. After the Working Group participants developed recommendations, they presented the recommendations to Workshop Members, comprising PUD Leadership, for discussion and validation of the recommendations.

17.2 North City Pure Water O&M Organization

This section details the staffing needs and organizational structure for the successful O&M of the North City Project facilities.

17.2.1 Alternative Analysis of Organizational Structure

In order to select the North City Pure Water O&M Organization's structure and determine where it should be incorporated within the City's existing O&M organization, the Working Group completed a thorough alternative analysis by which the recommended organizational structure was determined. The overall approach is illustrated on Figure 17-1.

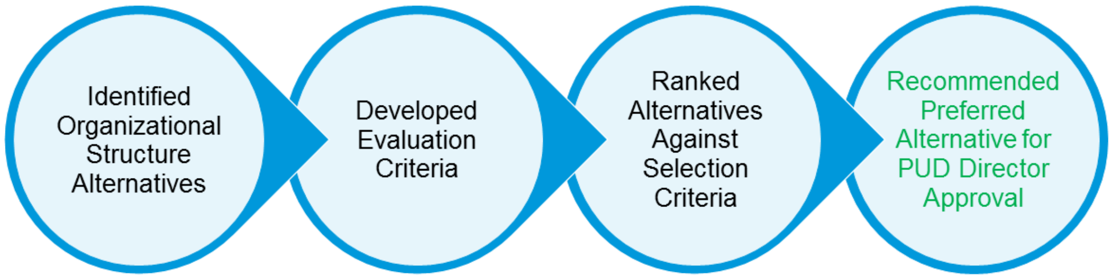

Figure 17-1: Alternative Analysis Steps

First, an assessment was conducted of how best to integrate the North City Pure Water O&M Organization into the City's existing O&M divisions. Four main options for this integration were identified:

1. ***Water.*** Pure Water Organization would be placed within the City's existing Water Division;
2. ***Pure Water.*** Pure Water Organization would become a new, separate Division;
3. ***Wastewater.*** Pure Water Organization would be placed within the City's existing Wastewater Division; and
4. ***Wastewater with Program Manager.*** Pure Water Organization would be placed within the City's existing Wastewater Organization for an interim basis under the direction of a new Program Manager, who would report to the Assistant Director of the System Management and Operations Branch.
    - As the next phase of the Program commences, it is anticipated that the Pure Water organization (NCPWF, NCPW Pump Station and Pipeline, and NCPW Dechlorination Facility), would become a separate division.

In addition to assessing how the North City Pure Water O&M Organization would integrate within the City's existing divisions, each North City Project facility was assessed separately to determine what facilities would be part of the new North City Pure Water O&M Organization and what facilities would be managed by existing divisions.

Each of the organizational options were assessed against 14 pre-selected evaluation criteria that were grouped into general categories:

- Stakeholders and Regulatory;
- Operational Reliability;
- Organizational Efficiency; and
- Financials.

17.2.2 O&M Organizational Structure Recommendation

The Working Group participated in the scoring of each alternative and confirmed their alternative analysis recommendation to add the North City Pure Water Organization within the City's existing Wastewater Division under a Program Manager as an interim phase, with the Pure Water Organization becoming a separate division as the next phase of the Program is initiated.

In a later review session with senior management, it was determined that the more effective staffing approach is to have the Pure Water organization be its own separate division under a Deputy Director from the start. The efficiencies gained from having the Pure Water Organization start as a separate, new division include:

- Establishes the Pure Water organization from the start, mitigating an organizational shift in a couple of years;
- Provides senior management staff to focus on developing the Pure Water organization and participate in planning efforts for Phase 2;
- Allows senior management staff to be involved in the development of emerging regulations and policies associated with Pure Water operations certification;
- Allows senior management staff in the wastewater division to maintain a focus on the large wastewater treatment and conveyance organization;
- Promotes flexibility for both water- and wastewater-certified operations staff to join the Pure Water Organization; and
- Furthers the public awareness that Pure Water is a safe, reliable water supply source.

Under this organizational structure, the North City Project facilities are assigned into divisions as presesnted in **Table** 17-1. Figure 17-2 illustrates the draft organizational structure envisioned by the City.

Table 17-1: North City Project Facilities Divisions

Pure Water Division	Existing Wastewater Division	Water
✓ NCPWF ✓ NCPW Pump Station and Pipeline ✓ NCPW Dechlorination Facility	✓ Morena Pump Station ✓ NCWRP	✓ Reservoir Infrastructure ✓ Miramar DWTP

17.3 Staffing Requirements and Full Time Equivalents

The Working Group identified the type and number of staff needed to operate the North City Project facilities. The staffing requirements are based partly on data gathered from the O&M of the 1 mgd NCDPWF, which comprises the same processes that will be included in the full-scale NCPWF. These data were verified against the staffing requirements for Orange County Water District's Groundwater Replenishment System.

It is important to note that the details included herein indicate how the City currently envisions staffing and operating the North City Project facilities. Adjustments may be made to this plan as the detailed design of the facilities progress and the final staffing plan is solidified. As illustrated on Figure 17-3 , the operation and maintenance of the North City Project facilities will initially be the responsibility of the PUD's Deputy Director of Wastewater Treatment and Disposal, who reports to the PUD's Assistant Director of the System Management and Operations Branch.

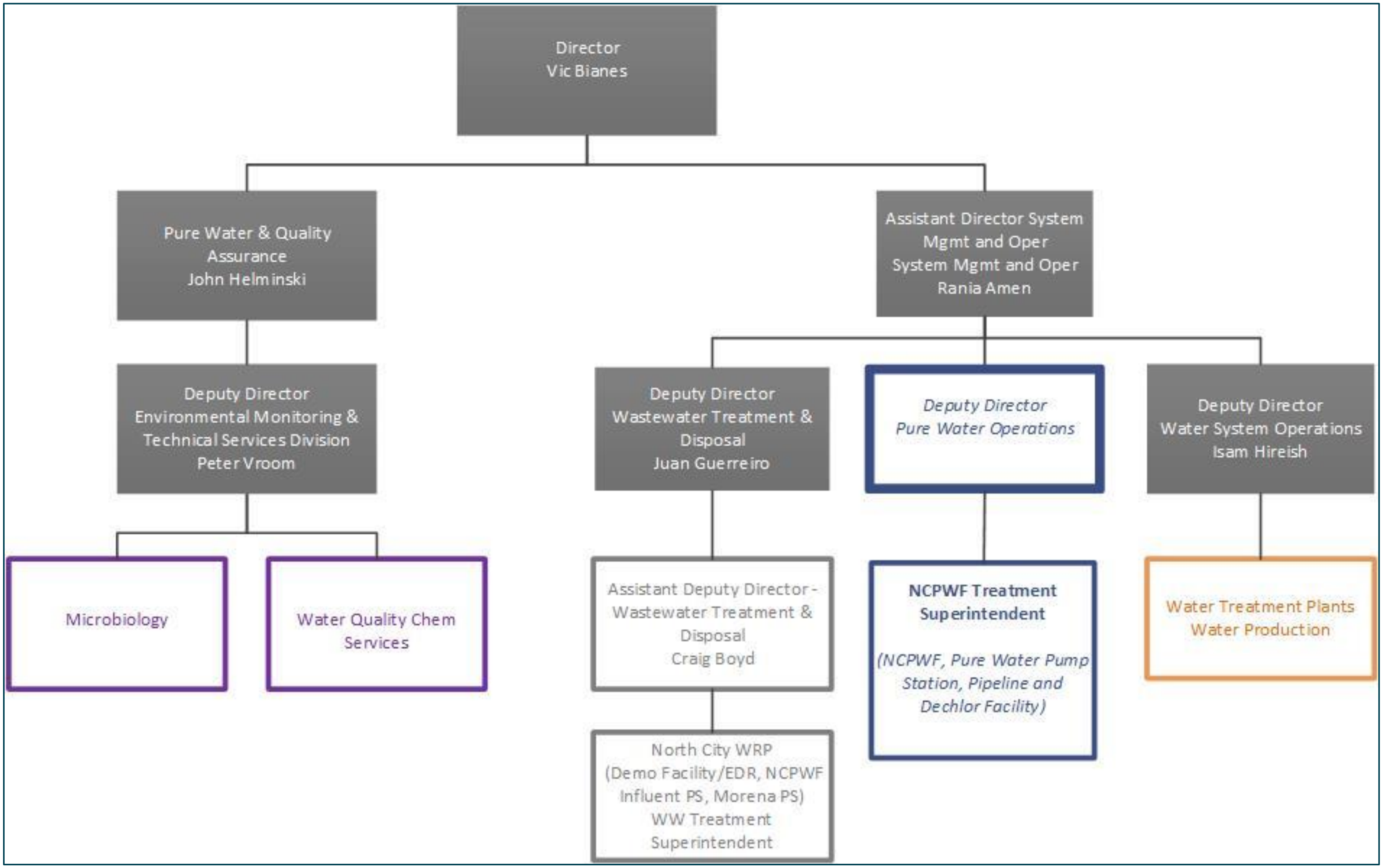

Figure 17-2: Draft North City Pure Water Organizational Structure

The draft NCPWF organizational structure is illustrated on Figure 17-3. The NCPWF O&M staff will be responsible for the safe, reliable operation of the NCPWF, NCPW Pump Station and Pipeline, and NCPW Dechlorination Facility.

The staffing analysis performed by the Working Group revealed that the new NCPWF will require upwards of 30 full-time equivalents to operate and maintain the NCPWF, NCPW Pump Station and Pipeline, and NCPW Dechlorination Facility. Lead supervisory staff include:

- Pure Water Treatment Superintendent;
- Senior Pure Water Operations Supervisor; and
- Senior Plant Technician Supervisor.

Refer to Section 17.4 for details on required level of experience for the staff positions illustrated on Figure 17-3.

The NCPWF staffing assumes the following:

- The NCPWF will be continuously manned, 24-hours per day/seven days per week, using two shifts (daytime and nighttime);
- Three operators are scheduled to be on each shift at the NCPWF;
- A Grade III Wastewater Operator or Grade 4 Water Operator with AWT 3 Certification will be onsite at all times; and
- The Pure Water Treatment Superintendent, who will be onsite during the day from Monday through Friday, will have a Grade V Wastewater Certification or a Grade 5 Water Certification, and an AWT 5 Certification.

It should be noted that this organizational structure is presented as an example and may be adjusted depending upon future needs and personnel, permitting requirements specified for the Project, and future certification requirements mandated by the SWRCB.

17.3.1 Water and Laboratory Organizational Impacts

In addition to the NCPWF staffing requirements, the North City Project will require additional water and laboratory staff.

Water Staff. Safe and reliable drinking water production is of upmost importance to the City; therefore, it was decided to add a Superintendent of Water Quality to the City's existing Water Treatment Division to address additional resource needs associated with the North City Project. This new Superintendent will focus on water quality of the City's water treatment plants and NCPWF.

Laboratory Staff. The staffing analysis performed by the Working Group indicated a need to increase Laboratory staff. It is currently projected that more than ten full-time equivalents will be required to accommodate the additional water quality testing requirements associated with the North City Project. These staff will be phased in prior to the start-up of North City Project facilities to ensure timely completion of required training.

17.3.2 NCWRP Organizational Impacts

The Morena Pump Station and Pipeline and expanded NCWRP will be operated 24-hours per day/seven days per week. Based on the Working Group's staffing analysis, it is envisioned that approximately ten additional full-time equivalents will be required to accommodate the increased workload.

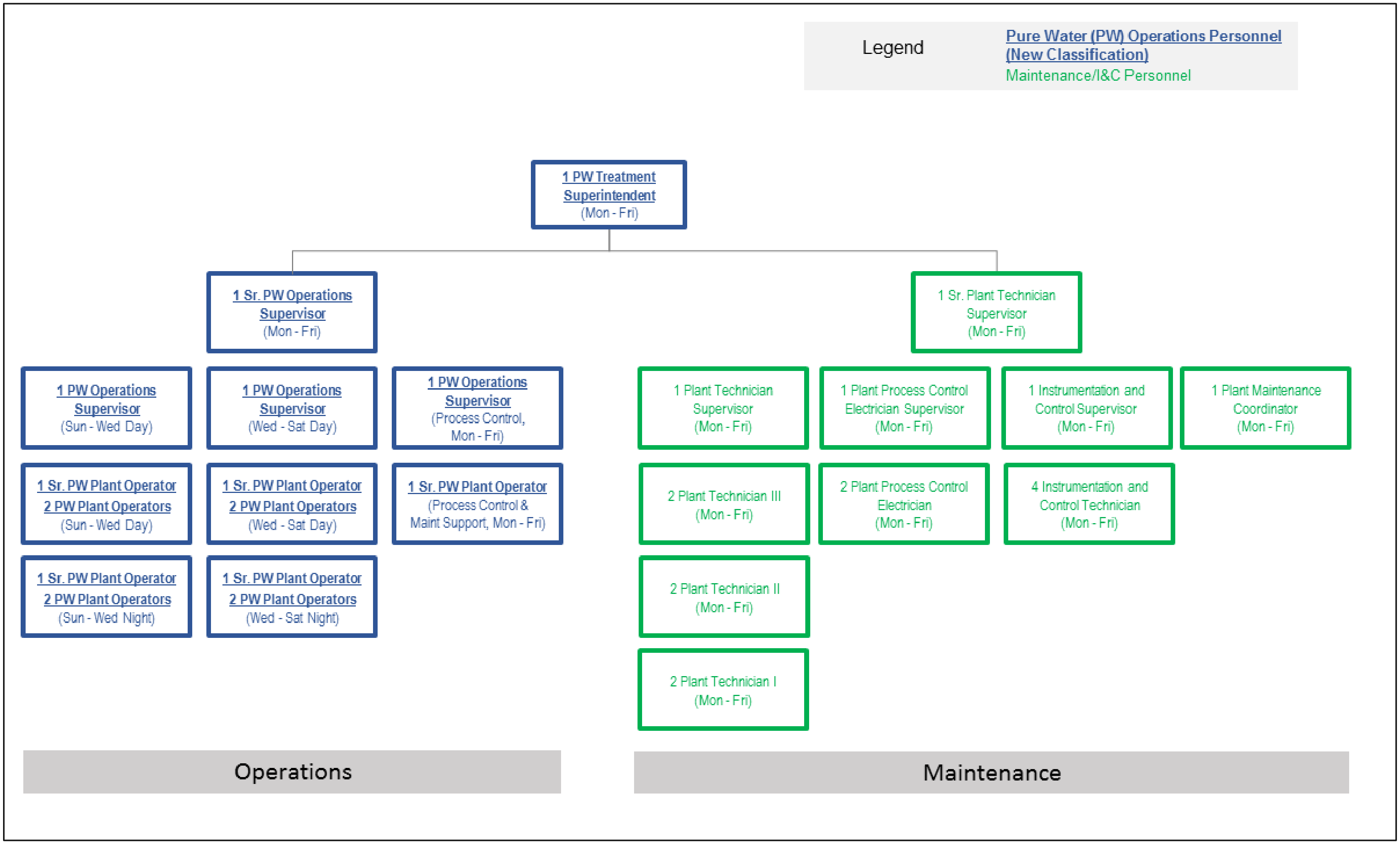

Figure 17-3: North City Pure Water O&M Organization

17.4 Job Classifications and Certifications

The draft responsibilities and required certifications and training for each position in the North City Pure Water O&M Organization are presented in Table 17-2. City staff have been involved in the planning of a new AWT Certification Program through participation in the SWRCB Advisory Group on Feasibility of Developing Criteria for Direct Potable Reuse and a collaborative effort led by the California Urban Water Agencies.

In line with California Urban Water Agencies Potable Reuse Operator Training and Certification Framework White Paper (CUWA, 2016), staff that have either a wastewater or drinking water operator certification will be able to fill an operator position at the NCPWF. The benefit of having staff with both of these backgrounds is that it provides the opportunity to bring a wider breadth of experience to the NCPWF and allows the City to recruit qualified staff from a larger pool of candidates.

17.4.1 Advanced Water Treatment Certification and Training Plan

In addition to the base wastewater and water operator certification requirements, senior NCPWF operations staff will adhere to the AWT Certification requirements, once finalized by the SWRCB. Because of the additional AWT Certification requirement envisioned for senior operations staff, the City anticipates that it will develop new job classifications and specifications for these positions.

It is currently estimated that the first AWT Certification exam will be available in 2018, prior to the commissioning of the NCPWF. At this time, the City understands that there will be three levels of certification: (1) AWT3 (lowest AWT certification available), (2) AWT4, and (3) AWT5 (highest certification available). Based on the limited information available at this time on the proposed AWT Certification Program, the City foresees the following certification requirements for the NCPWF operations staff:

- AWT5: Pure Water Treatment Superintendent;
- AWT4: Senior Pure Water Operations Supervisor; and
- AWT3: Pure Water Operations Supervisors and Senior Pure Water Plant Operators.

17.4.2 Training Plan

It is currently envisioned that the NCPWF operations training will include both classroom and practical, hands-on training. All NCPWF operations staff will be trained for at least three months at the NCDPWF, prior to commissioning of the NCPWF. During this time, they will learn about the daily operator duties, including how to start, stop, and adjust treatment processes; pro-actively identify potential issues; and perform troubleshooting independently. Classroom training modules, each consisting of a minimum of four hours of classroom theory, include:

- Ozone;
- BAC;
- MF;
- RO;
- UV/AOP; and
- Water Quality Treatment Goals and Monitoring Plan.

Table 17-2: NCPWF Job Classifications and Certification Requirements

Note that the following table is being finalized and subject to revision.

Position	Responsibilities Description	Certification
Operations		
Pure Water Treatment Superintendent	• Reports to Pure Water Operations Deputy Director • Fulfills signatory/Chief Plant Operator responsibilities • Plans, directs and coordinates, through subordinate supervisors, the operation and maintenance of the NCPWF and related facilities/equipment • Participates in the development and implementation of goals, objectives, policies and priorities; recommends and implements resulting policies and procedures • Ensures that facility is managed in a manner that effectively controls costs and meets all regulatory requirements • Distinguished from the Senior Wastewater Operations Supervisor by experience and leadership responsibilities	Grade V Wastewater Treatment Plant Operator's Certificate OR Grade 5 Water Treatment Certificate AND AWT5 training certification
Senior Pure Water Operations Supervisor	• Reports to Pure Water Treatment Superintendent • Plans and supervises the operation of the NCPWF and related facilities/equipment • Directs the daily testing of purified water in various stages of treatment; interprets test results to determine necessary changes in chemical dosage and treatment processes; manages purified water quality adjustments • Assumes responsibility for all critical decisions regarding operational changes, maintenance priorities, scheduling • Prepares compliance reports for numerous regulations of multiple federal, state, and local agencies • Distinguished from the Pure Water Operations Supervisor by certification level, experience and leadership responsibilities	Grade IV or higher Wastewater Treatment Plant Operator's Certificate OR Grade 5 Water Treatment Certificate AND AWT4 training certification
Pure Water Operations Supervisor (includes Process Control position)	• Reports to Senior Pure Water Operations Supervisor • Plans and supervises the operation of the NCPWF and related facilities/equipment • If not supervising the operation of the NCPWF, then responsible for process control: ○ Responsible for analyzing data from Laboratory and Distributed Control System data management systems and developing reports for Senior facility supervision ○ At direction of supervision, conducts in-plant testing to improve operating efficiency while ensuring continued plant performance ○ Reviews and develops specifications for procurement of chemicals and chemical application systems ○ Reviews and develops specifications for in-line analytical equipment and other equipment that is utilized to ensure consistent daily facility operations ○ Supervises and conducts special sampling, data gathering and analysis to troubleshoot plant operational issues and develops subsequent reports to ensure that facility Senior Pure Water Operations Supervisor has adequate information to make effective operational decisions • Distinguished from the Senior Pure Water Plant Operator by leadership responsibilities	Grade III or higher Wastewater Treatment Plant Operator's Certificate OR Grade 4 Water Treatment Certificate AND AWT3 training certification
Senior Pure Water Plant Operator (includes Process Control position)	• Reports to Pure Water Operations Supervisor • Leads work of a crew responsible for the operation of the NCPWF and related facilities/equipment • Performs more difficult and complex AWT and ancillary operation tasks requiring a significant degree of skill, knowledge and independent judgment • Performs light maintenance at plant • If not leading crew responsible for the operation of the NCPWF, then responsible for process control: ○ Orders treatment chemicals and other process supplies as needed ○ At direction of supervision, conducts in-plant testing to improve operating efficiency while ensuring continued plant performance ○ Ensures that in-line analytical and process control instrumentation is functional; troubleshoots as needed ○ Collects and delivers special samples per guidance of supervision; performs field analysis of samples as needed; conducts limited field and laboratory tests (e.g., antiscalant application testing) • Distinguished from the Wastewater/Water Plant Operator by certification level, experience and shift lead responsibilities	Grade III or higher Wastewater Treatment Plant Operator's Certificate OR Grade 4 or higher Water Treatment Certificate AND AWT3 training certification
Pure Water Plant Operator	• Reports to Pure Water Operations Supervisor • Operates designated AWT plant equipment on an assigned shift, following shift lead's instructions • Performs light maintenance at plant • Entry-level Pure Water operator position	Grade II or higher Wastewater Treatment Plant Operator's Certificate OR Grade 3 or higher Water Treatment Certificate

Position	Responsibilities Description	Certification
Maintenance		
Senior Plant Technician Supervisor	• Reports to the Pure Water Treatment Superintendent • Provides technical and administrative supervision over the maintenance and repair of a major NCPWF, NCPW Pump Station or NCPW Dechlorination Facility • Supervises Electro-Mechanical Maintenance crew and first level supervisory staff, which includes Plant Technician Supervisor, Instrumentation and Control Supervisor, Plant Process Control Supervisor, Plant Maintenance Coordinator • At direction of supervision, provides maintenance support to operations for in-plant testing to ensure continued plant performance and reduce costs by improving operating efficiency; ensure that sub-ordinate staff effectively supports effort • Works with Pure Water Treatment Superintendent to plan, coordinate and prioritize Electro-Mechanical work of Maintenance Crew	Preference: California Water Environment Association Mechanical Technology or Electrical Grade IV or commensurate 1 year of experience as a Plant Technician Supervisor, Plant Process Control Supervisor; Instrumentation and Control Supervisor, Maintenance Coordinator at a water, wastewater or AWT facility
Plant Technician Supervisor	• Reports to Principal Plant Tech Supervisor • Supervises skilled technicians performing installation, repair and maintenance of mechanical equipment in a highly interrelated plant setting • Develops and implements preventive maintenance schedules for a wide variety of complex plant equipment • May perform complex and difficult mechanical equipment maintenance and repair • Distinguished from the Plant Technician III by experience and lead responsibilities	Preference: Mechanical Technology Grade IV 3 years of experience maintaining, overhauling, repairing and installing mechanical equipment 1 year must have been in a lead capacity
Plant Technician III	• Reports to Plant Technician Supervisor • Inspects, installs, maintains, repairs, and overhauls a wide variety of complex and dissimilar mechanical equipment at the NCPWF and related facilities • Performs difficult maintenance, overhaul, repair and installation work • Distinguished from the Plant Technician II by experience and lead responsibilities	Preference: Mechanical Technology Grade III 3 years of experience maintaining, overhauling, repairing and installing mechanical equipment
Plant Technician II	• Reports to Plant Technician Supervisor • Inspects, installs, maintains, repairs, and overhauls a wide variety of complex and dissimilar mechanical equipment at the Pure Water Facility and related facilities • Distinguished from the Plant Technician I by experience and lead responsibilities	Preference: Mechanical Technology Grade II 2 years of experience maintaining, repairing and installing mechanical equipment
Plant Technician I	• Reports to Plant Technician Supervisor • Inspects, maintains and performs repairs to mechanical equipment at the NCPWF and related facilities • Entry level position	Preference: Mechanical Technology Grade I 1-year experience repairing mechanical equipment
Plant Maintenance Coordinator	• Reports to the Senior Plant Technician Supervisor • Plans maintenance activities • Develops maintenance strategies for equipment • Develop and evaluate maintenance performance reports	Preference: California Water Environment Association Mechanical Technology or Electrical Grade IV or commensurate

Position	Responsibilities Description	Certification
Electrical/Instrumentation and Controls		
Plant Process Control Supervisor	• Reports to Senior Plant Technician Supervisor • Supervises, plans, schedules, assigns and participates in the work of skilled subordinate staff who design, install, test, adjust, modify and maintain digital and logic circuitry, microprocessor controlled electrical and electronic devices and elements, such as programmable logic controllers, process control equipment, recorders, sensors, alarms, and controllers on a wide variety of electrical, electro-mechanical, pneumatic and hydraulic equipment and devices • Plans and performs: installation, testing, adjustments, modification and maintenance of complex fixed and portable electronic and telemetry systems and equipment • Designs, modifies and makes programming and software improvements on computerized system control and data acquisition operations • Analyzes problems and repairs electronic instrumentation control systems • Distinguished from the Plant Process Control Electrician by certification level, experience and lead responsibilities	Preference: California Water Environment Association Electrical/IC Technology Grade IV 4-5 year State-accredited Electrician Apprenticeship Program AND 2 years of experience as a journey-level Electrician AND 1 year of experience serving as a Plant Process Control Electrician
Plant Process Control Electrician	• Reports to Plant Process Control Electrician Supervisor • Installs, tests, adjusts, modifies and maintains the most complex electrical lighting, wiring and power systems, electrical machinery and equipment • Designs, modifies and makes programming and software improvements on computerized electrical system control and data acquisition operations • Analyzes problems and makes necessary repairs on electrical control systems • Designs, installs, tests, adjusts, modifies and maintains digital and logic circuitry, microprocessor controlled devices, elements and components such as programmable logic controllers, process control equipment, telemetering devices recorders, sensors, and controllers • Operates computer terminals, portable programming units or other complex electronic test equipment • May lead the work of lower level staff	Preference: California Water Environment Association Electrical/IC Technology Grade III 4-5 year accredited Electrician Apprenticeship Program OR 1 year of experience in all phases of work as a journey-level Electrician AND Satisfactory completion of the Appointing Authority's list of critical tasks for Plant Process Control Electrician
Instrumentation & Control Supervisor	• Reports to Senior Plant Technician Supervisor • Plans and performs: installation, testing, adjustments, modifications and maintenance of complex fixed and portable electronic and telemetry systems and equipment • Designs, modifies and makes programming and software improvements on computerized system control and data acquisition operations • Analyzes problems and repairs electronic instrumentation control systems • Supervises Instrumentation and Control Technicians • Distinguished from the Instrumentation and Control Technician by certification level, experience and lead responsibilities	Preference: California Water Environment Association Electrical/IC Technology Grade IV 4-5 year State-accredited Electronic Communications Technician Apprenticeship Program OR 4 years of experience as a journey-level Electrician AND 2 years of experience as Instrumentation and Controls Tech
Instrumentation and Control Technician	• Reports to Instrumentation & Control Supervisor • Designs, installs, tests, adjusts, modifies and maintains digital and logic circuitry, microprocessor controlled devices, elements and components such as programmable logic controllers, process control equipment, telemetering devices recorders, sensors, and controllers • Operates computer terminals, portable programming units or other complex electronic test equipment • May lead the work of lower level staff	Preference: California Water Environment Association Electrical/IC Technology Grade III 4-year accredited Electronics or Communications Technician Apprenticeship OR 1 year of experience as a journey-level Electronics Technician at a water or wastewater treatment plant or industrial production plant; AND Satisfactory completion of the Appointing Authority's list of critical tasks for Instrumentation and Control Technician

17.5 Hiring Plan

It is imperative to ensure that the appropriate staffing resources are hired and trained in time for the construction, commissioning, and start of operation of the North City Project facilities, including the NCPWF.

Figure 17-4 illustrates the preliminary hiring plan developed for all North City Project facilities, and it identifies the fiscal year in which staff are needed to fill the open positions. The plan is still a draft and is subject to revision.

As illustrated on Figure 17-4, the City will start hiring new staff for some key operation positions prior to the start of construction. More staff will be hired during construction to gain a better understanding of the facilities being built. The remainder of staff will be hired in time for contractor commissioning, with training completed at the NCDPWF prior to the start at the full-scale operation at the NCPWF. Note that the hiring plan illustrated on Figure 17-4 is subject to revision.

Legend
- Pure Water Operations Personnel (New Classification)
- Operations Personnel
- Maintenance/I&C Personnel
- Lab Personnel
- Water Personnel

	FY17 (July 2016 – July 2017)	FY18 (July 2017 – July 2018)	FY19 (July 2018 – July 2019)	FY20 (July 2019 – July 2020)	FY21 (July 2020 – July 2021)
Milestones			Feb 2019 NCWRP Construction; May 2019 NCPWF Construction	Jan 2020 NCWRP Commissioning	June 2021 NCPWF Commissioning
Senior Management		Deputy Director Pure Water Operations (1)			
North City Pure Water Facility		Senior Plant Technician Supervisor (1)	Pure Water Treatment Superintendent (1) Senior Pure Water Operations Supervisor (1) Pure Water Operations Supervisor: Process Control (1)	Plant Technician Supervisor (1) Plant Technician III (1) Plant Maintenance Coordinator (1) Plant Process Control Electrician Supervisor (1) Plant Process Control Electrician (1) I&C Supervisor (1) I&C Technician (1)	Pure Water Operations Supervisor (2) Senior Pure Water Plant Operator: Process Control (1) Senior Pure Water Plant Operator (4) Pure Water Plant Operator (8) Plant Technician III (1) Plant Technician II (2) Plant Technician I (2) Plant Process Control Electrician (1) I&C Technician (3)
North City Water Reclamation Plant & Morena PS/PL			Senior Wastewater Plant Operator (2)	Senior Wastewater Plant Operator (2) Wastewater Plant Operator (3) Plant Technician II (1) I&C Technician (1) MORENA: Plant Technician III (1)	MORENA: Plant Technician III (1)
Water Division & Laboratory	Associate Chemist (1)	WATER: Superintendent of Water Quality (1) Assistant Chemist (1)	Assistant Chemist (1)	Assistant Chemist (2)	Biologist III (1) Biologist II (3) Lab Tech (3)

Figure 17-4: Draft Hiring Plan for North City Pure Water Organization

18. Technical, Managerial and Financial Capacity

The 1996 federal Safe Drinking Water Act requires states to incorporate TMF capacity into public water system operations. In response to this requirement, California enacted Section 116540 of the Health and Safety Code, which states:

> *"No public water system that was not in existence on January 1, 1998, shall be granted a permit unless the system demonstrates to the DDW that the water supplier possesses adequate financial, managerial and technical capability to assure the delivery of pure, wholesome, and potable drinking water. This section shall also apply to any change of ownership of a public water system that occurs after January 1, 1998."*

Although DDW has yet to adopt specific TMF requirements for potable reuse system operations, this section summarizes the City's capacity using the TMF elements listed in DDW's TMF Assessment Form for Public Water System. Since the City's TMF capacity is highlighted throughout this report, references to other sections of the report are included whenever appropriate.

18.1 Technical Capacity

The following efforts led by the City are all good indicators of the City's technical capacity:

- Operation of water reclamation facilities for over 30 years;
- Execution of applied research in the potable reuse arena for the last 13 years;
- Initiation of an operator training program at the NCDPWF five years prior to the start-up of all facilities; and
- Inclusion of unprecedented number of state-of-the art treatment processes and fail-safe features in the Project.

18.1.1 Consolidation Feasibility

As mentioned in Section 12, the Miramar DWTP serves a regional area that includes the City of San Diego North of Interstate 8 and the City of Del Mar. The feasibility of further consolidating the City's existing water system is not an applicable criterion. It should be noted that as described in Section 5, the Metropolitan Sewerage System is a regional wastewater collection and treatment system that serves the City of San Diego, as well as a number of other nearby cities and agencies/districts.

18.1.2 System Description

Detailed descriptions of all elements of the Project, including the wastewater collection system, NCWRP, NCPWF, NCPW Pump Station and Pipeline, NCPW Dechlorination Facility, Miramar Reservoir, and Miramar DWTP, are provided in Section 6.

18.1.3 Certified Operators

Section 17 provides a general description of the City's proposed staffing plan and certification requirements. Since a statewide certification program has yet to be adopted for the operation of advanced treatment facilities, the City intends to develop an internal training program for the operation of the NCPWF. The North City Project OP, which will be submitted to DDW separately at a later date, will include all the required details related to operator training and certification. If DDW adopts new certification requirements prior to the start-up of the NCPWF, relevant sections of this report and the North City Project OP will be modified as needed to incorporate those requirements.

18.1.4 Source Capacity

The City's existing water system has the capacity to satisfy the maximum day demand of the system's service area. Approximately 85 percent of the system's overall demand is met using imported water conveyed through the SDCWA regional transmission system, while the remaining 15 percent is satisfied using local runoffs captured in nearby reservoirs.

Although these TMF criteria does not directly apply to the NCPWF, it is important to note that the Project is dependent on the diversion of 52 mgd of wastewater to produce 30 mgd of purified water and meet future NPR water demands totaling 11.8 mgd. Modeling of the Metropolitan Sewerage System, which included the latest predictions of wastewater unit generation rate and population growth, confirmed that enough wastewater can be diverted to the NCWRP with the addition of the Morena Pump Station and Pipeline. It should be noted that the modeling assumed a 15-mgd reduction of wastewater flow into the Metropolitan Sewerage System to account for additional diversions by the Padre Dam Municipal Water District to their planned reclamation facility in the future.

18.1.5 Operations Plan

Section 16 provides an overview of the City's North City Project OP. The OP, in its entirety, will be submitted to DDW separately at a later date, (prior to Project start-up), and will include all of the required details related to the O&M of the North City Project facilities.

18.1.6 Training

Section 17 provides a general description of the City's NCPWF Operator Training Plan. The North City Project OP, in its entirety, will be submitted to DDW separately at a later date, and will include all of the required details related to the applicable training requirements.

18.2 Managerial Capacity

Over the years, the City has demonstrated the capacity to proficiently manage several public systems serving a population of up to 2.2 million. To manage the Project facilities, the City intends to leverage the experience of its existing leaders and the established structure and best practices already in place, which have contributed to the successful management the City's water system, municipal and metropolitan wastewater systems, and NPR water system.

18.2.1 Ownership

The City's ownership of San Diego's water and wastewater systems is well established. As indicated in Section 2.3, the City operates the water and wastewater systems through the City's PUD and no other agencies are involved in the operation and maintenance of these City-owned systems. With the exception of one parcel and the need to acquire approximately ten permanent easements and multiple temporary construction easements, the City owns the real estate rights required to build all the project elements described in Section 6. The site of the Morena Pump Station near the intersection of Friars Road and Morena Boulevard is the only parcel that needs to be acquired for the Project. Discussions to acquire that parcel, which is currently owned by the Humane Society, have been initiated.

18.2.2 Water Rights

Implementation of the Project will not in any way change the water rights associated with the City's existing water system. The City owns all water rights in Miramar Reservoir, so it will not have to apply for a new water rights permit from the SWRCB. Although the production of 30 mgd of purified water will be offset by an equivalent decrease of imported water purchases, the City has no intention to give up any of its water allocation rights with the SDCWA.

The collection and treatment of wastewater through the Metropolitan Sewerage System is facilitated by separate transportation agreements between the City and each of the 12 Participating Agencies. Based on the terms of those agreements, the City has full ownership of all wastewater once it enters the system. Furthermore, it should be noted that a decrease in the ocean discharges from the PLWTP will also not impact water rights.

18.2.3 Organization

Section 2.3 provides a high-level description of the City's overall organizational structure as it relates to the North City Project. An overview of the North City Pure Water Organization developed as part of the City's O&M Readiness Plan is provided in Section 17. The North City Project OP, which will be submitted to DDW separately at a later date, will include all the required details related to the organization that will be put in place to manage, operate, and maintain all the facilities described in Section 6.

18.2.4 Emergency Response Plan

Several sections of this report satisfy the requirements of the TMF element Emergency Response Plan. As described in Section 13, the NCPWF includes provisions for reliability, including both failure prevention (redundancy and robustness), and failure response (resilience) elements. Section 14 specifies the measures to be taken to protect public health and the environment in the event of an emergency. Finally, Section 16 outlines a general framework for the North City Project OP, which will include emergency operating procedures.

18.2.5 Policies

The City already has a number of policies related to the operation of its wastewater, recycled water, and drinking water systems. Many of those policies will be applicable to the management, operation and maintenance of the North City Project. Some of the key policies will be highlighted in the North City Project OP, which will be submitted to DDW separately.

18.3 Financial Capacity

All wastewater, recycled water and drinking water revenues generated by the City are kept in funds that are separate from other City funds, including the General Fund. Those revenues can only be used to cover costs associated with the operation, maintenance and improvements of the wastewater, recycled water and drinking water systems, as well as to replenish various related reserve funds (e.g., Emergency Operating Reserve, Secondary Purchase Reserve, Rate Stabilization Fund Reserve, Pension Payment Stabilization Reserve, and the Emergency Capital Reserve). The City's financial processes are well established and allow for the separate budgeting, monitoring, and control of water and wastewater expenditures, as well as operating and capital improvement expenditures.

The City holds all its departments, including the PUD, to high fiscal standards through the City Charter and Council policies. These guidelines are put in place to ensure responsible long-range financial planning. The PUD has a strong financial position proven by its strong credit ratings, reserve balances, and financial monitoring processes. The City approved a Water rate increase plan for a five-year period in November 2015 following completion of a cost of service study. The PUD will continue to closely monitor and assess the funding needs of the Project, and will undertake additional cost of service studies to address those needs.

The City of San Diego's Fiscal Year 2017 Comprehensive Annual Financial Report is available online at https://www.sandiego.gov/comptroller/reports/#cafr

18.3.1 Budget Development

The City's annual operating budget is created in conjunction with the Mayor, City Council, City departments, Independent Budget Analyst, and public input. The City has a well-established process that consists of three main phases: (1) budget development, (2) budget review, and (3) budget adoption.

18.3.1.1 City's Budget Process

The City's budget process, which is typically initiated in November of each year, considers the fiscal and policy goals set for the upcoming fiscal year (July 1 – June 30), while following a timeline for budget adoption and the appropriation of funds codified in the City of San Diego's Charter. The process, which involves public hearings where input from San Diego residents is gathered, culminates with the adoption of an Appropriation Ordinance by the City Council prior to the beginning of each fiscal year on July 1. The City Charter was amended in November 2016 to include the requirement that the Appropriation Ordinance be approved before the start of each July 1 fiscal year.

The City of San Diego's Fiscal Year 2018 Adopted Budget is $3.6 billion and comprises five operating fund types and the Capital Improvements Program (CIP):

- General Fund;
- Special Revenue Funds;
- Capital Project Funds;
- Enterprise Funds;
- Internal Service Funds; and
- CIP.

Enterprise Funds account for specific services that are funded directly through rates, charges, and fees. The PUD's budget falls under the Enterprise Funds. Typically, these funds are intended to be fully self-supporting and are not subsidized by the City's General Fund.

The City of San Diego's Fiscal Year 2018 Adopted Budget is available online at http://www.sandiego.gov/fm/annual.

18.3.1.2 PUD's Budget Process

Each November, the PUD receives specific budget instructions from the City's Financial Management Department. These instructions are provided to all City departments to ensure consistency and alignment with the overall City budget. The PUD's budget process includes the development of separate operating and capital improvements budgets. The operating budget, which rolls up to the City's Enterprise Funds, includes expenditures such as personnel costs and fringe benefits, equipment and supplies, contractual services, energy and utilities, and other O&M related costs. The capital improvements budget, which rolls up to the City's CIP budget, includes new and on-going construction projects and planned improvements of existing facilities. The City CIP establishes structure and consistency by identifying, prioritizing, approving, and funding capital improvement projects through coordination of the participating City departments and the Mayor's Capital Improvements Program Review and Advisory Committee.

The PUD prepares a five-year operating budget and a ten-year CIP budget. The operating budget starts with budgeting reoccurring annual operating costs and then additional annual items are included. The managers of each section submit their requests and the City's Utilities Senior Executive Team reviews and prioritizes as needed. The CIP budget is reviewed by PUD staff and is prioritized based on system needs and condition assessment data. The CIP budget is reviewed and approved by the Utilities Senior Executive Team and submitted to Capital Improvements Program Review and Advisory Committee. The PUD budget submission is reviewed by the Financial Management Department before inclusion in the City's proposed budget.

The PUD operating budget involves three separate Enterprise Funds which are associated with the different services provided by the organization.

- ***Water Utility.*** Water services to the City of San Diego;
- ***Municipal Wastewater Utility.*** Wastewater collection services to the City of San Diego; and
- ***Metropolitan Wastewater Utility.*** Wastewater treatment and disposal services to the City of San Diego and 12 Participating Agencies.

The Municipal Wastewater Utility and Metropolitan Wastewater Utility funds are combined in the Comprehensive Annual Financial Report; the two funds represent the Sewer Utility.

The Sewer Utility includes a balance from the prior year, a continuing budget for the CIP and reserves totaling $376,782,399 with budgeted revenues of $391,799,388 to cover budgeted operating costs of $352,184,224 and the budgeted CIP expenditures of $100,212,336. The CIP is funded by current year revenues and the balance from prior year noted as the Continuing Appropriation-CIP. The Sewer Utility's projects a reserve balance at the end of fiscal year 2017 of $120.3 million.

The Water Utility includes a balance from the prior year, a continuing budget for the CIP and reserves totaling $193,314,931 with budgeted revenues of $728,070,035 to cover budgeted operating costs of $521,125,919 and the budgeted CIP of $208,431,474. The CIP budget is funded by current year revenues, and the balance from prior year noted as the Continuing Appropriation-CIP. The Water Utility's projects a reserve balance at the end of fiscal 2017 of $123.0 million.

The PUD CIP budget also involves the three enterprise funds mentioned above. Wastewater, water distribution/reclamation, and potable reuse projects, represent 15.6 percent, 21.7 percent and 15.6 percent of the City's Fiscal Year 2018 Adopted CIP Budget. The PUD's portion of the City's Fiscal Year 2018 CIP budget totals $251.6 million. Funding for water and wastewater CIP projects are provided by water and sewer rates and grants, and the funding approaches can include pay-go cash, bond financing, or state revolving fund loans.

18.3.1.3 Funding of the Pure Water Program

The total capital cost to build the Pure Water Program facilities and infrastructure is estimated to be approximately $3 billion (in 2016 dollars), of which approximately $1.2 billion will be a cost to the Water Utility. The remaining costs of the Pure Water Program (approximately $1.8 billion) will be a cost to the Metropolitan Wastewater Utility. All costs allocated to the Metropolitan Wastewater Utility are shared with the City's 12 Participating Agencies, which are required to pay their respective share of Sewer's Metropolitan Sub-System operation and maintenance and CIP costs, currently approximately 33 percent of the total program costs. The Pure Water Program estimated costs of approximately $3 billion will also be allocated to the Participating Agencies.

The PUD has determined that costs for the Pure Water Program will be allocated between the Water and Wastewater funds the following two ways: (1) all CIP and operational costs related to facilities for the conveyance of wastewater and the treatment of the wastewater through secondary treatment will be borne by the Metropolitan Wastewater Utility, and (2) all CIP and operational costs related to treatment and conveyance of process water post-secondary treatment will be borne by the Water Utility.

The first phase of the Pure Water Program is estimated to cost approximately $1.1 to 1.3 billion (in 2016 dollars). These estimated costs include delivery costs (e.g., program management, project management, construction management, environmental review, and engineering design), construction costs and other costs (e.g., land acquisition, and environmental mitigation). The delivery costs include both City personnel and consultant services costs.

Program costs are expected to be covered using various funding sources available to the City, but the City's main funding strategy involves the issuance of revenue bonds that will be paid back over time through water and wastewater rate increases.

The City anticipates that additional rate capacity will be necessary after Fiscal Year 2020. The City expects to perform a cost of service analysis to prepare a new rate case for recommended water and wastewater rate adjustments to address future capital program costs, O&M expenditures, and Pure Water Program capital expenditures.

18.3.2 Budget Control

The Financial Management Department oversees the City's budget and executes its budget monitoring responsibilities through the analysis of revenues and expenditures for operating funds included in the Annual Appropriation Ordinance. This analysis identifies any significant variances between budgeted and projected revenues and expenditures and provides relevant information to maintain budgetary control and balance.

The Financial Management Department monitors the City's annual operating budget throughout the fiscal year. Quarterly reports are produced and presented to the Budget and Government Efficiency Committee and City Council to forecast year-end results and aid in adjusting the budget throughout the year to address changes in revenues and expenditures.

On a monthly basis, the City Comptroller submits to the Mayor and to the City Council a summary statement of revenues and expenses for the preceding accounting period and the status of appropriations in comparison to actuals, in order to detail the financial condition of the City as mandated by the City's Charter Article V, Section 39 and Article VII, Section 89. These reports are known as Charter 39 Reports.

City departments are responsible for the regular monitoring of expenditures, encumbrances, and continuing appropriations of authorized CIP budgets in order to ensure accuracy and accountability within each project. The City Council annually approves the CIP budget and the allocation of funds for the projects included in the Appropriation Ordinance, which establishes capital spending limits in each fiscal year. These spending limits can only be amended during the year through City Council action.

Additionally, the Financial Management Department produces semi-annual CIP budget monitoring reports that tracks the City's CIP (including the Water Utility and Sewer Utility), and recommends any potential changes necessary for individual projects.

The City's Independent Budget Analyst reviews all of these reports and may provide recommendations for City Council consideration.

18.3.2.1 Tracking of PUD Operating and CIP Budgets

There is a detailed process for the PUD to monitor its revenues and expenses which includes internal and external reporting.

The Financial Management Department oversees the City's budget and executes its budget monitoring responsibilities through the analysis of revenues and expenditures for operating funds included in the annual Appropriation Ordinance. This analysis identifies any significant variances between budgeted and projected revenues and expenditures and provide relevant information to maintain budgetary control and balance. Departmental revenue and expenditure activity is monitored at least quarterly and presented to the Budget and Government Efficiency Committee and City Council at least three times a year. The Independent Budget Analyst reviews these quarterly reports and may provide recommendations for City Council consideration.

The Mid-Year Budget Monitoring Reports present year-end projections of revenues and expenditures incorporating six months of actual results and anticipated spending trends for the remaining six months of the fiscal year. The Mid-Year Budget Monitoring report is accompanied by a budget amendment resolution as further described in the Budget Control section. The Year-End Budget Monitoring Report is released to the City Council in late May in order to incorporate nine months of actual results in analysis. The Year-End Budget Monitoring Report is released to the City Council in advance of or on the same day as the City Council's first public hearing on final budget decisions for the upcoming fiscal year. This allows the City Council to have the most recent information regarding current fiscal year revenues and expenditures compared to the City's current budget prior to making final decisions on the budget for the upcoming fiscal year.

18.3.2.2 Available Reserve Funds

The PUD maintains various reserve funds to provide adequate cash balances to ensure that the City meets its cash flow obligations, minimizes borrowing costs,and maintains the highest credit ratings on its bonds and financial obligations. These reserve funds are operated in accordance with the City's Reserve Policy. In the event amounts contained in a particular reserve are below the anticipated reserve level as stated in the City Reserve Policy, the Mayor is to propose a plan as part of the budget for the subsequent fiscal year to replenish such reserve in a reasonable timeframe. A description of the various reserve funds is provided below.

18.3.2.2.a Water Utility Reserves

The City has established accounts within the Water Utility for five separate reserves: (1) Emergency Operating Reserve, (2) Secondary Purchase Reserve, (3) Rate Stabilization Fund Reserve, (4) Emergency Capital Reserve, and (5) Pension Payment Stabilization Reserve. As of June 30, 2017, the Water Utility had total reserves of approximately $123.0 million.

Emergency Operating Reserve. This fund reserve is intended to be used in the event of a catastrophe that prevents the City's water system from operating in its normal course of business. The reserve level is defined as the number of days of operation it could support in the event of a major disruption to the water system. The Emergency Operating Reserve target is equivalent to 70 days of operations. Use of the Emergency Operating Reserve is restricted to emergency situations, and City Council approval is required to appropriate funds from this reserve. Any request to utilize this fund reserve will include a plan and timeline for replenishment, which may be in conjunction with the City Council authorization of a future cost of service study and rate adjustment. As of June 30, 2017, there was $40.1 million in the Emergency Operating Reserve.

Secondary Purchase Reserve. This fund reserve was established to purchase additional water supply in case of a major drought or unforeseen emergency that diminishes the City's normal supply. The size of the reserve is equal to 6 percent of the annual water purchase budget. City Council action is required in order to appropriate funds from this reserve. As of June 30, 2017, there was $14.3 million in the Secondary Purchase Reserve.

Rate Stabilization Fund Reserve. This fund reserve was established and is maintained pursuant to the Master Installment Purchase Agreement. Transfers in and out of this fund reserve serve as a revolving mechanism to mitigate potential fluctuations in the rates for the water system operations, and maintain stable debt service coverage ratios for the City's outstanding obligations. The permitted uses of the Rate Stabilization Fund Reserve are limited to the O&M costs of the water system. The City Reserve Policy establishes a baseline target for this fund reserve in an amount equal to 5 percent of the prior fiscal year water system total operating revenues. If amounts on deposit in the Rate Stabilization Fund Reserve decrease below the baseline amount of 5 percent of the prior fiscal year water system total operating revenue, it will be replenished to the target level from any surplus Net System Revenue in the next fiscal year or in conjunction with the City Council authorization of a future cost of service study and rate adjustment. As of June 30, 2017, there was $62.1 million in the Rate Stabilization Fund Reserve.

Emergency Capital Reserve. This fund reserve is intended to be used for emergency capital needs. The reserve is budgeted annually at $5.0 million in the water system CIP budget. If the reserve is used to fund unforeseen emergency conditions resulting in the need to immediately repair or replace existing assets, approval from the Chief Financial Officer or the Chief Operating Officer is required. As of June 30, 2017, there was $5.0 million in the Emergency Capital Reserve.

Pension Payment Stabilization Reserve. This fund reserve is maintained to mitigate service delivery risk due to the unanticipated increases in the annual pension payment, the Actuarially Determined Contribution. As of June 30, 2016, there was $1.5 million in the Pension Payment Stabilization Reserve.

18.3.2.2.b Sewer Utility Reserves

The City has established accounts within the Sewer Utility (combination of Municipal Wastewater Utility and Metropolitan Wastewater Utility) for four separate reserves: (1) Emergency Operating Reserve, (2) Rate Stabilization Fund Reserve, (3) Emergency Capital Reserve, and (4) Pension Payment Stabilization Reserve. As of June 30, 2017, the Sewer Utility had total reserves of $120.3 million.

Emergency Operating Reserve. This fund reserve is intended to be used in the event of a catastrophe that prevents the wastewater system from operating in its normal course of business. The reserve level is defined as the number of days of operation it could support in the event of a major disruption to the wastewater system. The Emergency Operating Reserve target is equivalent to 70 days of operations. Use of the Emergency Operating Reserve is restricted to emergency situations, and City Council approval is required to appropriate these reserves. Any request to utilize this fund reserve will include a plan and timeline for replenishment, which may be in conjunction with the City Council authorization of a future cost of service study and rate adjustment. As of June 30, 2017, there was $48.3 million in the Emergency Operating Reserve.

Rate Stabilization Fund Reserve. This fund reserve was established and is maintained pursuant to the Master Installment Purchase Agreement. Transfers in and out of this fund reserve serve as a revolving mechanism to mitigate potential fluctuations in the rates for the wastewater system operations, and maintain stable debt service coverage ratios for the City's outstanding obligations. The permitted uses of the Rate Stabilization Fund Reserve are limited to the O&M costs of the wastewater system. The City Reserve Policy establishes a baseline target for this fund reserve in an amount equal to 5 percent of the prior fiscal year wastewater system total operating revenues. If amounts on deposit in the Rate Stabilization Fund Reserve decrease below the baseline amount of 5 percent of the prior fiscal year wastewater system total operating revenue, it will be replenished to the target level from any surplus Net System Revenue in the next fiscal year or in conjunction with the City Council authorization of a future cost of service study and rate adjustment. As of June 30, 2017, there was $65.3 million in Rate Stabilization Fund Reserve.

Emergency Capital Reserve. This fund reserve is intended to be used for emergency capital needs. The reserve is budgeted annually at $5.0 million in the wastewater system CIP budget. If the reserve is used to fund unforeseen emergency conditions resulting in the need to immediately repair or replace existing assets, approval from the Chief Financial Officer or the Chief Operating Officer is required. As of June 30, 2017, there was $5.0 million in the Emergency Capital Reserve.

Pension Payment Stabilization Reserve. This fund reserve is maintained to mitigate service delivery risk due to the unanticipated increases in the annual pension payment, the Actuarially Determined Contribution. As of June 30, 2016, there was $1.7 million in the Pension Payment Stabilization Reserve.

18.3.2.3 Funding of Required Ongoing Maintenance

The PUD continues to implement a CIP that is based upon on-going condition assessment of existing assets. The annual new appropriation for the Water and Wastewater Utility CIP has been approximately $300 - $400 million per fiscal year. The City is committed to setting aside appropriate funding each year to ensure the continued maintenance and timely replacement of all assets, including those associated with the North City Pure Water Project. This funding will be secured through the City's annual operating budget. The level of funding required for the ongoing maintenance of equipment will be established using the equipment vendor or manufacturer's recommended maintenance schedule.

Funding for the replacement of equipment (e.g., periodic replacement of membrane filters, RO units, and UV lamps) will be secured through the PUD's Operating or CIP budget. The PUD will use the vendor or manufacturer recommended replacement schedule and the continuous assessment of the equipment's operating condition as a basis for planning the long-term funding of all required equipment replacements.

If, for example, there were a catastrophic failure of the MF and RO membranes through an operational incident and all membranes needed to be replaced simultaneously, the funding could come from either the Emergency Operation Reserve or the Emergency Capital Reserve. The approximate cost of the MF modules and the RO elements is $3.2 million and $3.3 million, respectively. Based upon the information in Sections 18.3.2.2.a and 18.3.2.2.b, there are sufficient funds in reserve to address such an event.

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APPENDIX A: IAP Members

IAP Member	Background	Area of Expertise	Period of Participation	Role(s)[1]		
				Full IAP	Subcommittee(s)	
					AWPF	Limnology
Michael Anderson, Ph.D.	**Professor of Applied Limnology and Environmental Chemistry, University of California, Riverside (Riverside, CA)**	Limnology	**2009-present**	✓		✓
Richard Bull, Ph.D.	**Consulting Toxicologist** **MoBull Consulting (Richland, WA)**	Toxicology	**2004-present**	✓		
Amy Childress, Ph.D.	**Professor and Director of Environmental Engineering, University of Southern California (Los Angeles, CA)**	Membrane Processes	**2015-present**	✓		
Joseph A. Cotruvo, Ph.D.	**Principal, Joseph Cotruvo Associates (Washington, D.C.)**	Chemistry	**2004-present**	✓	✓	
James Crook, Ph.D., P.E., BCEE	**Water Reuse Consultant (Boston, MA)**	Water Reuse and Regulatory Compliance	**2004-present**	**Vice-Chair**	**Chair**	✓
Richard Gersberg, Ph.D.	**Professor and Head, Division of Occupational and Environmental Health , Director, Coastal and Marine Institute, San Diego State University (San Diego, CA)**	Public and Environmental Health	**2004-present**	✓	✓	✓
Sunny Jiang, Ph.D.	**Associate Professor, Civil & Environmental Engineering, University of California, Irvine (Irvine, CA)**	Microbiology	**2009-2012**	✓		✓
Audrey D. Levine, Ph.D., P.E., BCEE	**Research Leader, Environmental Solutions, Energy, Environment, & Material Sciences Global Business (Washington, D.C.)**	Treatment Engineering	**2009-2012**	✓	✓	
Christine L. Moe, Ph.D.	**Associate Professor and Director of the Center for Global Safe Water, Emory University (Atlanta, GA)**	Epidemiology and Microbiology	**2004-2006**	✓		
James E.T. Moncur, PhD.	**Director of the Water Resources Research Center, University of Hawaii (Honolulu, HI)**	Economics	**2004-2006**	✓		

IAP Member	Background	Area of Expertise	Period of Participation	Role(s)[1]		
				Full IAP	Subcommittee(s)	
					AWPF	Limnology
Derek Patel, M.D.	**Associate Clinical Professor of Medicine, University of California San Diego (San Diego, CA)**	Gastroenterology	**2004-2006**	✓		
Channah M. Rock, Ph.D.	**Water Quality Extension Specialist and Associate Professor, University of Arizona (Tucson, AZ)**	Water Quality	**2015-present**	✓		
Joan B. Rose, Ph.D.	**Homer Nowlin Endowed Chair for Water Research, Michigan State University (East Lansing, MI)**	Microbiology and Water Quality	**2004-2006**	✓		
David R. Schubert, Ph.D.	**Professor and Chair, Cellular Neurobiology Laboratory, The Salk Institute for Biological Studies (San Diego, CA)**	Research Science	**2009-present**	✓	✓	
George Tchobanoglous, PhD., P.E., NAE	**Professor Emeritus, University of California, Davis (Davis, CA)**	Environmental and Operations Engineering	**2004-present**	**Chair**	✓	**Chair**
Michael P. Wehner	**Assistant General Manager, Orange County Water District (Fountain Valley, CA)**	Water Quality and Utility Representative	**2004-present**	✓	✓	
Fred Zuckerman	**Mechanical Engineer, Member of the Tierrasanta Community Council (San Diego, CA)**	Local Perspective	**2004-2006**	✓		

[1] Member of full IAP and/or subcommittee. Chair and vice-chair are noted.

August 2015

NATIONAL WATER RESEARCH INSTITUTE

Independent Advisory Panel to Review the City of San Diego's Potable Reuse Plan

PANEL MEMBER BIOSKETCHES

<u>Panel Chair</u>

GEORGE TCHOBANOGLOUS, PH.D., P.E., NAE, BCEE
Professor Emeritus
University of California, Davis (Davis, California)

For over 35 years, wastewater expert George Tchobanoglous taught courses on water and wastewater treatment and solid waste management at the University of California, Davis, where he is Professor Emeritus in the Department of Civil and Environmental Engineering. He has authored or coauthored over 550 publications, including 23 textbooks and eight engineering reference books. Along with coauthors, he has written extensively on water reuse including the textbook *Water Reuse: Issues, Technologies, and Applications*, the WateReuse report *Direct Potable Reuse: A Path Forward*, and the NWRI White Paper *Direct Potable Reuse: Benefits for Public Water Supplies, Agriculture, the Environment, and Energy Conservation*. He has also given more than 550 presentations on a variety of environmental engineering subjects. Tchobanoglous has been past President of the Association of Environmental Engineering and Science Professors. Among his honors, he received the Athalie Richardson Irvine Clarke Prize from NWRI in 2003, was inducted to the National Academy of Engineers in 2004, and received an Honorary Doctor of Engineering degree from the Colorado School of Mines in 2005. In 2012, he received the first Excellence in Engineering Education Award from AAEE and AEESP. In 2013, he was selected as the AAEE and AEESP Kappe Lecturer. Currently, he serves as Chair of numerous expert panels, such as panels for the City of San Diego, Monterey Regional Water Pollution Control Agency, Orange County Sanitation District, and others. He also chaired the effort to develop a "Direct Potable Reuse Framework" document (2015) sponsored by WateReuse Association, NWRI, and other organizations. Tchobanoglous received a B.S. in Civil Engineering from the University of the Pacific, an M.S. in Sanitary Engineering from the University of California, Berkeley, and a Ph.D. in Environmental Engineering from Stanford University.

MICHAEL A. ANDERSON, PH.D.
Professor of Applied Limnology and Environmental Chemistry
Department of Environmental Sciences
University of California, Riverside (Riverside, California)

Michael Anderson, a Professor of Applied Limnology and Environmental Chemistry, has taught courses at the University of California, Riverside, since 1990. His research focus includes water and soil sciences, with particular emphasis in applied limnology and lake/reservoir management; surface water quality and modeling; fate of contaminants in waters, soils, and sediments; and environmental chemistry. Current research projects include laboratory, field, and modeling studies in support of the development of species conservation habitat at the Salton Sea, sponsored by the California DWR and DFG, and a survey of organochlorine pesticides and Polychlorinated Biphenyls (PCBs) in McGrath Lake that is funded by the Los Angeles Regional Water Quality Control Board. He and his students also recently completed studies quantifying the abundance and distribution of quagga mussel veligers in the reservoirs of the Colorado River Aqueduct, as well as assessing the ecological and biological conditions at Lake Elsinore. In addition, he has served on various panels and workgroups, including as member of the California Department of Water Resource's Salton Sea Hydrologic Technical Workgroup (2007-2008). At present, he serves on the NWRI Expert Panel for the State of California on developing water recycling criteria for indirect potable reuse through surface water augmentation and determining the feasibility of developing criteria for direct potable reuse. Anderson received a B.S. in Biology from Illinois Benedictine College, M.S. in Environmental Studies from Bemidji State University, and Ph.D. in Environmental Chemistry from Virginia Tech.

RICHARD BULL, PH.D.
Consulting Toxicologist
MoBull Consulting (Richland, Washington)

Since 2000, Richard Bull has been a Consulting Toxicologist with MoBull Consulting, where he conducts studies on the chemical problems encountered in water for water utilities, as well as federal, state, and local governments. Bull is a Professor Emeritus at Washington State University, where he maintains Adjunct Professor appointments in the College of Pharmacy and the Department of Environmental Science. Formerly, he served as a senior staff scientist at DOE's Pacific Northwest National Laboratory, Professor of Pharmacology/Toxicology at Washington State University, and Director of the Toxicology and Microbiology Division in the Cincinnati Laboratories for the U.S. Environmental Protection Agency. Bull has published extensively on research on central nervous system effects of heavy metals, the carcinogenic and toxicological effects of disinfectants and disinfection by-products, halogenated solvents, acrylamide, and other contaminants of drinking water. He has also served on many international scientific committees convened by the National Academy of Sciences, World Health Organization, and International Agency for Research on Cancer regarding various contaminants of drinking water. At present, Bull serves on the NWRI Expert Panel for the State of California on developing water recycling criteria for indirect potable reuse through surface water augmentation and determining the feasibility of developing criteria for direct potable reuse. He also serves on panels for the Orange County Water District and Los Angeles Department of Water and Power, among others. Bull received a B.S. in Pharmacy from the University of Washington and a Ph.D. in Pharmacology from the University of California, San Francisco.

AMY CHILDRESS, PH.D.
Professor and Director of Environmental Engineering
University of Southern California (Los Angeles, California)

Amy Childress has more than 20 years of experience researching membrane processes for water treatment, wastewater reclamation, and desalination. Most recently, she has investigated membrane contactor processes for innovative solutions to contaminant and energy challenges; pressure-driven membrane processes as industry standards for desalination and water reuse; membrane bioreactor technology; and colloidal and interfacial aspects of membrane processes. Childress has directed research funded by federal, state, and private agencies. Current research projects are funded by the U.S. Environmental Protection Agency, Strategic Environmental Research and Development Program, and California Department of Water Resources. Childress has received several awards, including the Association of Environmental Engineering and Science Professors Outstanding Publication Award and a National Science Foundation CAREER Award, and has served as President of the Association of Environmental Engineering and Science Professors and an editorial board member for several journals. She also serves on several expert panels, including as Chair of the expert panel to review Subsurface Desalination Intake and Potable Reuse Feasibility Studies being undertaken by the City of Santa Barbara, California. Childress received a B.S from the University of Maryland and both an M.S. and Ph.D. in Civil and Environmental Engineering from the University of California, Los Angeles.

JOSEPH A. COTRUVO, PH.D., BCES
President
Joseph Cotruvo & Associates, LLC (Washington, D.C.)

Joe Cotruvo is President of Joseph Cotruvo & Associates, an environmental and public health consulting firm in Washington, DC, and is active in the World Health Organization (WHO)/NSF International Collaborating Centre for Drinking Water Safety and Treatment. Previously, he served as Director of the Criteria and Standards Division of the U.S. Environmental Protection Agency Office of Drinking Water, where his organization developed the *Drinking Water Health Advisory System* and numerous *National Drinking Water-Quality Standards and Guidelines*. He was also Director of the EPA's Risk Assessment Division and a former Vice President for Environmental Health Sciences at NSF International. He is a member of WHO Drinking Water Guidelines development committees and he has led the recently published monograph on *Desalination Technology: Health and Environmental Impacts*. He also led studies on bromate metabolism through the American Water Works Association Research Foundation and on recycled water contaminants for the WateReuse Foundation. Cotruvo served as Chair of the Water Quality and Water Services Committee of the Board of Directors of the District of Columbia Water and Sewer Authority. He is also Chair of the WateReuse Association National Regulatory Committee and a member of a number of expert panels, such as panels for the Orange County Water District, Los Angeles Department of Water and Power, and New Mexico Environment Department. He is also an author of the "Direct Potable Reuse Framework" document (2015) sponsored by WateReuse Association, NWRI, and other organizations. Cotruvo received a B.S. in Chemistry from the University of Toledo and a Ph.D. in Physical Organic Chemistry from Ohio State University.

JAMES CROOK, PH.D., P.E., BCEE
Environmental Engineering Consultant (Boston, Massachusetts)

Jim Crook is an environmental engineering consultant (Boston, MA) with more than 40 years of experience in state government and consulting engineering arenas, serving public and private sectors in the U.S. and abroad. He has authored more than 100 publications and is an internationally recognized expert in water reclamation and reuse. He has been involved in numerous projects and research activities involving public health, regulations and permitting, water quality, risk assessment, treatment technology, and water reuse. Crook spent 15 years directing the California Department of Health Services' water reuse program, during which time he developed California's first comprehensive water reuse criteria. He also spent 15 years with consulting firms overseeing water reuse activities and is now an independent consultant specializing in water reuse. He currently serves on a number of advisory panels and committees, including serving as co-chair of an NWRI Expert Panel for the State of California on developing water recycling criteria for indirect potable reuse through surface water augmentation and determining the feasibility of developing criteria for direct potable reuse. Examples of other panels that he chairs include the long-term review of the Orange County Water District's Groundwater Replenishment System and the development of operational criteria for direct potable reuse for the State of New Mexico. He also served on a panel to develop a "Direct Potable Reuse Framework" document (2015) for the WateReuse Association, NWRI, and other sponsors. Among his honors, Crook was elected as a Water Environment Federation Fellow in 2014 and selected as the American Academy of Environmental Engineers' 2002 Kappe Lecturer and the WateReuse Association's 2005 Person of the Year. He received a B.S. in Civil Engineering from the University of Massachusetts and both an M.S. and Ph.D. in Environmental Engineering from the University of Cincinnati.

RICHARD GERSBERG, PH.D.
Professor and Head, Division of Occupational and Environmental Health
Graduate School of Public Health
San Diego State University (San Diego, California)

Rick Gersberg serves as a Professor and Head of the Division of Occupational and Environmental Health at San Diego State University. He specializes in water quality research and limnology, and has broad experience working with both chemical and microbiological pollutants and risk assessments. Prior to joining the California State University system in 1986, he was Director of Research for the San Diego Region Water Reclamation Agency and both a Project Manager and Environmental Consultant for Ecological Research Associates. Among his most recent activities, Gersberg was a member of the CALFED Bay-Delta Authority Science Program, in cooperation with California Sea Grant. He has also been actively involved in projects on the effects of global climate change on the coast of San Diego, California, and risk assessment regarding consuming fish and ocean recreation in Imperial Beach, California. He is currently the Principal Investigator of an EPA and SCERP-funded study to use polymerase chain reaction (PCR) methods do quantitate the levels of hepatitis A virus and enteroviruses in the recreational ocean waters near the U.S-Mexico border, and to examine the removal of these viruses (and selenium) by constructed wetlands treating the contaminated New River before it enters the Salton Sea, California. He also serves on an expert panel to review a Full Advanced Water Treatment Demonstration Project for the Padre Dam Municipal Water District (California). Gersberg received a B.S. in Biology from the City College of the City University of New York, an M.S. in Biology from the University of Houston, and a Ph.D. in Microbiology from the University of California, Davis.

CHANNAH M. ROCK, Ph.D.
Water Quality Extension Specialist and Assistant Professor
Department of Soil, Water, and Environmental Science
University of Arizona (Tucson, Arizona)

Channah Rock serves as a Water Quality Extension Specialist and Assistant Professor in the Department of Soil, Water, and Environmental Science at the University of Arizona. Her background in both microbiology and civil and environmental engineering has focused her work on better understanding how pathogens and indicators survive through water treatment and what factors can affect their persistence in the environment. Her research interests include microbiology, parasitology, virology, molecular biology, wastewater, and biosolids. Among her current research is a Water Research Foundation project (WRF #4508) on "Assessment of Techniques to Evaluate and Demonstrate the Safety of Water from Direct Potable Reuse Treatment Facilities," which involves the review of existing analytical methods for chemicals and pathogens for application in a DPR system. At present, she serves on an expert panel to review a Full Advanced Water Treatment Demonstration Project for the Padre Dam Municipal Water District (California). Rock received a B.S. in Microbiology from New Mexico State University, and both an M.S. and Ph.D. in Civil and Environmental Engineering from Arizona State University. She conducted post-doctoral research at the U.S. Department of Agriculture, Agricultural Research Service.

DAVID R. SCHUBERT, PH.D.
Professor and Chair, Cellular Neurobiology Laboratory
The Salk Institute for Biological Studies (La Jolla, California)

David Schubert, Professor and Head of the Cellular Neurobiology Laboratory, is interested in understanding the molecular basis of nerve cell death and developing drugs that block nerve cell death in Alzheimer's disease, Parkinson's disease, stroke, and other age-associated brain disorders. The focus of the drug development program is the use of biologically active natural products, compounds that occur normally in plants, as a starting point for the synthesis of chemical derivatives that are more potent and have better pharmacological properties than the plant product. His lab also works on amyloid protein, a toxic substance that accumulates in the brains of Alzheimer's patients. In addition to his laboratory work, Schubert is a member of San Diego County Science Advisory Board, a group that advises the Board of Supervisors on science-based issues. He is also a frequent contributor to the *Union-Tribune* editorial page on the subject of science policy. Schubert received a B.A. in Chemistry/Biochemistry from Indiana University and a Ph.D. in Cell Biology from the University of California, San Diego, with Postdoctoral work in Cell Biology/Genetics at Institut Pasteur in Paris, France.

MICHAEL P. WEHNER
Assistant General Manager
Orange County Water District (Fountain Valley, California)

Mike Wehner has almost 40 years of experience in water quality control and water resources management. Initially, he spent 20 years with the Orange County Health Care Agency. Since 1991, he has worked for the Orange County Water District (OCWD), where he currently serves as Assistant General Manager. Among his responsibilities, he directly manages the Water Quality and Technology Group, including Laboratory, Water Quality, Research and Development, and Health and Regulatory Affairs Departments. In this capacity, he is involved with numerous aspects with OCWD's Groundwater Replenishment System (the nation's largest IPR project), including providing technical guidance on treatment and quality, as well as managing monitoring programs for the purification facility and receiving groundwater. He was also manager of OCWD's 8-year Santa Ana River Water Quality and Health Study, which evaluated the impact of using effluent-dominated river waters for groundwater recharge. At present, Wehner serves on the Advisory Group on the "Feasibility of Developing Criteria for Direct Potable Reuse" for the California State Water Resources Control Board, as well as expert panels on groundwater replenishment projects for both the Los Angeles Department of Water and Power (California) and Monterey Regional Water Pollution Control Agency (California). He received a Masters of Public Administration from California State University Long Beach and a B.S. in Biological Sciences from the University of California, Irvine.

APPENDIX B: Summary of IAP Meetings

o.	Date	Topic
1	July 13-14, 2004	Initial meeting of the original IAP to discuss the viability of an increased water reuse program, including potential options for groundwater storage, expansion of the distribution system, reservoirs for recycled water, livestream discharge, wetlands development, and RA
2	May 15-16, 2005	Follow-up meeting of the original IAP to discuss and offer comments on the Draft Water Reuse Study (City, 2006)
3	November 30 – December 1, 2005	Follow-up meeting of the original IAP to discuss and offer comments on the Final Draft Water Reuse Study (City, 2006)
4	May 11-12, 2009	Introductory meeting of the full IAP to discuss the WPDP Scope
5	March 29-30, 2010	Limnology Subcommittee meeting to discuss set-up and calibration of the San Vicente Reservoir Model
6	September 2, 2010	Limnology Working Group meeting to specify and discuss details pertaining to the San Vicente Reservoir Model
7	October 21, 2010	AWPF Subcommittee meeting to discuss the draft Testing and Monitoring Plan for the WPDP AWPF
8	March 17, 2011	Limnology Working Group meeting to review San Vicente Reservoir modeling scenarios, determine potential “worst case scenarios,” and discuss pathogen removal
9	June 6-7, 2011	Second meeting of the full IAP to update the group on the Limnology Subcommittee, Limnology Working Group, and AWPF Subcommittee activities, and tour the AWPF
10	December 6, 2011	Limnology Subcommittee meeting to review and receive comments on the draft San Vicente Reservoir modeling study, and receive input on proposed reservoir public health-related regulatory conditions
11	December 19, 2011	AWPF Subcommittee meeting to review the AWPF operational and water quality data
12	March 9-21, 2012	Conference calls of an ad-hoc subcommittee to review and discuss Draft CDPH Proposal for Augmentation at San Vicente Reservoir

Meeting No.	Date	Topic
13	March 13, 2012	Limnology Subcommittee meeting to review the San Vicente Reservoir Water Quality Report
14	November 15-16, 2012	Third meeting of the full IAP to review and comment on the draft Demonstration Project, Quarterly Testing Report No. 4, and AWPF Study Report (City, 2013)
15	January 27-28, 2014	Limnology Subcommittee meeting to review the proposed Purified Water Program IPR/RA Project and hydrodynamic modeling studies at San Vicente and Otay Reservoirs
16	July 28, 2014	Limnology Subcommittee meeting to review the status of the Otay Reservoir tracer and modeling studies and the results of the San Vicente Reservoir modeling study
17	December 3, 2014	Limnology Subcommittee meeting to review and comment on the final results of the San Vicente Reservoir modeling study
18	March 2-3, 2015	Limnology Subcommittee meeting to review and comment on the San Vicente Reservoir Final Report, provide input on the scenarios in the Otay Reservoir modeling study, and comment on modeling of possible pumped storage project at San Vicente Reservoir
19	October 6-7, 2015	Full IAP meeting to introduce and provide input on the Miramar Concept Framework for the proposed Miramar Surface Water Augmentation (SWA) Project
20	July 11, 2016	Limnology Subcommittee meeting to provide input on modeling of Miramar Reservoir and comment on the proposed approach for demonstrating compliance with Miramar Reservoir receiving water standards
21	September 30, 2016	Limnology Subcommittee meeting to review modeling of Miramar Reservoir and comment on the proposed approach for demonstrating compliance with dilution criteria in the draft regulations for IPR using SWA
22	October 9-10, 2017	Full IAP meeting to provide input on the modeling studies of Miramar Reservoir relative to the surface water augmentations regulations and reservoir operational criteria, and review the pathogen study for the North City Water Reclamation Plant based on the pathogen sampling conducted for the Miramar Project.

APPENDIX C: 2000 CTR Standards

2001 CTR Standards

Federal Register

Thursday,

May 18, 2000

Part III

Environmental Protection Agency

40 CFR Part 131

Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California; Rule

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 131

[FRL–6587–9]

RIN 2040–AC44

Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California

AGENCY: Environmental Protection Agency.

ACTION: Final rule.

SUMMARY: This final rule promulgates: numeric aquatic life criteria for 23 priority toxic pollutants; numeric human health criteria for 57 priority toxic pollutants; and a compliance schedule provision which authorizes the State to issue schedules of compliance for new or revised National Pollutant Discharge Elimination System permit limits based on the federal criteria when certain conditions are met.

EPA is promulgating this rule based on the Administrator's determination that numeric criteria are necessary in the State of California to protect human health and the environment. The Clean Water Act requires States to adopt numeric water quality criteria for priority toxic pollutants for which EPA has issued criteria guidance, the presence or discharge of which could reasonably be expected to interfere with maintaining designated uses.

EPA is promulgating this rule to fill a gap in California water quality standards that was created in 1994 when a State court overturned the State's water quality control plans which contained water quality criteria for priority toxic pollutants. Thus, the State of California has been without numeric water quality criteria for many priority toxic pollutants as required by the Clean Water Act, necessitating this action by EPA. These Federal criteria are legally applicable in the State of California for inland surface waters, enclosed bays and estuaries for all purposes and programs under the Clean Water Act.

EFFECTIVE DATE: This rule shall be effective May 18, 2000.

ADDRESSES: The administrative record for today's final rule is available for public inspection at the U.S. Environmental Protection Agency, Region 9, Water Division, 75 Hawthorne Street, San Francisco, California 94105, between the hours of 8:00 a.m. and 4:30 p.m. For access to the administrative record, call Diane E. Fleck, P.E., Esq. at 415 744–1984 for an appointment. A reasonable fee will be charged for photocopies.

FOR FURTHER INFORMATION CONTACT: Diane E. Fleck, P.E., Esq. or Philip Woods, U.S. Environmental Protection Agency, Region 9, Water Division, 75 Hawthorne Street, San Francisco, California 94105, 415–744–1984 or 415–744–1997, respectively.

SUPPLEMENTARY INFORMATION: This preamble is organized according to the following outline:

A. Potentially Affected Entities

Citizens concerned with water quality in California may be interested in this rulemaking. Entities discharging pollutants to waters of the United States in California could be affected by this rulemaking since water quality criteria are used by the State in developing National Pollutant Discharge Elimination System (NPDES) permit limits. Categories and entities that ultimately may be affected include:

Category	Examples of potentially affected entities
Industry	Industries discharging pollutants to surface waters in California or to publicly-owned treatment works.
Municipalities	Publicly-owned treatment works discharging pollutants to surface waters in California

This table is not intended to be exhaustive, but rather provides a guide for readers regarding entities likely to be affected by this action. This table lists the types of entities that EPA is now aware could potentially be affected by this action. Other types of entities not listed in the table could also be affected. To determine whether your facility might be affected by this action, you should carefully examine the applicability criteria in § 131.38(c). If you have questions regarding the applicability of this action to a particular entity, consult the persons listed in the preceding **FOR FURTHER INFORMATION CONTACT** section.

B. Introduction and Overview

1. Introduction

This section introduces the topics which are addressed in the preamble and provides a brief overview of EPA's basis and rationale for promulgating Federal criteria for the State of California. Section C briefly describes the evolution of the efforts to control toxic pollutants; these efforts include the changes enacted in the 1987 CWA Amendments, which are the basis for this rule. Section D summarizes California's efforts since 1987 to implement the requirements of CWA section 303(c)(2)(B) and describes EPA's procedure and actions for determining whether California has fully implemented CWA section 303(c)(2)(B). Section E provides the rationale and approach for developing this final rule, including a discussion of EPA's legal basis for this final rule. Section F describes the development of the criteria included in this rule. Section G summarizes the provisions of the final rule and discusses implementation issues. Sections H, I, J, K , L, M, N, O, P, and Q briefly address the requirements of Executive Order 12866, the Unfunded Mandates Reform Act of 1995, the Regulatory Flexibility Act, the Paperwork Reduction Act, the Endangered Species Act, the Congressional Review Act, Executive Order 13084, Consultation and Coordination with Indian Tribal Governments, the National Technology Transfer and Advancement Act, and Executive Order 13132, Federalism, respectively.

The proposal for this rulemaking was published in the **Federal Register** on August 5, 1997. Changes from the proposal are generally addressed in the body of this preamble and specifically addressed in the response to comments document included in the administrative record for this rulemaking. EPA responded to all comments on the proposed rule, including comments received after the September 26, 1997, deadline. Although EPA is under no legal obligation to respond to late comments, EPA made a policy decision to respond to all comments.

Since detailed information concerning many of the topics in this preamble was published previously in the **Federal Register** in preambles for this and other rulemakings, references are frequently made to those preambles. Those rulemakings include: Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California; Proposed Rule, 62 FR 42159, August 5, 1997 (referred to as the ''proposed CTR''); Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants, 57 FR 60848, December 22, 1992 (referred to as the ''National Toxics Rule'' or ''NTR''); and the NTR as amended by Administrative Stay of Federal Water Quality Criteria for Metals and Interim Final Rule, Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance—Revision of Metals Criteria, 60 FR 22228, May 4, 1995 (referred to as the ''National Toxics Rule [NTR], as amended''). The NTR, as amended, is codified at 40 CFR 131.36. A copy of the proposed CTR and its preamble, and the NTR, as amended, and its preambles are contained in the administrative record for this rulemaking.

EPA is making this final rule effective upon publication. Under the Administrative Procedure Act, 5 U.S.C. 553(d)(3), agencies must generally publish a rule no more than 30 days prior to the effective date of the rule except as otherwise provided for by the Agency for good cause. The purpose of the 30-day waiting period is to give affected parties a reasonable time to adjust their behavior before the final rule takes effect. See *Omnipoint Corp.* v. *F.C.C.,* 78 F.3d 620, 630–631 (D.C. Cir. 1996); *Riverbend Farms, Inc.* v. *Madigan*, 958 F.2d 1479, 1485 (9th Cir. 1992).

In this instance, EPA finds good cause to make the final rule effective upon publication. In order to find good cause, an Agency needs to find that the 30-day period would be: (1) Impracticable, (2) unnecessary, or (3) contrary to the public interest. Here EPA is relying on the second reason to support its finding of good cause. EPA also notes that the State has requested EPA to make the rule immediately effective.

EPA finds that in this instance, waiting 30 days to make the rule effective is unnecessary. As explained in further detail elsewhere in this preamble, this rule is not self implementing; rather it establishes ambient conditions that the State of California will implement in future permit proceedings. These permit proceedings will, by regulation, take longer than 30 days to complete. This means that although the rule is immediately effective, no discharger's conduct would be altered under the rule in less than 30 days, and therefore the 30-day period is unnecessary.

2. Overview

This final rule establishes ambient water quality criteria for priority toxic pollutants in the State of California. The criteria in this final rule will supplement the water quality criteria promulgated for California in the NTR, as amended. In 1991, EPA approved a number of water quality criteria (discussed in section D), for the State of California. Since EPA had approved these criteria, it was not necessary to include them in the 1992 NTR for these criteria. However, the EPA-approved criteria were subsequently invalidated in State litigation. Thus, this final rule contains criteria to fill the gap created by the State litigation.

This final rule does not change or supersede any criteria previously promulgated for the State of California in the NTR, as amended. Criteria which EPA promulgated for California in the NTR, as amended, are footnoted in the final table at 131.38(b)(1), so that readers may see the criteria promulgated in the NTR, as amended, for California and the criteria promulgated through this rulemaking for California in the same table. This final rule is not intended to apply to waters within Indian Country. EPA recognizes that there are possibly waters located wholly or partly in Indian Country that are included in the State's basin plans. EPA will work with the State and Tribes to identify any such waters and determine whether further action to protect water quality in Indian Country is necessary.

This rule is important for several environmental, programmatic and legal reasons. Control of toxic pollutants in surface waters is necessary to achieve the CWA's goals and objectives. Many of California's monitored river miles, lake acres, and estuarine waters have elevated levels of toxic pollutants. Recent studies on California water bodies indicate that elevated levels of toxic pollutants exist in fish tissue which result in fishing advisories or bans. These toxic pollutants can be attributed to, among other sources, industrial and municipal discharges.

Water quality standards for toxic pollutants are important to State and EPA efforts to address water quality problems. Clearly established water quality goals enhance the effectiveness of many of the State's and EPA's water programs including permitting, coastal water quality improvement, fish tissue quality protection, nonpoint source controls, drinking water quality protection, and ecological protection. Numeric criteria for toxic pollutants allow the State and EPA to evaluate the adequacy of existing and potential control measures to protect aquatic ecosystems and human health. Numeric criteria also provide a more precise basis for deriving water quality-based effluent limitations (WQBELs) in

National Pollutant Discharge Elimination System (NPDES) permits and wasteload allocations for total maximum daily loads (TMDLs) to control toxic pollutant discharges. Congress recognized these issues when it enacted section 303(c)(2)(B) to the CWA.

While California recognizes the need for applicable water quality standards for toxic pollutants, its adoption efforts have been stymied by a variety of factors. The Administrator has decided to exercise her CWA authorities to move forward the toxic control program, consistent with the CWA and with the State of California's water quality standards program.

Today's action will also help restore equity among the States. The CWA is designed to ensure all waters are sufficiently clean to protect public health and/or the environment. The CWA allows some flexibility and differences among States in their adopted and approved water quality standards, but it should be implemented in a manner that ensures a level playing field among States. Although California has made important progress toward satisfying CWA requirements, it has not satisfied CWA section 303(c)(2)(B) by adopting numeric water quality criteria for toxic pollutants. This section was added to the CWA by Congress in 1987. Prior to today, the State of California had been the only State in the Nation for which CWA section 303(c)(2)(B) had remained substantially unimplemented after EPA's promulgation of the NTR in December of 1992. Section 303(c)(4) of the CWA authorizes the EPA Administrator to promulgate standards where necessary to meet the requirements of the Act. The Administrator determined that this rule was a necessary and important component for the implementation of CWA section 303(c)(2)(B) in California.

EPA acknowledges that the State of California is working to satisfy CWA section 303(c)(2)(B). When the State formally adopts, and EPA approves, criteria consistent with statutory requirements, as envisioned by Congress in the CWA, EPA intends to stay this rule. If within the applicable time frame for judicial review, the States' standards are challenged, EPA will withdraw this rule after such judicial review is complete and the State standards are sustained.

C. Statutory and Regulatory Background

The preamble to the August 5, 1997, proposed rule provided a general discussion of EPA's statutory and regulatory authority to promulgate water quality criteria for the State of California. See 62 FR 42160–42163. EPA is including that discussion in the record for the final rule. Commenters questioned EPA's authority to promulgate certain aspects of the proposal. EPA is responding to those comments in the appropriate sections of this preamble, and in the response to comments document included in the administrative record for this rulemaking. Where appropriate, EPA's responses expand upon the discussion of statutory and regulatory authority found in the proposal.

D. California Water Quality Standards Actions

1. California Regional Water Quality Control Board Basin Plans, and the Inland Surface Waters Plan (ISWP) and the Enclosed Bays and Estuaries Plan (EBEP) of April 1991

The State of California regulates water quality through its State Water Resources Control Board (SWRCB) and through nine Regional Water Quality Control Boards (RWQCBs). Each of the nine RWQCBs represents a different geographic area; area boundaries are generally along watershed boundaries. Each RWQCB maintains a Basin Plan which contains the designated uses of the water bodies within its respective geographic area within California. These designated uses (or ''beneficial uses'' under State law) together with legally-adopted criteria (or ''objectives'' under State law), comprise water quality standards for the water bodies within each of the Basin areas. Each of the nine RWQCBs undergoes a triennial basin planning review process, in compliance with CWA section 303. The SWRCB provides assistance to the RWQCBs.

Most of the Basin Plans contain conventional pollutant objectives such as dissolved oxygen. None of the Basin Plans contains a comprehensive list of priority toxic pollutant criteria to satisfy CWA section 303(c)(2)(B). The nine RWQCBs and the SWRCB had intended that the priority toxic pollutant criteria contained in the three SWRCB statewide plans, the Inland Surface Waters Plan (ISWP), the Enclosed Bays and Estuaries Plan (EBEP), and the Ocean Plan, apply to all basins and satisfy CWA section 303(c)(2)(B).

On April 11, 1991, the SWRCB adopted two statewide water quality control plans, the ISWP and the EBEP. These statewide plans contained narrative and numeric water quality criteria for toxic pollutants, in part to satisfy CWA section 303(c)(2)(B). The water quality criteria contained in the SWRCB statewide plans, together with the designated uses in each of the Basin Plans, created a set of water quality standards for waters within the State of California.

Specifically, the two plans established water quality criteria or objectives for all fresh waters, bays and estuaries in the State. The plans contained water quality criteria for some priority toxic pollutants, provisions relating to whole effluent toxicity, implementation procedures for point and nonpoint sources, and authorizing compliance schedule provisions. The plans also included special provisions affecting waters dominated by reclaimed water (labeled as Category (a) waters), and waters dominated by agricultural drainage and constructed agricultural drains (labeled as Category (b) and (c) waters, respectively).

2. EPA's Review of California Water Quality Standards for Priority Toxic Pollutants in the ISWP and EBEP, and the National Toxics Rule

The EPA Administrator has delegated the responsibility and authority for review and approval or disapproval of all new or revised State water quality standards to the EPA Regional Administrators (see 40 CFR 131.21). Thus, State actions under CWA section 303(c)(2)(B) are submitted to the appropriate EPA Regional Administrator for review and approval.

In mid-April 1991, the SWRCB submitted to EPA for review and approval the two statewide water quality control plans, the ISWP and the EBEP. On November 6, 1991, EPA Region 9 formally concluded its review of the SWRCB's plans. EPA approved the narrative water quality criterion and the toxicity criterion in each of the plans. EPA also approved the numeric water quality criteria contained in both plans, finding them to be consistent with the requirements of section 303(c)(2)(B) of the CWA and with EPA's national criteria guidance published pursuant to section 304(a) of the CWA.

EPA noted the lack of criteria for some pollutants, and found that, because of the omissions, the plans did not fully satisfy CWA section 303(c)(2)(B). The plans did not contain criteria for all listed pollutants for which EPA had published national criteria guidance. The ISWP contained human health criteria for only 65 pollutants, and the EBEP contained human health criteria for only 61 pollutants for which EPA had issued section 304(a) guidance criteria. Both the ISWP and EBEP contained aquatic life criteria for all pollutants except cyanide and chromium III (freshwater only) for which EPA has CWA section

304(a) criteria guidance. The SWRCB's administrative record stated that all priority pollutants with EPA criteria guidance were likely to be present in California waters. However, the SWRCB's record contained insufficient information to support a finding that the excluded pollutants were not reasonably expected to interfere with designated uses of the waters of the State.

Although EPA approved the statewide selenium objective in the ISWP and EBEP, EPA disapproved the objective for the San Francisco Bay and Delta, because there was clear evidence that the objective would not protect the designated fish and wildlife uses (the California Department of Health Services had issued waterfowl consumption advisories due to selenium concentrations, and scientific studies had documented selenium toxicity to fish and wildlife). EPA restated its commitment to object to National Pollutant Discharge Elimination System (NPDES) permits issued for San Francisco Bay that contained effluent limits based on an objective greater than 5 parts per billion (ppb) (four day average) and 20 ppb (1 hour average), the freshwater criteria. EPA reaffirmed its disapproval of Californias' site-specific selenium objective for portions of the San Joaquin River, Salt Slough, and Mud Slough. EPA also disapproved of the categorical deferrals and exemptions. These disapprovals included the disapproval of the State's deferral of water quality objectives to effluent dominated streams (Category a) and to streams dominated by agricultural drainage (Category b), and the disapproval of the exemption of water quality objectives to constructed agricultural drains (Category c). EPA found the definitions of the categories imprecise and overly broad which could have led to an incorrect interpretation.

Since EPA had disapproved portions of each of the California statewide plans which were necessary to satisfy CWA section 303(c)(2)(B), certain disapproved aspects of California's water quality standards were included in EPA's promulgation of the National Toxics Rule (NTR) (40 CFR 131.36, 57 FR 60848). EPA promulgated specific criteria for certain water bodies in California.

The NTR was amended, effective April 14, 1995, to stay certain metals criteria which had been promulgated as total recoverable. Effective April 15, 1995, EPA promulgated interim final metals criteria as dissolved concentrations for those metals which had been stayed (Administrative Stay of Federal Water Quality Criteria for Metals and Interim Final Rule, Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance—Revision of Metals Criteria; 60 FR 22228, 22229, May 4, 1995 [the NTR, as amended]). The stay was in response to a lawsuit against EPA challenging, among other issues, metals criteria expressed as total recoverable concentrations. A partial Settlement Agreement required EPA to stay specific metals criteria in the NTR. EPA then promulgated certain metals criteria in the dissolved form through the use of conversion factors. These factors are listed in the NTR, as amended. A scientific discussion of these criteria is found in a subsequent section of this preamble.

Since certain criteria have already been promulgated for specific water bodies in the State of California in the NTR, as amended, they are not within the scope of today's final rule. However, for clarity in reading a comprehensive rule for the State of California, these criteria are incorporated into 40 CFR 131.38(d)(2). Footnotes to the Table in 40 CFR 131.38(b)(1) and 40 CFR 131.38(d)(3) clarify which criteria (and for which specific water bodies) were promulgated by the NTR, as amended, and are therefore excluded from this final rule. The appropriate (freshwater or saltwater) aquatic life criteria which were promulgated in the NTR, as amended, for all inland surface waters and enclosed bays and estuaries include: chromium III and cyanide. The appropriate (water and organism or organism only) human health criteria which were promulgated in the NTR, as amended, for all inland surface waters and enclosed bays and estuaries include:

antimony
thallium
asbestos
acrolein
acrylonitrile
carbon tetrachloride
chlorobenzene
1,2-dichloroethane
1,1-dichloroethylene
1,3-dichloropropylene
ethylbenzene
1,1,2,2-tetrachloroethane
tetrachloroethylene
1,1,2-trichloroethane
trichloroethylene
vinyl chloride
2,4-dichlorophenol
2-methyl-4,6-dinitrophenol
2,4-dinitrophenol
benzidine
bis(2-chloroethyl)ether
bis(2-ethylhexyl)phthalate
3,3-dichlorobenzidine
diethyl phthalate
dimethyl phthalate
di-n-butyl phthalate
2,4-dinitrotoluene
1,2-diphenylhydrazine
hexachlorobutadiene
hexachlorocyclopentadiene
hexachloroethane
isophorone
nitrobenzene
n-nitrosodimethylamine
n-nitrosodiphenylamine

Other pollutant criteria were promulgated in the NTR, as amended, for specific water bodies, but not all inland surface waters and enclosed bays and estuaries.

3. Status of Implementation of CWA Section 303(c)(2)(B)

Shortly after the SWRCB adopted the ISWP and EBEP, several dischargers filed suit against the State alleging that it had not adopted the two plans in compliance with State law. The plaintiffs in a consolidated case included: the County of Sacramento, Sacramento County Water Agency; Sacramento Regional County Sanitation District; the City of Sacramento; the City of Sunnyvale; the City of San Jose; the City of Stockton; and Simpson Paper Company.

The dischargers alleged that the State had not adopted the ISWP and EBEP in compliance with the California Administrative Procedures Act (Gov Code. Section 11340, *et seq.*), the California Environmental Quality Act (Pub. Re Code, Section 21000, *et seq.*), and the Porter-Cologne Act (Wat. Code, Section 13200, *et seq.*). The allegation that the State did not sufficiently consider economics when adopting water quality objectives, as allegedly required by Section 13241 of the Porter Cologne Act, was an important issue in the litigation.

In October of 1993, the Superior Court of California, County of Sacramento, issued a tentative decision in favor of the dischargers. In March of 1994, the Court issued a substantively similar final decision in favor of the dischargers. Final judgments from the Court in July of 1994 ordered the SWRCB to rescind the ISWP and EBEP. On September 22, 1994, the SWRCB formally rescinded the two statewide water quality control plans. The State is currently in the process of readopting water quality control plans for inland surface waters, enclosed bays and estuaries.

CWA section 303(c)(2)(B) was fully implemented in the State of California from December of 1992, when the NTR was promulgated, until September of 1994, when the SWRCB was required to rescind the ISWP and EBEP. The provisions for California in EPA's NTR together with the approved portions of

California's ISWP and EBEP implemented the requirements of CWA section 303(c)(2)(B). However, since September of 1994, when the SWRCB rescinded the ISWP and EBEP, the requirements of section 303(c)(2)(B) have not been fully implemented in California.

The scope of today's rule is to re-establish criteria for the remaining priority toxic pollutants to meet the requirements of section 303(c)(2)(B) of the CWA. Pursuant to section 303(c)(4), the Administrator has determined that it is necessary to include in today's action criteria for priority toxic pollutants, which are not covered by the NTR, as amended, or by the State through EPA-approved site-specific criteria, for waters of the United States in the State of California.

4. State-Adopted, Site-Specific Criteria for Priority Toxic Pollutants

The State has the discretion to develop site-specific criteria when appropriate e.g., when statewide criteria appear over-or under-protective of designated uses. Periodically, the State through its RWQCBs will adopt site-specific criteria for priority toxic pollutants within respective Basin Plans. These criteria are intended to be effective throughout the Basin or throughout a designated water body. Under California law, these criteria must be publicly reviewed and approved by the RWQCB, the SWRCB, and the State's Office of Administrative Law (OAL). Once this adoption process is complete, the criteria become State law.

These criteria must be submitted to the EPA Regional Administrator for review and approval under CWA section 303. These criteria are usually submitted to EPA as part of a RWQCB Basin Plan Amendment, after the Amendment has been adopted under the State's process and has become State law.

a. State-Adopted Site-Specific Criteria Under EPA Review

The State of California has recently reviewed and updated all of its RWQCB Basin Plans. All of the Basin Plans have completed the State review and adoption process and have been submitted to EPA for review and approval. Some of the Basin Plans contain site-specific criteria. In these cases, the State-adopted site-specific criteria are used for water quality programs.

EPA has not yet concluded consultation under the Endangered Species Act with the U.S. Department of Interior, Fish and Wildlife Service, and the U.S. Department of Commerce, National Marine Fisheries Service, on EPA's tentative approval/disapproval actions on the RWQCB Basin Plans. In this situation, the more stringent of the two criteria (the State-adopted site-specific criteria in the RWQCB Basin Plans, or the Federal criteria in this final rule), would be used for water quality programs including the calculation of water quality-based effluent criteria in National Pollutant Discharge Elimination System (NPDES) permits.

b. State-Adopted Site-Specific Criteria With EPA Approval

In several cases, the EPA Regional Administrator has already reviewed and approved State-adopted site-specific criteria within the State of California. Several of these cases are discussed in this section. All of the EPA approval letters referenced in today's preamble are contained in the administrative record for today's rule.

Sacramento River: EPA has approved site-specific acute criteria for copper, cadmium and zinc in the Sacramento River, upstream of Hamilton City, in the Central Valley Region (RWQCB for the Central Valley Region) of the State of California. EPA approved these site-specific criteria by letter dated August 7, 1985. Specifically, EPA approved for the Sacramento River (and tributaries) above Hamilton City, a copper criterion of 5.6 µg/l (maximum), a zinc criterion of 16 µg/l (maximum) and a cadmium criterion of 0.22 µg/l (maximum), all in the dissolved form using a hardness of 40 mg/l as CaCO3. (These criteria were actually adopted by the State and approved by EPA as equations which vary with hardness.) These ''maximum'' criteria correspond to acute criteria in today's final rule. Therefore, Federal acute criteria for copper, cadmium, and zinc for the Sacramento River (and tributaries) above Hamilton City are not necessary to protect the designated uses and are not included in the final rule. However, the EPA Administrator is making a finding that it is necessary to include chronic criteria for copper, cadmium and zinc for the Sacramento River (and tributaries) above Hamilton City, as part of the statewide criteria promulgated in today's final rule.

San Joaquin River: The selenium criteria in this rule are not applicable to portions of the San Joaquin River, in the Central Valley Region, because selenium criteria have been either previously approved by EPA or previously promulgated by EPA as part of the NTR. EPA approved and disapproved State-adopted site-specific selenium criteria in portions of the San Joaquin River, in the Central Valley Region of the State of California (RWQCB for the Central Valley Region). EPA's determination on these site-specific criteria is contained in a letter dated April 13, 1990.

Specifically, EPA approved for the San Joaquin River, mouth of Merced River to Vernalis, an aquatic life selenium criterion of 12 µg/l (maximum with the understanding that the instantaneous maximum concentration may not exceed the objective more than once every three years). Today's final rule does not affect this Federally-approved, State-adopted site-specific acute criterion, and it remains in effect for the San Joaquin River, mouth of Merced River to Vernalis. Therefore, an acute criterion for selenium in the San Joaquin River, mouth of Merced River to Vernalis is not necessary to protect the designated use and thus is not included in this final rule.

By letter dated April 13, 1990, EPA also approved for the San Joaquin River, mouth of Merced River to Vernalis, a State-adopted site-specific aquatic life selenium criterion of 5 µg/l (monthly mean); however, EPA disapproved a State-adopted site-specific selenium criterion of 8 µg/l (monthly mean—critical year only) for these waters. Subsequently, EPA promulgated a chronic selenium criterion of 5 µg/l (4 day average) for waters of the San Joaquin River from the mouth of the Merced River to Vernalis in the NTR. This chronic criterion applies to all water quality programs concerning the San Joaquin River, mouth of Merced River to Vernalis. Today's final rule does not affect the Federally-promulgated chronic selenium criterion of 5 µg/l (4 day average) set forth in the NTR. This previously Federally-promulgated criterion remains in effect for the San Joaquin River, mouth of Merced River to Vernalis.

Grassland Water District, San Luis National Wildlife Refuge, and Los Banos State Wildlife Refuge: EPA approved for the Grassland Water District, San Luis National Wildlife Refuge, and Los Banos State Wildlife Refuge, a State-adopted site-specific aquatic life selenium criterion of 2 µg/l (monthly mean) by letter dated April 13, 1990. This Federally-approved, State-adopted site-specific chronic criterion remains in effect for the Grassland Water District, San Luis National Wildlife Refuge and Los Banos State Wildlife Refuge. Therefore it is not necessary to include in today's final rule, a chronic criterion for selenium for the Grassland Water District, San Luis National Wildlife Refuge and Los Banos State Wildlife Refuge, and thus, it is not included in this final rule.

San Francisco Regional Board Basin Plan of 1986: EPA approved several priority toxic pollutant objectives (CWA criteria) that were contained in the1986 San Francisco Regional Board Basin Plan, as amended by SWRCB Resolution Numbers 87–49, 87–82 and 87–92, by letters dated September 2, 1987 and December 24, 1987. This Basin Plan, the SWRCB Resolutions, and the EPA approval letters are contained in the administrative record for this rulemaking. It is not necessary to include these criteria for priority toxic pollutants that are contained in the San Francisco Regional Board's 1986 Basin Plan as amended, and approved by EPA. Priority pollutants in this situation are footnoted in the matrix at 131.38(b)(1) with footnote ''b.'' Where gaps exist in the State adoption and EPA approval of priority toxic pollutant objectives, the criteria in today's rule apply.

EPA is assigning ''human health, water and organism consumption'' criteria to waters with the States' municipal or ''MUN'' beneficial use designation in the Basin Plan. Also, some pollutants regulated through the Basin Plan have different averaging periods, *e.g.,* one hour as compared with the rule's ''short-term.'' However, where classes of chemicals, such as polynuclear aromatic hydrocarbons, or PAHs, and phenols, are regulated through the Basin Plan, but not specific chemicals within the category, specific chemicals within the category are regulated by today's rule.

E. Rationale and Approach for Developing the Final Rule

This section explains EPA's legal basis for today's final rule, and discusses EPA's general approach for developing the specific requirements for the State of California.

1. Legal Basis

CWA section 303(c) specifies that adoption of water quality standards is primarily the responsibility of the States. However, CWA section 303(c) also describes a role for the Federal government to oversee State actions to ensure compliance with CWA requirements. If EPA's review of the States' standards finds flaws or omissions, then the CWA authorizes EPA to correct the deficiencies (see CWA section 303(c)(4)). This water quality standards promulgation authority has been used by EPA to issue final rules on several separate occasions, including the NTR, as amended, which promulgated criteria similar to those included here for a number of States. These actions have addressed both insufficiently protective State criteria and/or designated uses and failure to adopt needed criteria. Thus, today's action is not unique.

The CWA in section 303(c)(4) provides two bases for promulgation of Federal water quality standards. The first basis, in paragraph (A), applies when a State submits new or revised standards that EPA determines are not consistent with the applicable requirements of the CWA. If, after EPA's disapproval, the State does not amend its rules so as to be consistent with the CWA, EPA is to promptly propose appropriate Federal water quality standards for that State. The second basis for an EPA action is in paragraph (B), which provides that EPA shall promptly initiate promulgation ''* * * in any case where the Administrator determines that a revised or new standard is necessary to meet the requirements of this Act.'' EPA is using section 303(c)(4)(B) as the legal basis for today's final rule.

As discussed in the preamble to the NTR, the Administrator's determination under CWA section 303(c)(4) that criteria are necessary to meet the requirements of the Act could be supported in several ways. Consistent with EPA's approach in the NTR, EPA interprets section 303(c)(2)(B) of the CWA to allow EPA to act where the State has not succeeded in establishing numeric water quality standards for toxic pollutants. This inaction can be the basis for the Administrator's determination under section 303(c)(4) that new or revised criteria are necessary to ensure designated uses are protected.

EPA does not believe that it is necessary to support the criteria in today's rule on a pollutant-specific, water body-by-water-body basis. For EPA to undertake an effort to conduct research and studies of each stream segment or water body across the State of California to demonstrate that for each toxic pollutant for which EPA has issued CWA section 304(a) criteria guidance there is a ''discharge or presence'' of that pollutant which could reasonably ''be expected to interfere with'' the designated use would impose an enormous administrative burden and would be contrary to the statutory directive for swift action manifested by the 1987 addition of section 303(c)(2)(B) to the CWA. Moreover, because these criteria are ambient criteria that define attainment of the designated uses, their application to all water bodies will result in additional controls on dischargers only where necessary to protect the designated uses.

EPA's interpretation of section 303(c)(2)(B) is supported by the language of the provision, the statutory framework and purpose of section 303, and the legislative history. In adding section 303(c)(2)(B) to the CWA, Congress understood the existing requirements in section 303(c)(1) for States to conduct triennial reviews of their water quality standards and submit the results of those reviews to EPA and in section 303(c)(4)(B) for promulgation. CWA section 303(c) includes numerous deadlines and section 303(c)(4) directs the Administrator to act ''promptly'' where the Administrator determines that a revised or new standard is necessary to meet the requirements of the Act. Congress, by linking section 303(c)(2)(B) to the section 303(c)(1) three-year review period, gave States a last chance to correct this deficiency on their own. The legislative history of the provision demonstrates that chief Senate sponsors, including Senators Stafford, Chaffee and others wanted the provision to eliminate State and EPA delays and force quick action. Thus, to interpret CWA section 303(c)(2)(B) and (c)(4) to require such a cumbersome pollutant specific effort on each stream segment would essentially render section 303(c)(2)(B) meaningless. The provision and its legislative background indicate that the Administrator's determination to invoke section 303(c)(4)(B) authority can be met by the Administrator making a generic finding of inaction by the State without the need to develop pollutant specific data for individual stream segments. Finally, the reference in section 303(c)(2)(B) to section 304(a) criteria suggests that section 304(a) criteria serve as default criteria; that once EPA has issued them, States were to adopt numeric criteria for those pollutants based on the 304(a) criteria, unless they had other scientifically defensible criteria. EPA also notes that this rule follows the approach EPA took nationally in promulgating the NTR for States that failed to comply with CWA section 303(c)(2)(B). 57 FR 60848, December 22, 1992. EPA incorporates the discussion in the NTR preamble as part of this rulemaking record.

This determination is supported by information in the rulemaking record showing the discharge or presence of priority toxic pollutants throughout the State. While this data is not necessarily complete, it constitutes a strong record supporting the need for numeric criteria for priority toxic pollutants with section 304(a) criteria guidance where the State does not have numeric criteria.

Today's final rule would not impose any undue or inappropriate burden on the State of California or its dischargers. It merely puts in place numeric criteria for toxic pollutants that are already used in other States in implementing CWA programs. Under this rulemaking, the State of California retains the ability to adopt alternative water quality criteria simply by completing its criteria adoption process. Upon EPA approval of those criteria, EPA will initiate action to stay the Federally-promulgated criteria and subsequently withdraw them.

2. Approach for Developing This Rule

In summary, EPA developed the criteria promulgated in today's final rule as follows. Where EPA promulgated criteria for California in the NTR, EPA has not acted to amend the criteria in the NTR. Where criteria for California were not included in the NTR, EPA used section 304(a) National criteria guidance documents as a starting point for the criteria promulgated in this rule. EPA then determined whether new information since the development of the national criteria guidance documents warranted any changes. New information came primarily from two sources. For human health criteria, new or revised risk reference doses and cancer potency factors on EPA's Integrated Risk Information System (IRIS) as of October 1996 form the basis for criteria values (see also 63 FR 68354). For aquatic life criteria, updated data sets resulting in revised criteria maximum concentrations (CMCs) and criteria continuous concentrations (CCCs) formed the basis for differences from the national criteria guidance documents. Both of these types of changes are discussed in more detail in the following sections. This revised information was used to develop the water quality criteria promulgated here for the State of California.

F. Derivation of Criteria

1. Section 304(a) Criteria Guidance Process

Under CWA section 304(a), EPA has developed methodologies and specific criteria guidance to protect aquatic life and human health. These methodologies are intended to provide protection for all surface waters on a national basis. The methodologies have been subject to public review, as have the individual criteria guidance documents. Additionally, the methodologies have been reviewed by EPA's Science Advisory Board (SAB) of external experts.

EPA has included in the record of this rule the aquatic life methodology as described in ''Appendix B—Guidelines for Deriving Water Quality Criteria for the Protection of Aquatic Life and Its Uses'' to the ''Water Quality Criteria Documents; Availability'' (45 FR 79341, November 28, 1980) as amended by the ''Summary of Revisions to Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses'' (50 FR 30792, July 29, 1985). (**Note:** Throughout the remainder of this preamble, this reference is described as the 1985 Guidelines. Any page number references are to the actual guidance document, not the notice of availability in the **Federal Register**. A copy of the 1985 Guidelines is available through the National Technical Information Service (PB85–227049), is in the administrative record for this rule, and is abstracted in Appendix A of *Quality Criteria for Water,* 1986.) EPA has also included in the administrative record of this rule the human health methodology as described in ''Appendix C—Guidelines and Methodology Used in the Preparation of Health Effects Assessment Chapters of the Consent Decree Water Criteria Documents'' (45 FR 79347, November 28, 1980). (Note: Throughout the remainder of this preamble, this reference is described as the Human Health Guidelines or the 1980 Guidelines.) EPA also recommends that the following be reviewed: ''Appendix D—Response to Comments on Guidelines for Deriving Water Quality Criteria for the Protection of Aquatic Life and Its Uses,'' (45 FR 79357, November 28, 1980); ''Appendix E—Responses to Public Comments on the Human Health Effects Methodology for Deriving Ambient Water Quality Criteria'' (45 FR 79368, November 28, 1980); and ''Appendix B—Response to Comments on Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses'' (50 FR 30793, July 29, 1985). EPA placed into the administrative record for this rulemaking the most current individual criteria guidance for the priority toxic pollutants included in today's rule. (**Note:** All references to appendices are to the associated **Federal Register** publication.)

EPA received many comments related to the issue of what criteria should apply in the CTR if the CWA section 304(a) criteria guidance is undergoing re-evaluation, or if new data are developed that may affect a recommended criterion. As science is always evolving, EPA is faced with the challenge of promulgating criteria that reflect the best science and sound science. EPA addressed this challenge in some detail in its **Federal Register** notice that contained the Agency's current section 304(a) criteria guidance (63 FR 68335, December 10, 1998). There, EPA articulated its policy, reiterated here, that the existing criteria guidance represent the Agency's best assessment until such time as EPA's re-evaluation of a criteria guidance value for a particular chemical is complete. The reason for this is that both EPA's human health criteria guidance and aquatic life criteria guidance are developed taking into account numerous variables. For example, for human health criteria guidance, EPA evaluates many diverse toxicity studies, whose results feed into a reference dose or cancer potency estimate that, along with a number of exposure factors and determination of risk level, results in a guidance criterion. For aquatic life, EPA evaluates many diverse aquatic toxicity studies to determine chronic and acute toxicity taking into account how other factors (such as pH, temperature or hardness) affect toxicity. EPA also, to the extent possible, addresses bioaccumulation or bioconcentration. EPA then uses this toxicity information along with exposure information to determine the guidance criterion. Importantly, EPA subjects such evaluation to peer review and/or public comment.

For these reasons, EPA generally does not make a change to the 304(a) criteria guidance based on a partial picture of the evolving science. This makes sense, because to address one piece of new data without looking at all relevant data is less efficient and results in regulatory impacts that may go back and forth, when in the end, the criteria guidance value does not change that much. Certain new changes, however, do warrant change in criteria guidance, such as a change in a value in EPA's Integrated Risk Information System (IRIS) because it represents the Agency consensus about human health impacts. These changes are sufficiently examined across the Agency such that EPA believes they can be incorporated into EPA's water quality criteria guidance. EPA has followed this approach in the CTR. Included in the administrative record for today's rule is a document entitled ''Status of Clean Water Act Section 304(a) Criteria'' which further explains EPA's policy on managing change to criteria guidance.

2. Aquatic Life Criteria

Aquatic life criteria may be expressed in numeric or narrative form. EPA's 1985 Guidelines describe an objective, internally consistent and appropriate way of deriving chemical-specific, numeric water quality criteria for the protection of the presence of, as well as the uses of, both fresh and salt water aquatic organisms.

An aquatic life criterion derived using EPA's CWA section 304(a) method ''might be thought of as an estimate of the highest concentration of a substance in water which does not present a significant risk to the aquatic organisms in the water and their uses.'' (45 FR 79341.) EPA's guidelines are designed to derive criteria that protect aquatic communities. EPA's 1985 Guidelines attempt to provide a reasonable and adequate amount of protection with only a small possibility of substantial overprotection or underprotection. As discussed in detail below, there are several individual factors which may make the criteria somewhat overprotective or underprotective. The approach EPA is using is believed to be as well balanced as possible, given the state of the science.

Numerical aquatic life criteria derived using EPA's 1985 Guidelines are expressed as short-term and long-term averages, rather than one number, in order that the criterion more accurately reflect toxicological and practical realities. The combination of a criterion maximum concentration (CMC), a short-term concentration limit, and a criterion continuous concentration (CCC), a four-day average concentration limit, are designed to provide protection of aquatic life and its uses from acute and chronic toxicity to animals and plants, without being as restrictive as a one-number criterion would have to be (1985 Guidelines, pages 4 & 5). The terms CMC and CCC are the formal names for the two (acute and chronic) values of a criterion for a pollutant; however, this document will also use the informal synonyms acute criterion and chronic criterion.

The two-number criteria are intended to identify average pollutant concentrations which will produce water quality generally suited to maintenance of aquatic life and designated uses while restricting the duration of excursions over the average so that total exposures will not cause unacceptable adverse effects. Merely specifying an average value over a time period may be insufficient unless the time period is short, because excursions higher than the average may kill or cause substantial damage in short periods.

A minimum data set of eight specified families is recommended for criteria development (details are given in the 1985 Guidelines, page 22). The eight specific families are intended to be representative of a wide spectrum of aquatic life. For this reason it is not necessary that the specific organisms tested be actually present in the water body. EPA's application of its guidelines to develop the criteria matrix in this rule is judged by the Agency to be appropriate for all waters of the United States (U.S.), and to all ecosystems (1985 Guidelines, page 4) including those waters of the U.S. and ecosystems in the State of California.

Fresh water and salt water (including both estuarine and marine waters) have different chemical compositions, and freshwater and saltwater species often do not inhabit the same water. To provide additional accuracy, criteria are developed for fresh water and for salt water.

For this rule, EPA updated freshwater aquatic life criteria contained in CWA section 304(a) criteria guidance first published in the early 1980's and later modified in the NTR, as amended, for the following ten pollutants: arsenic, cadmium, chromium (VI), copper, dieldrin, endrin, lindane (gamma BHC), nickel, pentachlorophenol, and zinc. The updates used as the basis for this rule are explained in a technical support document entitled, *1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water* (U.S. EPA–820–B–96–001, September 1996), available in the administrative record to this rulemaking; this document presents the derivation of each of the final CMCs and CCCs and the toxicity studies from which the updated freshwater criteria for the ten pollutants were derived.

The polychlorinated biphenyls (PCB) criteria in the criteria matrix for this rule differs from that in the NTR, as amended; for this rule, the criteria are expressed as the sum of seven aroclors, while for the NTR, as amended, the criteria are expressed for each of seven aroclors. The aquatic life criteria for PCBs in the CTR are based on the criteria contained in the 1980 criteria guidance document for PCBs which is included in the administrative record for this rule. This criteria document explains the derivation of aquatic life criteria based on total PCBs. For more information see the Response to Comments document for this rule. Today's chronic aquatic life criteria for PCBs are based on a final residue value (FRV). In EPA's guidelines for deriving aquatic life criteria, an FRV-based criterion is intended to prevent concentrations of pollutants in commercially or recreationally important aquatic species from affecting the marketability of those species or affecting the wildlife that consume aquatic life.

The proposed CTR included an updated freshwater and saltwater aquatic life criteria for mercury. In today's final rule, EPA has reserved the mercury criteria for freshwater and saltwater aquatic life, but is promulgating human health criteria for mercury for all surface waters in California. In some instances, the human health mercury criteria included in today's final rule may not protect some aquatic species or threatened or endangered species. In such instances, more stringent mercury limits may be determined and implemented through use of the State's narrative criterion. The reasons for reserving the mercury aquatic life numbers are explained in further detail in Section L, Endangered Species Act.

a. Freshwater Acute Selenium Criterion

EPA proposed a different freshwater acute aquatic life criterion for selenium for this rule than was promulgated in the NTR, as amended. EPA's proposed action was consistent with EPA's proposed selenium criterion maximum concentration for the Water Quality Guidance for the Great Lakes System (61 FR 58444, November 14, 1996). This proposal took into account data showing that selenium's two most prevalent oxidation states, selenite and selenate, present differing potentials for aquatic toxicity, as well as new data which indicated that various forms of selenium are additive. Additivity increases the toxicity of mixtures of different forms of the pollutant. The proposed approach produces a different selenium acute criterion concentration, or CMC, depending upon the relative proportions of selenite, selenate, and other forms of selenium that are present.

The preamble to the August 5, 1997, proposed rule provided a lengthy discussion of this proposed criterion for the State of California. See 62 FR 42160–42208. EPA incorporates that discussion here as part of this rulemaking record. In 1996, a similar discussion was included in the proposed rule for the Great Lakes System. Commenters questioned several aspects of the Great Lakes proposal. EPA is continuing to respond to those comments, and to follow up with additional literature review and toxicity testing. In addition, the U.S. FWS and U.S. NMFS (collectively, the Services) are concerned that EPA's proposed criterion may not be sufficiently protective of certain threatened and endangered species in California. Because the Services believe there is a lack of data to show for certain that the proposed criterion would not affect threatened and endangered species, the Services prefer that EPA further investigate the protectiveness of the criterion before finalizing the proposed criterion. Therefore, EPA is not promulgating a final acute freshwater selenium criterion at this time.

b. Dissolved Metals Criteria

In December of 1992, in the NTR, EPA promulgated water quality criteria for several States that had failed to meet the requirements of CWA section 303(c)(2)(B). Included among the water quality criteria promulgated were numeric criteria for the protection of aquatic life for 11 metals: arsenic, cadmium, chromium (III), chromium (VI), copper, lead, mercury, nickel, selenium, silver and zinc. Criteria for two metals applied to the State of California: chromium III and selenium.

The Agency received extensive public comment during the development of the NTR regarding the most appropriate approach for expressing the aquatic life metals criteria. The principal issue was the correlation between metals that are measured and metals that are bioavailable and toxic to aquatic life. It is now the Agency's policy that the use of dissolved metal to set and measure compliance with aquatic life water quality standards is the recommended approach, because dissolved metal more closely approximates the bioavailable fraction of the metal in the water column than does total recoverable metal.

Since EPA's previous aquatic life criteria guidance had been expressed as total recoverable metal, to express the criteria as dissolved, conversion factors were developed to account for the possible presence of particulate metal in the laboratory toxicity tests used to develop the total recoverable criteria. EPA included a set of recommended freshwater conversion factors with its Metals Policy (see Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria, Martha G. Prothro, Acting Assistant Administrator for Water, October 1, 1993). Based on additional laboratory evaluations that simulated the original toxicity tests, EPA refined the procedures used to develop freshwater conversion factors for aquatic life criteria. These new conversion factors were made available for public review and comment in the amendments to the NTR on May 4, 1995, at 60 FR 22229. They are also contained in today's rule at 40 CFR 131.38(b)(2).

The preamble to the August 5, 1997, proposed rule provided a more detailed discussion of EPA's metals policy concerning the aquatic life water quality criteria for the State of California. See 62 FR 42160–42208. EPA incorporates that discussion here as part of this rulemaking record. Many commenters strongly supported the Agency's policy on dissolved metals aquatic life criteria. A few commenters expressed an opinion that the metals policy may not provide criteria that are adequately protective of aquatic or other species. Responses to those comments are contained in a memo to the CTR record entitled "Discussion of the Use of Dissolved Metals in the CTR" (February 1, 2000, Jeanette Wiltse) and EPA's response to comments document which are both contained in the administrative record for the final rule.

Calculation of Aquatic Life Dissolved Metals Criteria: Metals criteria values for aquatic life in today's rule in the matrix at 131.38(b)(1) are shown as dissolved metal. These criteria have been calculated in one of two ways. For freshwater metals criteria that are hardness-dependent, the metals criteria value is calculated separately for each hardness using the table at 40 CFR 131.38(b)(2). (The hardness-dependent freshwater values presented in the matrix at 40 CFR 131.38(b)(1) have been calculated using a hardness of 100 mg/l as CaCO3 for illustrative purposes only.) The hardness-dependent criteria are then multiplied by the appropriate conversion factors in the table at 40 CFR 131.38(b)(2). Saltwater and freshwater metals criteria that are not hardness-dependent are calculated by taking the total recoverable criteria values (from EPA's national section 304(a) criteria guidance, as updated and described in section F.2.a.) before rounding, and multiplying them by the appropriate conversion factors. The final dissolved metals criteria values, as they appear in the matrix at 40 CFR 131.38(b)(1), are rounded to two significant figures.

Translators for Dissolved to Total Recoverable Metals Limits: EPA's National Pollutant Discharge Elimination System (NPDES) regulations require that limits for metals in permits be stated as total recoverable in most cases (see 40 CFR 122.45(c)) except when an effluent guideline specifies the limitation in another form of the metal, the approved analytical methods measure only dissolved metal, or the permit writer expresses a metal's limit in another form (*e.g.,* dissolved, specific valence, or total) when required to carry out provisions of the CWA. This is because the chemical conditions in ambient waters frequently differ substantially from those in the effluent and these differences result in changes in the partitioning between dissolved and absorbed forms of the metal. This means that if effluent limits were expressed in the dissolved form, additional particulate metal could dissolve in the receiving water causing the criteria to be exceeded. Expressing criteria as dissolved metal requires translation between different metal forms in the calculation of the permit limit so that a total recoverable permit limit can be established that will achieve water quality standards. Thus, it is important that permitting authorities and other authorities have the ability to translate between dissolved metal in ambient waters and total recoverable metal in effluent.

EPA has completed guidance on the use of translators to convert from dissolved metals criteria to total recoverable permit limits. The document, *The Metals Translator: Guidance for Calculating a Total Recoverable Permit Limit From a Dissolved Criterion* (EPA 823–B–96–007, June 1996), is included in the administrative record for today's rule. This technical guidance examines how to develop a metals translator which is defined as the fraction of total recoverable metal in the downstream water that is dissolved, *i.e.,* the dissolved metal concentration divided by the total recoverable metal concentration. A translator may take one of three forms: (1) It may be assumed to be equivalent to the criteria guidance conversion factors; (2) it may be developed directly as the ratio of dissolved to total recoverable metal; and (3) it may be developed through the use of a partition coefficient that is functionally related to the number of metal binding sites on the adsorbent in the water column (*e.g.,* concentrations of total suspended solids or TSS). This guidance document discusses these three forms of translators, as well as field study designs, data generation and analysis, and site-specific study plans to generate site-specific translators.

California Regional Water Quality Control Boards may use any of these methods in developing water quality-based permit limits to meet water quality standards based on dissolved metals criteria. EPA encourages the State to adopt a statewide policy on the use of translators so that the most appropriate method or methods are used consistently within California.

c. Application of Metals Criteria

In selecting an approach for implementing the metals criteria, the principal issue is the correlation between metals that are measured and metals that are biologically available and toxic. In order to assure that the metals criteria are appropriate for the chemical conditions under which they are applied, EPA is providing for the adjustment of the criteria through application of the ''water-effect ratio'' procedure. EPA notes that performing the testing to use a site-specific water-effect ratio is optional on the part of the State.

In the NTR, as amended, EPA identified the water-effect ratio (WER) procedure as a method for optional site-specific criteria development for certain metals. The WER approach compares bioavailability and toxicity of a specific pollutant in receiving waters and in laboratory waters. A WER is an appropriate measure of the toxicity of a material obtained in a site water divided by the same measure of the toxicity of the same material obtained simultaneously in a laboratory dilution water.

On February 22, 1994, EPA issued *Interim Guidance on the Determination and Use of the Water-Effect Ratios for Metals* (EPA 823-B–94–001) now incorporated into the updated Second Edition of the Water Quality Standards Handbook, Appendix L. A copy of the Handbook is contained in the administrative record for today's rule. In accordance with the WER guidance and where application of the WER is deemed appropriate, EPA strongly encourages the application of the WER on a watershed or water body basis as part of a water quality criteria in California as opposed to the application on a discharger-by-discharger basis through individual NPDES permits. This approach is technically sound and an efficient use of resources. However, discharger specific WERs for individual NPDES permit limits are possible and potentially efficient where the NPDES discharger is the only point source discharger to a specific water body.

The rule requires a default WER value of 1.0 which will be assumed, if no site-specific WER is determined. To use a WER other than the default of 1.0, the rule requires that the WER must be determined as set forth in EPA's WER guidance or by another scientifically defensible method that has been adopted by the State as part of its water quality standards program and approved by EPA.

The WER is a more comprehensive mechanism for addressing bioavailability issues than simply expressing the criteria in terms of dissolved metal. Consequently, expressing the criteria in terms of dissolved metal, as done in today's rule for California, does not completely eliminate the utility of the WER. This is particularly true for copper, a metal that forms reduced-toxicity complexes with dissolved organic matter.

The *Interim Guidance on Determination and Use of Water-Effect Ratios for Metals* explains the relationship between WERs for dissolved criteria and WERs for total recoverable criteria. Dissolved measurements are to be used in the site-specific toxicity testing underlying the WERs for dissolved criteria. Because WERs for dissolved criteria generally are little affected by elevated particulate concentrations, EPA expects those WERs to be somewhat less than WERs for total recoverable criteria in such situations. Nevertheless, after the site-specific ratio of dissolved to total metal has been taken into account, EPA expects a permit limit derived using a WER for a dissolved criterion to be similar to the permit limit that would be derived from the WER for the corresponding total recoverable criterion.

d. Saltwater Copper Criteria

The saltwater copper criteria for aquatic life in today's rule are 4.8 μg/l (CMC) and 3.1 μg/l (CCC) in the dissolved form. These criteria reflect new data including data collected from studies for the New York/New Jersey Harbor and the San Francisco Bay indicating a need to revise the former copper 304(a) criteria guidance document to reflect a change in the saltwater CMC and CCC aquatic life values. These data also reflect a comprehensive literature search resulting in added toxicity test data for seven new species to the database for the saltwater copper criteria. EPA believes these new data have national implications and the national criteria guidance now contains a CMC of 4.8 μg/l dissolved and a CCC of 3.1 μg/l dissolved. In the amendments to the NTR, EPA noticed the availability of data to support these changes to the NTR, and solicited comments. The data can be found in the draft document entitled, *Ambient Water Quality Criteria—Copper, Addendum 1995.* This document is available from the Office of Water Resource Center and is available for review in the administrative record for today's rule.

e. Chronic Averaging Period

In establishing water quality criteria, EPA generally recommends an ''averaging period'' which reflects the duration of exposure required to elicit effects in individual organisms (TSD, Appendix D–2). The criteria continuous concentration, or CCC, is intended to be the highest concentration that could be maintained indefinitely in a water body without causing an unacceptable effect on the aquatic community or its uses (TSD, Appendix D–1). As aquatic organisms do not generally experience steady exposure, but rather fluctuating exposures to pollutants, and because aquatic organisms can generally tolerate higher concentrations of pollutants over a shorter periods of time, EPA expects that the concentration of a pollutant can exceed the CCC without causing an unacceptable effect if (a) the magnitude and duration of exceedences are appropriately limited and (b) there are compensating periods of time during which the concentration is below the CCC. This is done by specifying a duration of an ''averaging period'' over which the average concentration should not exceed the CCC more often than specified by the frequency (TSD, Appendix D–1).

EPA is promulgating a 4-day averaging period for chronic criteria, which means that measured or predicted ambient pollutant concentrations should be averaged over a 4-day period to determine attainment of chronic criteria. The State may apply to EPA for approval of an alternative averaging period. To do so, the State must submit to EPA the basis for such alternative averaging period.

The most important consideration for setting an appropriate averaging period is the length of time that sensitive organisms can tolerate exposure to a pollutant at levels exceeding a criterion without showing adverse effects on survival, growth, or reproduction. EPA believes that the chronic averaging period must be shorter than the duration of the chronic tests on which the CCC is based, since, in some cases, effects are elicited before exposure of the entire duration. Most of the toxicity tests used to establish the chronic criteria are conducted using steady exposure to toxicants for a least 28 days (TSD, page 35). Some chronic tests, however, are much shorter than this (TSD, Appendix D–2). EPA selected the 4-day averaging period based on the shortest duration in which chronic test effects are sometimes observed for certain species and toxicants. In addition, EPA believes that the results of some chronic tests are due to an acute effect on a sensitive life stage that occurs some time during the test, rather than being caused by long-term stress or long-term accumulation of the test material in the organisms.

Additional discussion of the rationale for the 4-day averaging period is contained in Appendix D of the TSD. Balancing all of the above factors and data, EPA believes that the 4-day averaging period falls within the scientifically reasonable range of values for choice of the averaging period, and is an appropriate length of time of pollutant exposure to ensure protection of sensitive organisms.

EPA established a 4-day averaging period in the NTR. In settlement of litigation on the NTR, EPA stated that it was ''in the midst of conducting, sponsoring, or planning research related to the basis for and application of'' water quality criteria and mentioned the issue of averaging period. See Partial Settlement Agreement in *American Forest and Paper Ass'n, Inc. et al.* v. *U.S. EPA* (Consolidated Case No. 93–0694 (RMU), D.D.C.). EPA is re-evaluating issues raised about averaging periods and will, if appropriate, revise the 1985 Guidelines.

EPA received public comment relevant to the averaging period during the comment period for the 1995 Amendments to the NTR (60 FR 22228, May 4, 1995), although these public comments did not address the chronic averaging period separately from the allowable excursion frequency and the design flow. Comments recommended that EPA use the 30Q5 design flow for chronic criteria.

While EPA is undertaking analysis of the chronic design conditions as part of the revisions to the 1985 Guidelines, EPA has not yet completed this work. Until this work is complete, for the reasons set forth in the TSD, EPA continues to believe that the 4-day chronic averaging period represents a reasonable, defensible value for this parameter.

EPA added language to the final rule which will enable the State to adopt alternative averaging periods and frequencies and associated design flows where appropriate. The State may apply to EPA for approval of alternative averaging periods and frequencies and related design flows; the State must submit the bases for any changes. Before approving any change, EPA will publish for public comment, a notice proposing the changes.

f. Hardness

Freshwater aquatic life criteria for certain metals are expressed as a function of hardness because hardness and/or water quality characteristics that are usually correlated with hardness can reduce or increase the toxicities of some metals. Hardness is used as a surrogate for a number of water quality characteristics which affect the toxicity of metals in a variety of ways. Increasing hardness has the effect of decreasing the toxicity of metals. Water quality criteria to protect aquatic life may be calculated at different concentrations of hardnesses measured in milligrams per liter (mg/l) as calcium carbonate ($CaCO_3$).

Section 131.38(b)(2) of the final rule presents the hardness-dependent equations for freshwater metals criteria. For example, using the equation for zinc, the total recoverable CMCs at a hardness of 10, 50, 100 or 200 mg/l as $CaCO_3$ are 17, 67, 120 and 220 micrograms per liter (µg/l), respectively. Thus, the specific value in the table in the regulatory text is for illustrative purposes only. Most of the data used to develop these hardness equations for deriving aquatic life criteria for metals were in the range of 25 mg/l to 400 mg/l as $CaCO_3$, and the formulas are therefore most accurate in this range. The majority of surface waters nationwide and in California have a hardness of less than 400 mg/l as $CaCO_3$.

In the past, EPA generally recommended that 25 mg/l as $CaCO_3$ be used as a default hardness value in deriving freshwater aquatic life criteria for metals when the ambient (or actual) hardness value is below 25 mg/l as $CaCO_3$. However, use of the approach results in criteria that may not be fully protective. Therefore, for waters with a hardness of less than 25 mg/l as $CaCO_3$, criteria should be calculated using the actual ambient hardness of the surface water.

In the past, EPA generally recommended that if the hardness was over 400 mg/l, two options were available: (1) Calculate the criterion using a default WER of 1.0 and using a hardness of 400 mg/l in the hardness equation; or (2) calculate the criterion using a WER and the actual ambient hardness of the surface water in the equation. Use of the second option is expected to result in the level of protection intended in the 1985 Guidelines whereas use of the first option is thought to result in an even more protective aquatic life criterion. At high hardness there is an indication that hardness and related inorganic water quality characteristics do not have as much of an effect on toxicity of metals as they do at lower hardnesses. Related water quality characteristics do not correlate as well at higher hardnesses as they do at lower hardnesses. Therefore, if hardness is over 400 mg/l as $CaCO_3$, a hardness of 400 mg/l as $CaCO_3$ should be used with a default WER of 1.0; alternatively, the WER and actual hardness of the surface water may be used.

EPA requested comments in the NTR amendments on the use of actual ambient hardness for calculating criteria when the hardness is below 25 mg/l as $CaCO_3$, and when hardness is greater than 400 mg/l as $CaCO_3$. Most of the comments received were in favor of using the actual hardness with the use of the water-effect ratio (1.0 unless otherwise specified by the permitting authority) when the hardness is greater than 400 mg/l as $CaCO_3$. A few commenters did not want the water-effect ratio to be mandatory in calculating hardness, and other commenters had concerns about being responsible for deriving an appropriate water-effect ratio. Overall, the commenters were in favor of using the actual hardness when calculating hardness-dependent freshwater metals criteria for hardness between 0–400 mg/l as $CaCO_3$. EPA took those comments into account in promulgating today's rule.

A hardness equation is most accurate when the relationships between hardness and the other important inorganic constituents, notably alkalinity and pH, are nearly identical in all of the dilution waters used in the toxicity tests and in the surface waters to which the equation is to be applied. If an effluent raises hardness but not alkalinity and/or pH, using the hardness of the downstream water might provide a lower level of protection than intended by the 1985 guidelines. If it appears that an effluent causes hardness to be inconsistent with alkalinity and/or pH, the intended level of protection will usually be maintained or exceeded if either (1) data are available to demonstrate that alkalinity and/or pH do not affect the toxicity of the metal, or (2) the hardness used in the hardness equation is the hardness of upstream water that does not contain the effluent. The level of protection intended by the 1985 guidelines can also be provided by using the WER procedure.

In some cases, capping hardness at 400 mg/l might result in a level of protection that is higher than that intended by the 1985 guidelines, but any such increase in the level of protection can be overcome by use of the WER procedure. For metals whose criteria are expressed as hardness equations, use of the WER procedure will generally be intended to account for effects of such water quality characteristics as total organic carbon on the toxicities of metals. The WER procedure is equally useful for accounting for any deviation from a hardness equation in a site water.

3. Human Health Criteria

EPA's CWA section 304(a) human health criteria guidance provides criteria recommendations to minimize adverse human effects due to substances in ambient water. EPA's CWA section 304(a) criteria guidance for human health are based on two types of toxicological endpoints: (1) carcinogenicity and (2) systemic toxicity (i.e., all other adverse effects other than cancer). Thus, there are two procedures for assessing these health effects: one for carcinogens and one for non-carcinogens.

If there are no data on how a chemical agent causes cancer, EPA's existing human health guidelines assume that carcinogenicity is a ''non-threshold phenomenon,'' that is, there are no ''safe'' or ''no-effect levels'' because even extremely small doses are assumed to cause a finite increase in the incidence of the effect (i.e., cancer). Therefore, EPA's water quality criteria guidance for carcinogens are presented as pollutant concentrations corresponding to increases in the risk of developing cancer. See Human Health Guidelines at 45 FR 79347.

With existing criteria, pollutants that do not manifest any apparent carcinogenic effect in animal studies (i.e., systemic toxicants), EPA assumes that the pollutant has a threshold below which no effect will be observed. This assumption is based on the premise that a physiological mechanism exists within living organisms to avoid or overcome the adverse effect of the pollutant below the threshold concentration.

Note: Recent changes in the Agency's cancer guidelines addressing these assumptions are described in the Draft Water Quality Criteria Methodology: Human Health, 63 FR 43756, August 14, 1998.

The human health risks of a substance cannot be determined with any degree of confidence unless dose-response relationships are quantified. Therefore, a dose-response assessment is required before a criterion can be calculated. The dose-response assessment determines the quantitative relationships between the amount of exposure to a substance and the onset of toxic injury or disease. Data for determining dose-response relationships are typically derived from animal studies, or less frequently, from epidemiological studies in exposed populations.

The dose-response information needed for carcinogens is an estimate of the carcinogenic potency of the compound. Carcinogenic potency is defined here as a general term for a chemical's human cancer-causing potential. This term is often used loosely to refer to the more specific carcinogenic or cancer slope factor which is defined as an estimate of carcinogenic potency derived from animal studies or epidemiological data of human exposure. It is based on extrapolation from test exposures of high doses over relatively short periods of time to more realistic low doses over a lifetime exposure period by use of linear extrapolation models. The cancer slope factor, q1*, is EPA's estimate of carcinogenic potency and is intended to be a conservative upper bound estimate (e.g. 95% upper bound confidence limit).

For non-carcinogens, EPA uses the reference dose (RfD) as the dose-response parameter in calculating the criteria. For non-carcinogens, oral RfD assessments (hereinafter simply ''RfDs'') are developed based on pollutant concentrations that cause threshold effects. The RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious effects during a lifetime. See Human Health Guidelines. The RfD was formerly referred to as an ''Acceptable Daily Intake'' or ADI. The RfD is useful as a reference point for gauging the potential effect of other doses. Doses that are less than the RfD are not likely to be associated with any health risks, and are therefore less likely to be of regulatory concern. As the frequency of exposures exceeding the RfD increases and as the size of the excess increases, the probability increases that adverse effect may be observed in a human population. Nonetheless, a clear conclusion cannot be categorically drawn that all doses below the RfD are ''acceptable'' and that all doses in excess of the RfD are ''unacceptable.'' In extrapolating non-carcinogen animal test data to humans to derive an RfD, EPA divides either a No Observed-Adverse Effect Level (NOAEL), Lowest Observed Adverse Effect Level (LOAEL), or other benchmark dose observed in animal studies by an ''uncertainty factor'' which is based on professional judgment of toxicologists and typically ranges from 10 to 10,000.

For CWA section 304(a) human health criteria development, EPA typically considers only exposures to a pollutant that occur through the ingestion of water and contaminated fish and shellfish. Thus, the criteria are based on an assessment of risks related to the surface water exposure route only where designated uses are drinking water and fish and shellfish consumption.

The assumed exposure pathways in calculating the criteria are the consumption of 2 liters per day of water at the criteria concentration and the consumption of 6.5 grams per day of fish and shellfish contaminated at a level equal to the criteria concentration but multiplied by a ''bioconcentration factor.'' The use of fish and shellfish consumption as an exposure factor requires the quantification of pollutant residues in the edible portions of the ingested species.

Bioconcentration factors (BCFs) are used to relate pollutant residues in aquatic organisms to the pollutant concentration in ambient waters. BCFs are quantified by various procedures depending on the lipid solubility of the pollutant. For lipid soluble pollutants, the average BCF is calculated from the weighted average percent lipids in the edible portions of fish and shellfish, which is about 3%; or it is calculated from theoretical considerations using the octanol/water partition coefficient. For non-lipid soluble compounds, the BCF is determined empirically. The assumed water consumption is taken from the National Academy of Sciences publication *Drinking Water and Health* (1977). (Referenced in the Human Health Guidelines.) This value is appropriate as it includes a margin of safety so that the general population is protected. See also EPA's discussion of the 2.0 liters/day assumption at 61 FR 65183 (Dec. 11, 1996). The 6.5 grams per day contaminated fish and shellfish consumption value was equivalent to the average per-capita consumption rate of all (contaminated and non-contaminated) freshwater and estuarine fish and shellfish for the U.S. population. See Human Health Guidelines.

EPA assumes in calculating water quality criteria that the exposed individual is an average adult with body weight of 70 kilograms. EPA assumes 6.5 grams per day of contaminated fish and shellfish consumption and 2.0 liters per day of contaminated drinking water consumption for a 70 kilogram person in calculating the criteria. Regarding issues concerning criteria development and differences in dose per kilogram of body weight, RfDs are always derived based on the most sensitive health effect endpoint. Therefore, when that basis is due to a chronic or lifetime health effect, the exposure parameters assume the exposed individual to be the average adult, as indicated above.

In the absence of this final rule, there may be particular risks to children. EPA believes that children are protected by the human health criteria contained in this final rule. Children are protected against other less sensitive adverse health endpoints due to the conservative way that the RfDs are derived. An RfD is a public health protective endpoint. It is an amount of a chemical that can be consumed on a daily basis for a lifetime without expecting an adverse effect. RfDs are based on sensitive health endpoints and are calculated to be protective for sensitive human sub-populations including children. If the basis of the RfD was due to an acute or shorter-term developmental effect, EPA uses exposure parameters other than those indicated above. Specifically, EPA uses parameters most representative of the population of concern (*e.g.,* the health criteria for nitrates based on infant exposure parameters). For carcinogens, the risk assessments are upper bound one in a million (10^{-6}) lifetime risk numbers. The risk to children is not likely to exceed these upper bounds estimates and may be zero at low doses. The exposure assumptions for drinking water and fish protect children because they are conservative for infants and children. EPA assumes 2 liters of untreated surface water and 6.5 grams of freshwater and estuarine fish are consumed each day. EPA believes the adult fish consumption assumption is conservative for children because children generally consume marine fish not freshwater and estuarine.

EPA has a process to develop a scientific consensus on oral reference dose assessments and carcinogenicity assessments (hereinafter simply cancer slope factors or slope factors or q1*s). Through this process, EPA develops a consensus of Agency opinion which is then used throughout EPA in risk management decision-making. EPA maintains an electronic data base which contains the official Agency consensus for oral RfD assessments and carcinogenicity assessments which is known as the Integrated Risk Information System (IRIS). It is available for use by the public on the National Institutes of Health's National Library of Medicine's TOXNET system, and through diskettes from the National Technical Information Service (NTIS). (NTIS access number is PB 90–591330.)

Section 304(a)(1) of the CWA requires EPA to periodically revise its criteria guidance to reflect the latest scientific knowledge: ''(A) On the kind and extent of all identifiable effects on health and welfare * * *; (B) on the concentration and dispersal of pollutants, or their byproducts, through biological, physical, and chemical processes; and (C) on the effects of pollutants on the biological community diversity, productivity, and stability, including information on the factors affecting eutrophication rates of organic and inorganic sedimentation for varying types of receiving waters.'' In developing up-to-date water quality criteria for the protection of human health, EPA uses the most recent IRIS values (RfDs and q1*s) as the toxicological basis in the criterion calculation. IRIS reflects EPA's most current consensus on the toxicological assessment for a chemical. In developing the criteria in today's rule, the IRIS values as of October 1996 were used together with currently accepted exposure parameters for bioconcentration, fish and shellfish and water consumption, and body weight. The IRIS cover sheet for each pollutant criteria included in today's rule is contained in the administrative record.

For the human health criteria included in today's rule, EPA used the Human Health Guidelines on which criteria recommendations from the appropriate CWA section 304(a) criteria guidance document were based. (These documents are also placed in the administrative record for today's rule.) Where EPA has changed any parameters in IRIS used in criteria derivation since issuance of the criteria guidance document, EPA recalculated the criteria recommendation with the latest IRIS information. Thus, there are differences between the original 1980 criteria guidance document recommendations, and those in this rule, but this rule presents EPA's most current CWA section 304(a) criteria recommendation. The basis (q1* or RfD) and BCF for each pollutant criterion in today's rule is contained in the rule's Administrative Record Matrix which is included in the administrative record for the rule. In addition, all recalculated human health numbers are denoted by an ''a'' in the criteria matrix in 40 CFR 131.38(b)(1) of the rule. The pollutants for which a revised human health criterion has been calculated since the December 1992 NTR include:

mercury
dichlorobromomethane
1,2-dichloropropane
1,2-trans-dichloroethylene
2,4-dimethylphenol
acenaphthene
benzo(a)anthracene
benzo(a)pyrene
benzo(b)flouranthene
benzo(k)flouranthene
2-chloronaphthalene
chrysene
dibenzo(a,h)anthracene
indeno(1,2,3-cd)pyrene
N-nitrosodi-n-propylamine
alpha-endosulfan
beta-endosulfan
endosulfan sulfate
2-chlorophenol
butylbenzyl phthalate
polychlorinated biphenyls.

In November of 1991, the proposed NTR presented criteria for several pollutants in parentheses. These were pollutants for which, in 1980, insufficient information existed to develop human health water quality criteria, but for which, in 1991, sufficient information existed. Since these criteria did not undergo the public review and comment in a manner similar to the other water quality criteria presented in the NTR (for which sufficient information was available in 1980 to develop a criterion, as presented in the 1980 criteria guidance documents), they were not proposed for adoption into the water quality criteria, but were presented to serve as notice for inclusion in future State triennial reviews. Today's rule promulgates criteria for these nine pollutants:

copper
1, 2-dichloropropane
1,2-trans-dichloroethylene
2,4-dimethylphenol
acenaphthene
2-chloronaphthalene
N-nitrosodi-n-propylamine
2-chlorophenol
butylbenzene phthalate

All the criteria are based on IRIS values—either an RfD or q1*—which were listed on IRIS as of November 1991, the date of the proposed NTR. These values have not changed since the final NTR was published in December of 1992. The rule's Administrative Record Matrix in the administrative record of today's rule contains the specific RfDs, q1*s, and BCFs used in calculating these criteria.

Proposed Changes to the Human Health Criteria Methodology: EPA recently proposed revisions to the 1980 ambient water quality criteria derivation guidelines (the Human Health Guidelines). See *Draft Water Quality Criteria Methodology: Human Health,* 63 FR 43756, August 14, 1998; see also *Draft Water Quality Criteria Methodology: Human Health,* U.S. EPA Office of Water, EPA 822–Z–98–001. The EPA revisions consist of five documents: *Draft Water Quality Criteria Methodology: Human Health,* EPA 822–Z–98–001; *Ambient Water Quality Criteria Derivation Methodology Human Health, Technical Support Document, Final Draft,* EPA–822–B–98–005; and three Ambient Water Quality Criteria for the Protection of Human Health, Drafts—one each for Acrylonitrile, 1,3-Dichloropropene (1,3-DCP), and Hexachlorobutadiene (HCBD), respectively, EPA–822–R–98–006, –005, and –004. All five documents are contained in the administrative record for today's rule.

The proposed methodology revisions reflect significant scientific advances that have occurred during the past nineteen years in such key areas as cancer and noncancer risk assessments, exposure assessments and bioaccumulation. For specific details on these proposed changes and others, please refer to the **Federal Register** notice or the EPA document.

It should be noted that some of the proposed changes may result in significant numeric changes in the ambient water quality criteria. However, EPA will continue to rely on existing criteria as the basis for regulatory and non-regulatory decisions, until EPA revises and reissues a 304(a) criteria guidance using the revised final human health criteria methodology. The existing criteria are still viewed as scientifically acceptable by EPA. The intention of the proposed methodology revisions is to present the latest scientific advancements in the areas of risk and exposure assessment in order to incrementally improve the already sound toxicological and exposure bases for these criteria. As EPA's current human health criteria are the product of many years worth of development and peer review, it is reasonable to assume that revisiting all existing criteria, and incorporating peer review into such review, could require comparable amounts of time and resources. Given these circumstances, EPA proposed a process for revisiting these criteria as part of the overall revisions to the methodology for deriving human health criteria. This process is discussed in the Implementation Section of the Notice of *Draft Revisions to the Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health* (see 63 FR 43771–43776, August 14, 1998).

The State of California in its Ocean Plan, adopted in 1990 and approved by EPA in 1991, established numeric water quality criteria using an average fish and shellfish consumption rate of 23 grams per day. This value is based on an earlier California Department of Health Services estimate. The State is currently in the process of readopting its water quality control plans for inland surface waters, enclosed bays, and estuaries. The State intends to consider information on fish and shellfish consumption rates evaluated and summarized in a report prepared by the State's Pesticide and Environmental Toxicology Section of the Office of Environmental Health Hazard Assessment of the California Environmental Protection Agency. The report, entitled, *Chemicals in Fish Report No. 1: Consumption of Fish and Shellfish in California and the United States,* was published in final draft form in July of 1997, and released to the public on September 16, 1997. The report is currently undergoing final evaluation, and is expected to published in final form in the near future. This final draft report is contained in the administrative record for today's rule. Although EPA has not used this fish consumption value here because this information has not yet been finalized, the State may use any appropriate higher state-specific fish and shellfish consumption rates in its readoption of criteria in its statewide plans.

a. 2,3,7,8-TCDD (Dioxin) Criteria

In today's action, EPA is promulgating human health water quality criteria for 2,3,7,8-tetrachlorodibenzo-p-dioxin (''dioxin'') at the same levels as promulgated in the NTR, as amended. These criteria are derived from EPA's 1984 CWA section 304(a) criteria guidance document for dioxin.

For National Pollutant Discharge Elimination System (NPDES) purposes, EPA supports the regulation of other dioxin and dioxin-like compounds through the use of toxicity equivalencies or TEQs in NPDES permits (see discussion below). For California waters, if the discharge of dioxin or dioxin-like compounds has reasonable potential to cause or contribute to a violation of a narrative criterion, numeric water quality-based effluent limits for dioxin or dioxin-like compounds should be included in NPDES permits and should be expressed using a TEQ scheme.

EPA has been evaluating the health threat posed by dioxin nearly continuously for over two decades. Following issuance of the 1984 criteria guidance document, evaluating the health effects of dioxin and recommending human health criteria for dioxin, EPA prepared draft reassessments reviewing new scientific information relating to dioxin in 1985 and 1988. EPA's Science Advisory Board (SAB), reviewing the 1988 draft reassessment, concluded that while the risk assessment approach used in 1984 criteria guidance document had inadequacies, a better alternative was unavailable (see SAB's *Dioxin Panel Review of Documents from the Office or Research and Development relating to the Risk and Exposure Assessment of 2,3,7,8-TCDD* (EPA–SAB–EC–90–003, November 28, 1989) included in the administrative record for today's rule). Between 1988 and 1990, EPA issued numerous reports and guidances relating to the control of dioxin discharges from pulp and paper mills. See e.g., EPA Memorandum, ''Strategy for the Regulation of Discharges of PHDDs & PHDFs from Pulp and Paper Mills to the Waters of the United States,'' from Assistant Administrator for Water to Regional Water Management Division Directors and NPDES State Directors, dated May 21, 1990 (AR NL–16); EPA Memorandum, ''State Policies, Water Quality Standards, and Permit Limitations Related to 2,3,7,8-TCDD in Surface Water,'' from the Assistant Administrator for Water to Regional Water Management Division Directors, dated January 5, 1990 (AR VA–66). These documents are available in the administrative record for today's rule.

In 1991, EPA's Administrator announced another scientific reassessment of the risks of exposure to dioxin (see Memorandum from Administrator William K. Reilly to Erich W. Bretthauer, Assistant Administrator for Research and Development and E. Donald Elliott, General Counsel, entitled *Dioxin: Follow-Up to Briefing on Scientific Developments,* April 8, 1991, included in the administrative record for today's rule). At that time, the Administrator made clear that while the reassessment was underway, EPA would continue to regulate dioxin in accordance with existing Agency policy. Thereafter, the Agency proceeded to regulate dioxin in a number of environmental programs, including standards under the Safe Drinking Water Act and the CWA.

The Administrator's promulgation of the dioxin human health criteria in the 1992 NTR affirmed the Agency's decision that the ongoing reassessment should not defer or delay regulating this potent contaminant, and further, that the risk assessment in the 1984 criteria guidance document for dioxin continued to be scientifically defensible. Until the reassessment process was completed, the Agency could not ''say with any certainty what the degree or directions of any changes in the risk estimates might be'' (57 FR 60863–64).

The basis for the dioxin criteria as well as the decision to include the dioxin criteria in the 1992 NTR pending the results of the reassessment were challenged. See *American Forest and Paper Ass'n, Inc. et al.* v. *U.S. EPA* (Consolidated Case No. 93–0694 (RMU) D.D.C.). By order dated September 4, 1996, the Court upheld EPA's decision. EPA's brief and the Court's decision are included in the administrative record for today's rule.

EPA has undertaken significant effort toward completion of the dioxin reassessment. On September 13, 1994, EPA released for public review and comment a draft reassessment of toxicity and exposure to dioxin. See *Health Assessment Document for 2,3,7,8-Tetrachlorobenzo-p-Dioxin (TCDD) and Related Compounds,* U.S. EPA, 1994. EPA is currently addressing comments made by the public and the SAB and anticipates that the final revised reassessment will go to the SAB in the near future. With today's rule, the Agency reaffirms that, notwithstanding the on-going risk reassessment, EPA intends to continue to regulate dioxin to avoid further harm to public health, and the basis for the dioxin criteria, both in terms of the cancer potency and the exposure estimates, remains scientifically defensible. The fact that EPA is reassessing the risk of dioxin, virtually a continuous process to evaluate new scientific information, does not mean that the current risk assessment is ''wrong''. It continues to be EPA's position that until the risk assessment for dioxin is revised, EPA supports and will continue to use the existing risk assessment for the regulation of dioxin in the environment. Accordingly, EPA today promulgates dioxin criteria based on the 1984 criteria guidance document for dioxin and promulgated in the NTR in 1992.

Toxicity Equivalency: The State of California, in its 1991 water quality control plans, adopted human health criteria for dioxin and dioxin-like compounds based on the concept of toxicity equivalency (TEQ) using toxicity equivalency factors (TEFs). EPA Region 9 reviewed and approved the State's use of the TEQ concept and TEFs in setting the State's human health water quality criteria for dioxin and dioxin-like compounds.

In 1987, EPA formally embraced the TEQ concept as an interim procedure to estimate the risks associated with exposures to 210 chlorinated dibenzo-p-dioxin and chlorinated dibenzofuran (CDD/CDF) congeners, including 2,3,7,8-TCDD. This procedure uses a set of derived TEFs to convert the concentration of any CDD/CDF congener into an equivalent concentration of 2,3,7,8-TCDD. In 1989, EPA updated its TEFs based on an examination of relevant scientific evidence and a recognition of the value of international consistency. This updated information can be found in EPA's 1989 *Update to the Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-dioxins and -dibenzofurans (CDDs and CDFs)* (EPA/625/3–89/016, March 1989). EPA had been active in an international effort aimed at adopting a common set of TEFs (International TEFs/89 or I–TEFs/89), to facilitate information exchange on environmental contamination of CDD/CDF. This document reflects EPA's support of an internationally consistent set of TEFs, the I–TEFs/89. EPA uses I–TEFs/89 in many of its regulatory programs.

In 1994, the World Health Organization (WHO) revised the TEF scheme for dioxins and furans to include toxicity from dioxin-like compounds (Ahlborg et al., 1994). However, no changes were made to the TEFs for dioxins and furans. In 1998, the WHO re-evaluated and revised the previously established TEFs for dioxins (Ds), furans (Fs) and dioxin-like compounds (Vanden Bers, 1998). The nomenclature for this TEF scheme is TEQDFP–WHO98, where TEQ represents the 2,3,7,8-TCDD Toxic Equivalence of the mixture, and the subscript DFP indicates that dioxins (Ds) furans (Fs) and dioxin-like compounds (P) are included in the TEF scheme. The subscript 98 following WHO displays the year changes were made to the TEF scheme.

EPA intends to use the 1998 WHO TEF scheme in the near future. At this point however, EPA will support the use of either the 1989 interim procedures or the 1998 WHO TEF scheme but encourages the use of the 1998 WHO TEF scheme in State programs. EPA expects California to use a TEF scheme in implementing the 2,3,7,8-TCDD water quality criteria contained in today's rule. The TEQ and TEF approach provide a methodology for setting NPDES water quality-based permit limits that are protective of human health for dioxin and dioxin-like compounds.

Several commenters requested EPA to promulgate criteria for other forms of dioxin, in addition to 2,3,7,8-TCDD. EPA's draft reassessment for dioxin examines toxicity based on the TEQ concept and I–TEFs/89. When EPA completes the dioxin reassessment, the Agency intends to adopt revised 304(a) water quality criteria guidance based on the reassessment for dioxin. If necessary, EPA will then act to amend the NTR and CTR to reflect the revised 304(a) water quality criteria guidance.

b. Arsenic Criteria

EPA is not promulgating human health criteria for arsenic in today's rule. EPA recognizes that it promulgated human health water quality criteria for arsenic for a number of States in 1992, in the NTR, based on EPA's 1980 section 304(a) criteria guidance for arsenic established, in part, from IRIS values current at that time. However, a number of issues and uncertainties existed at the time of the CTR proposal concerning the health effects of arsenic. These issues and uncertainties were summarized in ''Issues Related to Health Risk of Arsenic'' which is contained in the administrative record for today's rule. During the period of this rulemaking action, EPA commissioned a study of arsenic health effects by the National Research Council (NRC) arm of the National Academy of Sciences. EPA received the NRC report in March of 1999. EPA scientists reviewed the report, which recommended that EPA lower the Safe Drinking Water Act arsenic maximum contaminant level (MCL) as soon as possible (The arsenic MCL is currently 50 μg/l.) The bladder cancer analysis in the NRC report will provide part of the basis for the risk assessment of a proposed revised arsenic MCL in the near future. After promulgating a revised MCL for drinking water, the Agency plans to revise the CWA 304(a) human health criteria for arsenic in order to harmonize the two standards. Today's rule defers promulgating arsenic criteria based on the Agency's previous risk assessment of skin cancer. In the meantime, permitting authorities in California should rely on existing narrative water quality criteria to establish effluent limitations as necessary for arsenic. California has previously expressed its science and policy position by establishing a criterion level of 5 μg/l for arsenic. Permitting authorities may, among other considerations, consider that value when evaluating and interpreting narrative water quality criteria.

c. Mercury Criteria

The human health criteria promulgated here use the latest RfD in EPA's Integrated Risk Information System (IRIS) and the weighted average practical bioconcentration factor (PBCF) from the 1980 section 304(a) criteria guidance document for mercury. EPA considered the approach used in the Great Lakes Water Quality Guidance (''Guidance'') incorporating Bioaccumulation Factors (BAFs), but rejected this approach for reasons outlined below. The equation used here to derive an ambient water quality criterion for mercury from exposure to organisms and water is:

$$\mathrm{HHC} = \frac{\mathrm{RfD} \times \mathrm{BW}}{\mathrm{WC} + (\mathrm{FC} \times \mathrm{PBCF})}$$

Where:

RfD = Reference Dose
BW = Body Weight
WC = Water Consumption
FC = Total Fish and Shellfish Consumption per Day
PBCF = Practical Bioconcentration Factor (weighted average)

For mercury, the most current RfD from IRIS is 1 x 10^{-4} mg/kg/day. The RfD used a benchmark dose as an estimate of a No Observed Adverse Effect Level (NOAEL). The benchmark dose was calculated by applying a Weibel model for extra risk to all neurological effects observed in 81 Iraqi children exposed in utero as reported in Marsh, et. al. (1987). Maternal hair mercury was the measure of exposure. Extra risk refers to an adjustment for background incidence of a given health effect. Specifically, the extra risk is the added incidence of observing an effect above the background rate relative to the proportion of the population of interest that is not expected to exhibit such as effect. The resulting estimate was the lower 95% statistical bound on the 10% extra risk; this was 11 ppm mercury in maternal hair. This dose in hair was converted to an equivalent ingested amount by applying a model based on data from human studies; the resulting benchmark dose was 1 x 10^{-3} mg/kg body weight /day. The RfD was calculated by dividing the benchmark dose by a composite uncertainty factor of 10. The uncertainty factor was used to account for variability in the human population, in particular the wide variation in biological half-life of methylmercury and the variation that is observed in the ration of hair mercury to mercury in the blood. In addition the uncertainty factor accounts for lack of a two-generation reproductive study and the lack of data on long term effects of childhood mercury exposures. The RfD thus calculated is 1 x 10^{-4} mg/kg body weight/day or 0.1 µg/kg/day. The body weight used in the equation for the mercury criteria, as discussed in the Human Health Guidelines, is a mean adult human body weight of 70 kg. The drinking water consumption rate, as discussed in the Human Health Guidelines, is 2.0 liters per day.

The bioconcentration factor or BCF is defined as the ratio of chemical concentration in the organism to that in surrounding water. Bioconcentration occurs through uptake and retention of a substance from water only, through gill membranes or other external body surfaces. In the context of setting exposure criteria it is generally understood that the terms ''BCF'' and ''steady-state BCF'' are synonymous. A steady-state condition occurs when the organism is exposed for a sufficient length of time that the ratio does not change substantially.

The BCFs that were used herein are the ''Practical Bioconcentration Factors (PBCFs)'' that were derived in 1980: 5500 for fresh water, 3765 for estuarine coastal waters, and 9000 for open oceans. See pages C–100–1 of Ambient Water Quality Criteria for Mercury (EPA 440/5–80–058) for a complete discussion on the PBCF. Because of the way they were derived, these PBCFs take into account uptake from food as well as uptake from water. A weighted average PBCF was calculated to take into account the average consumption from the three waters using the following equation:

$$\text{Weighted Average Practical BCF} = \frac{\sum(\text{FC} \times \text{PBCF})}{\sum(\text{FC})} = \frac{(0.00172)(5500) + (0.00478)(3765) + (0.0122)(9000)}{0.00172 + 0.00478 + 0.0122} = \frac{137.3}{0.0187} = 7342.6$$

Given the large value for the weighted average PBCF, the contribution of drinking water to total daily intake is negligible so that assumptions concerning the chemical form of mercury in drinking water become less important. The human health mercury criteria promulgated for this rule are based on the latest RfD as listed in IRIS and a weighted PBCF from the 1980 § 304(a) criteria guidance document for mercury.

On March 23, 1995 (60 FR 15366), EPA promulgated the Great Lakes Water Quality Guidance (''Guidance''). The Guidance incorporated bioaccumulation factors (BAFs) in the derivation of criteria to protect human health because it is believed that BAFs are a better predictor than BCFs of the concentration of a chemical within fish tissue since BAFs include consideration of the uptake of contaminants from all routes of exposure. A bioaccumulation factor is defined as the ratio (in L/kg) of a substance's concentration in tissue to the concentration in the ambient water, in situations where both the organism and its food are exposed and the ratio does not change substantially over time. The final Great Lakes Guidance establishes a hierarchy of four methods for deriving BAFs for non-polar organic chemicals: (1) Field-measured BAFs; (2) predicted BAFs derived using a field-measured biota-sediment accumulation factor; (3) predicted BAFs derived by multiplying a laboratory-measured BCF by a food chain multiplier; and (4) predicted BAFs derived by multiplying a BCF calculated from the log Kow by a food-chain multiplier. The final Great Lakes Guidance developed BAFs for trophic levels three and four fish of the Great Lakes Basin. Respectively, the BAFs for mercury for trophic level 3 and 4 fish were: 27,900 and 140,000.

The BAF promulgated in the GLI was developed specifically for the Great Lakes System. It is uncertain whether the BAFs of 27,900 and 140,000 are appropriate for use in California at this time; therefore, today's final rule does not use the GLI BAF in establishing human health criteria for mercury in California. The magnitude of the BAF for mercury in a given system depends on how much of the total mercury is present in the methylated form. Methylation rates vary widely from one water body to another for reasons that are not fully understood. Lacking the data, it is difficult to determine if the BAF used in the GLI represents the true potential for mercury to bioaccumulate in California surface waters. The true, average BAF for California could be higher or lower. For more information see EPA's Response to Comments document in the administrative record for this rule (specifically comments CTR–002–007(b) and CTR–016–007).

EPA is developing a national BAF for mercury as part of revisions to its 304(a) criteria for human health; however, the BAF methodology that will be used is currently under evaluation as part of EPA's revisions to its National Human Health Methodology (see section F.3 above). EPA applied a similar methodology in its Mercury Study Report to Congress (MSRC) to derive a BAF for methylmercury. The MSRC is available through NTIS (EPA–452/R–97–003). Although a BAF was derived in the MSRC, EPA does not intend to use this BAF for National application. EPA is engaged in a separate effort to incorporate additional mercury bioaccumulation data that was not considered in the MSRC, and to assess uncertainties with using a National BAF approach for mercury. Once the proposed revised human health methodology, including the BAF component, is finalized, EPA will revise its 304(a) criteria for mercury to reflect changes in the underlying methodology, recommendations contained in the MSRC, and recommendations in a National Academy of Science report on human health assessment of methylmercury. When EPA changes its 304(a) criteria recommendation for mercury, States and Tribes will be expected to review their water quality standards for mercury and make any revisions necessary to ensure their standards are scientifically defensible.

New information may become available regarding the bioaccumulation of mercury in certain water bodies in California. EPA supports the use of this information to develop site-specific criteria for mercury. Further, if a California water body is impaired due to mercury fish tissue or sediment contamination, loadings of mercury could contribute to or exacerbate the impairment. Therefore, one option regulatory authorities should consider is to include water quality-based effluent limits (WQBELs) in permits based on mass for discharges to the impaired water body. Such WQBELs must be derived from and comply with applicable State water quality standards (including both numeric and narrative criteria) and assure that the discharge does not cause or contribute to a violation of water quality standards.

d. Polychlorinated Biphenyls (PCBs) Criteria

The NTR, as amended, calculated human health criteria for PCBs using a cancer potency factor of 7.7 per mg/kg-day from the Agency's IRIS. This cancer potency factor was derived from the Norback and Weltman (1985) study which looked at rats that were fed Aroclor 1260. The study used the linearized multistage model with a default cross-species scaling factor (body weight ratio to the ⅔ power). Although it is known that PCB mixtures vary greatly as to their potency in producing biological effects, for purposes of its carcinogenicity assessment, EPA considered Aroclor 1260 to be representative of all PCB mixtures. The Agency did not pool data from all available congener studies or generate a geometric mean from these studies, since the Norback and Weltman study was judged by EPA as acceptable, and not of marginal quality, in design or conduct as compared with other studies. Thereafter, the Institute for Evaluating Health Risks (IEHR, 1991) reviewed the pathological slides from the Norback and Weltman study, and concluded that some of the malignant liver tumors should have been interpreted as nonmalignant lesions, and that the cancer potency factor should be 5.1 per mg/kg-day as compared with EPA's 7.7 per mg/kg-day.

The Agency's peer-reviewed reassessment of the cancer potency of PCBs published in a final report, *PCBs: Cancer Dose-Response Assessment and Applications to Environmental Mixtures* (EPA/600/P–96/001F), adopts a different approach that distinguishes among PCB mixtures by using information on environmental processes. (The report is included in the administrative record of today's rule.) The report considers all cancer studies (which used commercial mixtures only) to develop a range of cancer potency factors, then uses information on environmental processes to provide guidance on choosing an appropriate potency factor for representative classes of environmental mixtures and different pathways. The reassessment provides that, depending on the specific application, either central estimates or upper bounds can be appropriate. Central estimates describe a typical individual's risk, while upper bounds provide assurance (*i.e.,* 95% confidence) that this risk is not likely to be underestimated if the underlying model is correct. Central estimates are used for comparing or ranking environmental hazards, while upper bounds provide information about the precision of the comparison or ranking. In the reassessment, the use of the upper bound values were found to increase cancer potency estimates by two or three-fold over those using central tendency. Upper bounds are useful for estimating risks or setting exposure-related standards to protect public health, and are used by EPA in quantitative cancer risk assessment. Thus, the cancer potency of PCB mixtures is determined using a tiered approach based on environmental exposure routes with upper-bound potency factors (using a body weight ratio to the ¾ power) ranging from 0.07 (lowest risk and persistence) to 2 (high risk and persistence) per mg/kg-day for average lifetime exposures to PCBs. It is noteworthy that bioaccumulated PCBs appear to be more toxic than commercial PCBs and appear to be more persistent in the body. For exposure through the food chain, risks can be higher than other exposures.

EPA issued the final reassessment report on September 27, 1996, and updated IRIS to include the reassessment on October 1, 1996. EPA updated the human health criteria for PCBs in the National Toxics Rule on September 27, 1999. For today's rule, EPA derived the human health criteria for PCBs using a cancer potency factor of 2 per mg/kg-day, an upper bound potency factor reflecting high risk and persistence. This decision is based on recent multimedia studies indicating that the major pathway of exposure to persistent toxic substances such as PCBs is via dietary exposure (*i.e.,* contaminated fish and shellfish consumption).

Following is the calculation of the human health criterion (HHC) for organism and water consumption:

$$HHC = \frac{RF \times BW \times (1{,}000\ \mu g/mg)}{q1^* \times [WC + (FC \times BCF)]}$$

Where:

RF = Risk Factor = 1 x 10^{-6}
BW = Body Weight = 70 kg
q1* = Cancer slope factor = 2 per mg/kg-day
WC = Water Consumption = 2 l/day
FC = Fish and Shellfish Consumption = 0.0065 kg/day
BCF = Bioconcentration Factor = 31,200

the HHC (µg/l) = 0.00017 µg/l (rounded to two significant digits).

Following is the calculation of the human health criterion for organism only consumption:

$$HHC = \frac{RF \times BW \times (1{,}000\ \mu g/mg)}{q1^* \times FC \times BCF}$$

Where:

RF = Risk Factor = 1 x 10^{-6}
BW = Body Weight = 70 kg
q1* = Cancer slope factor = 2 per mg/kg-day
FC = Total Fish and Shellfish Consumption per Day = 0.0065 kg/day
BCF = Bioconcentration Factor = 31,200

the HHC (µg/l) = 0.00017 µg/l (rounded to two significant digits).

The criteria are both equal to 0.00017 µg/l and apply to total PCBs. *See PCBs: Cancer Dose Response Assessment and Application to Environmental Mixtures* (EPA/600/9–96–001F). For a discussion of the body weight, water consumption, and fish and shellfish consumption factors, see the Human Health Guidelines. For a discussion of the BCF, see the 304(a) criteria guidance document for PCBs (included in the administrative record for today's rule).

e. Excluded Section 304(a) Human Health Criteria

As is the case in the NTR, as amended, today's rule does not promulgate criteria for certain priority pollutants for which CWA section 304(a) criteria guidance exists because those criteria were not based on toxicity to humans or aquatic organisms. The basis for those particular criteria is organoleptic effects (*e.g.,* taste and odor) which would make water and edible aquatic life unpalatable but not toxic. Because the basis for this rule is to protect the public health and aquatic life from toxicity consistent with the language and intent in CWA section 303(c)(2)(B), EPA is promulgating criteria only for those priority toxic pollutants whose criteria recommendations are based on toxicity. The CWA section 304(a) human health criteria based on organoleptic effects for zinc and 3-methyl-4-chlorophenol are excluded for this reason. See the 1992 NTR discussion at 57 FR 60864.

f. Cancer Risk Level

EPA's CWA section 304(a) criteria guidance documents for priority toxic pollutants that are based on carcinogenicity present concentrations for upper bound risk levels of 1 excess cancer case per 100,000 people (10^{-5}), per 1,000,000 people (10^{-6}), and per 10,000,000 people (10^{-7}). However, the criteria documents do not recommend a particular risk level as EPA policy.

As part of the proposed rule, EPA requested and received comment on the adoption of a 10^{-5} risk level for carcinogenic pollutants. The effect of a 10^{-5} risk level would have been to increase (*i.e.,* make less stringent) carcinogenic pollutant criteria values (noted in the matrix by footnote c) that are not already promulgated in the NTR, by one order of magnitude. For example, the organism-only criterion for gamma BHC (pollutant number 105 in the matrix) is 0.013 µg/l; the criterion based on a 10^{-5} risk level would have been 0.13 µg/l. EPA received several comments that indicated a preference for a higher (10^{-4} and 10^{-5}) risk level for effluent dependent waters or other types of special circumstances.

In today's rule, EPA is promulgating criteria that protect the general population at an incremental cancer risk level of one in a million (10^{-6}) for all priority toxic pollutants regulated as carcinogens, consistent with the criteria promulgated in the NTR for the State of California. Standards adopted by the State contained in the Enclosed Bays and Estuaries Plan (EBEP), and the Inland Surface Waters Plan (ISWP), partially approved by EPA on November 6, 1991, and the Ocean Plan approved by EPA on June 28, 1990, contained a risk level of 10^{-6} for most carcinogens. The State has historically protected at a 10^{-6} risk level for carcinogenic pollutants.

EPA, in its recent human health methodology revisions, proposed acceptable lifetime cancer risk for the general population in the range of 10^{-5} to 10^{-6}. EPA also proposed that States and Tribes ensure the most highly exposed populations do not exceed a 10^{-4} risk level. However, EPA's draft methodology revisions also stated that it will derive 304(a) criteria at a 10^{-6} risk level, which the Agency believes reflects the appropriate risk for the general population and which applies a risk management policy which ensures protection for all exposed population groups. (Draft Water Quality Criteria Methodology: Human Health, EPA 822–Z–98–001, August 1998, Appendix II, page 72).

Subpopulations within a State may exist, such as recreational and subsistence anglers, who as a result of greater exposure to a contaminant are at greater risk than the standard 70 kilogram person eating 6.5 grams per day of fish and shellfish and drinking 2.0 liters per day of drinking water with pollutant levels meeting the water quality criteria. EPA acknowledges that at any given risk level for the general population, those segments of the population that are more highly exposed face a higher relative risk. For example, if fish are contaminated at a level permitted by criteria derived on the basis of a risk level of 10^{-6}, individuals consuming up to 10 times the assumed fish consumption rate would still be protected at a 10^{-5} risk level. Similarly, individuals consuming 100 times the general population rate would be protected at a 10^{-4} risk level. EPA, therefore, believes that derivation of criteria at the 10^{-6} risk level is a reasonable risk management decision protective of designated uses under the CWA. While outside the scope of this rule, EPA notes that States and Tribes, however, have the discretion to adopt water quality criteria that result in a higher risk level (*e.g.,* 10^{-5}). EPA expects to approve such criteria if the State or Tribe has identified the most highly exposed subpopulation within the State or Tribe, demonstrates the chosen risk level is adequately protective of the most highly exposed subpopulation, and has completed all necessary public participation.

This demonstration has not happened in California. Further, the information that is available on highly exposed subpopulations in California supports the need to protect the general population at the 10^{-6} level. California has cited the Santa Monica Bay Seafood Consumption Study as providing the best available data set for estimating consumption of sport fish and shellfish in California for both marine or freshwater sources (Chemicals in Fish Report No. 1: Consumption of Fish and Shellfish in California and the United States, Final Draft Report, July 1997). Consumption rates of sport fish and shellfish of 21g/day, 50 g/day, 107 g/day, and 161 g/day for the median, mean, 90th, and 95th percentile rates, respectively, were determined from this study. Additional consumption of commercial species in the range of approximately 8 to 42 g/day would further increase these values. Clearly the consumption rates for the most highly exposed subpopulation within the State exceeds 10 times the 6.5 g/day rates used in the CTR. Therefore, use of a risk level of 10^{-5} for the general population would not be sufficient to protect the most highly exposed population in California at a 10^{-4} risk level. On the other hand, even the most highly exposed subpopulations cited in the California study do not have consumption rates approaching 100 times the 6.5 g/day rates used in the CTR. The use of the 10^{-6} risk level to protect average level consumers does not subject these subpopulations to risk levels as high as 10^{-4}.

EPA believes its decision to establish a 10^{-6} risk level for the CTR is also consistent with EPA's policy in the NTR to select the risk level that reflect the policies or preferences of CWA programs in the affected States. California adopted standards for priority toxic pollutants for its ocean waters in 1990 using a 10^{-6} risk level to protect human health (California Ocean Plan, 1990). In April 1991, and again in November 1992, California adopted standards for its inland surface waters and enclosed bays and estuaries in its Inland Surface Waters Plan (ISWP) and its Enclosed Bays and Estuaries Plan (EBEP) using a 10^{-6} risk level. To be consistent with the State's water quality standards, EPA used a 10^{-6} risk level for California in the NTR at 57 FR 60867. The State has continued using a 10^{-6} risk level to protect human health for its standards that were not withdrawn with the ISWP and EBEP. The most recent expression of risk level preference is contained in the Draft Functional Equivalent Document, Amendment of the Water Quality Control Plan for Ocean Waters of California, October 1998, where the State recommended maintaining a consistent risk level of 10^{-6} for the human health standards that it was proposing to revise.

EPA received several comments requesting a 10^{-5} risk level based on the risk level chosen for the Great Lakes Water Quality Guidance (the Guidance). There are several differences between the guidelines for the derivation of human health criteria contained in the Guidance and the California Toxics Rule (CTR) that make a 10^{-5} risk factor appropriate for the Guidance, but not for the CTR. These differences result in criteria developed using the 10^{-5} risk factor in the Guidance being at least as stringent as criteria derived under the CTR using a 10^{-6} risk factor. The relevant aspects of the Guidance include:

- Use of fish consumption rates that are considerably higher than fish consumption rates for the CTR.
- Use of bioaccumulation factors rather than bioconcentration factors in

estimating exposure, considerably increasing the dose of carcinogens to sensitive subgroups.

- Consideration of additivity of effects of mixtures for both carcinogenic and noncarcinogenic pollutants.

This combination of factors increase the calculated carcinogenic risk substantially under the Guidance (the combination would generally be more than one order of magnitude), making a lower overall risk factor acceptable. The Guidance risk factor provides, in fact, criteria with at least the same level of protection against carcinogens as criteria derived with a higher risk factor using the CTR. A lower risk factor for the CTR would not be appropriate absent concomitant changes in the derivation procedures that provide equivalent risk protection.

G. Description of Final Rule

1. Scope

Paragraph (a) in 40 CFR 131.38, entitled ''Scope,'' states that this rule is a promulgation of criteria for priority toxic pollutants in the State of California for inland surface waters, enclosed bays, and estuaries. Paragraph (a) in 40 CFR 131.38 also states that this rule contains an authorizing compliance schedule provision.

2. EPA Criteria for Priority Toxic Pollutants

EPA's criteria for California are presented in tabular form at 40 CFR 131.38. For ease of presentation, the table that appears combines water quality criteria promulgated in the NTR, as amended, that are outside the scope of this rulemaking, with the criteria that are within the scope of today's rule. This is intended to help readers determine applicable water quality criteria for the State of California. The table contains footnotes for clarification.

Paragraph (b) in 40 CFR 131.38 presents a matrix of the applicable EPA aquatic life and/or human health criteria for priority toxic pollutants in California. Section 303(c)(2)(B) of the CWA addresses only pollutants listed as ''toxic'' pursuant to section 307(a) of the CWA for which EPA has developed section 304(a) criteria guidance. As discussed earlier in this preamble, the section 307(a) list of toxics contains 65 compounds and families of compounds, which potentially include thousands of specific compounds. Of these, the Agency identified a list of 126 ''priority toxic pollutants'' to implement the CWA (see 40 CFR 131.36(b)). Reference in this rule to priority toxic pollutants, toxic pollutants, or toxics refers to the 126 priority toxic pollutants.

EPA has not developed both aquatic life and human health CWA section 304(a) criterion guidance for all of the priority toxic pollutants. The matrix in 40 CFR 131.38(b) contains human health criteria in Column D for 92 priority toxic pollutants which are divided into Column 1: criteria for water consumption (i.e., 2.0 liters per day) and aquatic organism consumption (i.e., 6.5 grams per day of aquatic organisms); and Column 2: criteria for aquatic organism consumption only. The term aquatic organism includes fish and shellfish such as shrimp, clams, oysters and mussels. One reason the total number of priority toxic pollutants with criteria today differs from the total number of priority toxic pollutants contained in earlier published CWA section 304(a) criteria guidance is because EPA has developed and is promulgating chromium criteria for two valence states with respect to aquatic life criteria. Thus, although chromium is a single priority toxic pollutant, there are two criteria for chromium for aquatic life protection. See pollutant 5 in today's rule at 40 CFR 131.38(b). Another reason is that EPA is promulgating human health criteria for nine priority pollutants for which health-based national criteria have been calculated based on information obtained from EPA's IRIS database (EPA provided notice of these nine criteria in the NTR for inclusion in future State triennial reviews. See 57 FR 60848, 60890).

The matrix contains aquatic life criteria for 23 priority pollutants. These are divided into freshwater criteria (Column B) and saltwater criteria (Column C). These columns are further divided into acute and chronic criteria. The aquatic life criteria are considered by EPA to be protective when applied under the conditions described in the section 304(a) criteria documents and in the TSD. For example, water body uses should be protected if the criteria are not exceeded, on average, once every three year period. It should be noted that the criteria maximum concentrations (the acute criteria) are short-term concentrations and that the criteria continuous concentrations (the chronic criteria) are four-day averages. It should also be noted that for certain metals, the actual criteria are equations which are included as footnotes to the matrix. The toxicity of these metals is water hardness dependent and may be adjusted. The values shown in the table are illustrative only, based on a hardness expressed as calcium carbonate of 100 mg/l. Finally, the criterion for pentachlorophenol is pH dependent. The equation is the actual criterion and is included as a footnote. The value shown in the matrix is for a pH of 7.8. Several of the freshwater aquatic life criteria are incorporated into the matrix in the format used in the 1980 criteria methodology which uses a final acute value instead of a continuous maximum concentration. This distinction is noted in footnote g of the table.

The final rule at 40 CFR 131.38(c) establishes the applicability of the criteria to the State of California. 40 CFR 131.38(d) is described later in Section F, of this preamble. EPA has included in this rule provisions necessary to implement numeric criteria in a way that maintains the level of protection intended. These provisions are included in 40 CFR 131.38(c) of today's rule. For example, in order to do steady state waste load allocation analyses, most States have low flow values for streams and rivers which establish flow rates for various purposes. These low flow values become design flows for sizing treatment plants and developing water quality-based effluent limits and/or TMDLs. Historically, these design flows were selected for the purposes of waste load allocation analyses which focused on instream dissolved oxygen concentrations and protection of aquatic life. With the publication of the 1985 TSD, EPA introduced hydrologically and biologically based analyses for the protection of aquatic life and human health. (These concepts have been expanded subsequently in EPA's *Technical Guidance Manual for Performing Wasteload Allocations, Book 6, Design Conditions,* U.S. EPA, 1986. These analyses are included in Appendix D of the revised TSD. The discussion here is greatly simplified and is provided to support EPA's decision to promulgate design flows for instream flows and thereby maintain the adequacy of the criteria for priority toxic pollutants.) EPA recommended either of two methods for calculating acceptable low flows, the traditional hydrologic method developed by the U.S. Geological Survey or a biological based method developed by EPA. Other methods for evaluating the instream flow record may be available; use of these methods may result in TMDLs and/or water quality-based effluent limitations which adequately protect human health and/or aquatic life. The results of either of these two methods, or an equally protective alternative method, may be used.

The State of California may adopt specific design flows for streams and rivers to protect designated uses against the effects of toxics. EPA believes it is important to specify design flows in today's rule so that, in the absence of state design flows, the criteria promulgated today would be implemented appropriately. The TSD also recommends the use of three dynamic models to perform wasteload allocations. Dynamic wasteload models do not generally use specific steady state design flows but accomplish the same effect by factoring in the probability of occurrence of stream flows based on the historical flow record.

The low flows specified in the rule explicitly contain duration and frequency of occurrence which represent certain probabilities of occurrence. Likewise, the criteria for priority toxic pollutants are defined with duration and frequency components. Dynamic modeling techniques explicitly predict the effects of variability in receiving water, effluent flow, and pollution variation. Dynamic modeling techniques, as described in the TSD, allow for calculating wasteload allocations that meet the criteria for priority toxic pollutants without using a single, worst-case concentration based on a critical condition. Either dynamic modeling or steady state modeling can be used to implement the criteria promulgated today. For simplicity, only steady state conditions are discussed here. Clearly, if the criteria were implemented using design flows that are too high, the resulting toxic controls would not be adequate, because the resulting ambient concentrations would exceed EPA's criteria.

In the case of aquatic life, assuming exceedences occur more frequently than once in three years on the average, exceedences would result in diminished vitality of stream ecosystems characterized by the loss of desired species. Numeric water quality criteria should apply at all flows that are equal to or greater than flows specified below. The low flow values are:

Type of criteria	Design flow
Acute Aquatic Life (CMC).	1 Q 10 or 1 B 3
Chronic Aquatic Life (CCC).	7 Q 10 or 4 B 3
Human Health	harmonic mean flow

Where:

1 Q 10 is the lowest one day flow with an average recurrence frequency of once in 10 years determined hydrologically;

1 B 3 is biologically based and indicates an allowable exceedence of once every 3 years. It is determined by EPA's computerized method (DFLOW model);

7 Q 10 is the lowest average 7 consecutive day low flow with an average recurrence frequency of once in 10 years determined hydrologically;

4 B 3 is biologically based and indicates an allowable exceedences for 4 consecutive days once every 3 years. It is determined by EPA's computerized method (DFLOW model);

EPA is requiring that the harmonic mean flow be applied with human health criteria. The harmonic mean is a standard calculated statistical value. EPA's model for human health effects assumes that such effects occur because of a long-term exposure to low concentration of a toxic pollutant, for example, two liters of water per day for seventy years. To estimate the concentrations of the toxic pollutant in those two liters per day by withdrawal from streams with a high daily variation in flow, EPA believes the harmonic mean flow is the correct statistic to use in computing such design flows rather than other averaging techniques. (For a description of harmonic means see ''Design Stream Flows Based on Harmonic Means,'' Lewis A. Rossman, Jr. of Hydraulics Engineering, Vol. 116, No. 7, July, 1990.)

All waters (including lakes, estuaries, and marine waters), whether or not suitable for such hydrologic calculations, are subject to the criteria promulgated today. Such criteria will need to be attained at the end of the discharge pipe, unless the State authorizes a mixing zone. Where the State plans to authorize a mixing zone, the criteria would apply at the locations allowed by the mixing zone. For example, the chronic criteria (CCC) would apply at the defined boundary of the chronic mixing zone. Discussion of and guidance on these factors are included in the revised TSD in Chapter 4.

EPA is aware that the criteria promulgated today for some of the priority toxic pollutants are at concentrations less than EPA's current analytical detection limits. Analytical detection limits have never been an acceptable basis for setting water quality criteria since they are not related to actual environmental impacts. The environmental impact of a pollutant is based on a scientific determination, not a measuring technique which is subject to change. Setting the criteria at levels that reflect adequate protection tends to be a forcing mechanism to improve analytical detection methods. See 1985 Guidelines, page 21. As the methods improve, limits based on the actual criteria necessary to protect aquatic life and human health become measurable. The Agency does not believe it is appropriate to promulgate criteria that are not sufficiently protective. EPA discusses this issue further in its Response to Comment Document for today's final rule.

EPA does believe, however, that the use of analytical detection limits are appropriate for assessing *compliance* with National Pollutant Discharge Elimination System (NPDES) permit limits. This view of the role of detection limits was first articulated in guidance for translating dioxin criteria into NPDES permit limits. See ''Strategy for the Regulation of Discharges of PHDDs and PHDFs from Pulp and Paper Mills to Waters of the U.S.'' Memorandum from the Assistant Administrator for Water to the Regional Water Management Division Directors, May 21, 1990. This guidance presented a model for addressing toxic pollutants which have criteria less than current detection limits. EPA, in more recent guidance, recommends the use of the ''minimum level'' or ML for reporting sample results to assess compliance with WQBELs (TSD page 111). The ML, also called the ''quantification level,'' is the level at which the entire analytical system gives recognizable mass spectra and acceptable calibration points, i.e., the point at which the method can reliably quantify the amount of pollutant in the sample. States can use their own procedures to average and otherwise account for monitoring data, *e.g.,* quantifying results below the ML. These results can then be used to assess compliance with WQBELs. (See 40 CFR part 132, Appendix F, Procedure 8.B.) This approach is applicable to priority toxic pollutants with criteria less than current detection limits. EPA's guidance explains that standard analytical methods may be used for purposes of assessing compliance with permit limits, but not for purposes of establishing water quality criteria or permit limits. Under the CWA, analytical methods are appropriately used in connection with NPDES permit limit compliance assessments. Because of the function of water quality criteria, EPA has not considered the sensitivity of analytical methods in deriving the criteria promulgated today.

EPA has promulgated 40 CFR 131.38(c)(3) to determine when freshwater or saltwater aquatic life criteria apply. This provision incorporates a time parameter to better define the critical condition. The structure of the paragraph is to establish applicable rules and to allow for site-specific exceptions where the rules are not consistent with actual field conditions. Because a distinct separation generally does not exist between freshwater and saltwater aquatic communities, EPA is establishing the following: (1) The freshwater criteria apply at salinities of 1 part per thousand and below at locations where this occurs 95% or more of the time; (2) saltwater criteria apply at salinities of 10 parts per thousand and above at locations where this occurs 95% more of the time; and (3) at salinities between 1 and 10 parts per thousand the more stringent of the two apply unless EPA approves the application of the freshwater or saltwater criteria based on an appropriate biological assessment. The percentiles included here were selected to minimize the chance of overlap, that is, one site meeting both criteria. Determination of these percentiles can be done by any reasonable means such as interpolation between points with measured data or by the application of calibrated and verified mathematical models (or hydraulic models). It is not EPA's intent to require actual data collection at particular locations.

In the brackish water transition zones of estuaries with varying salinities, there generally will be a mix of freshwater and saltwater species. Generally, therefore, it is reasonable for the more stringent of the freshwater or saltwater criteria to apply. In evaluating appropriate data supporting the alternative set of criteria, EPA will focus on the species composition as its preferred method. This assignment of criteria for fresh, brackish and salt waters was developed in consultation with EPA's research laboratories at Duluth, Minnesota and Narragansett, Rhode Island. The Agency believes such an approach is consistent with field experience.

Paragraph (d) in 40 CFR 131.38 lists the designated water and use classifications for which the criteria apply. The criteria are applied to the beneficial use designations adopted by the State of California; EPA has not promulgated any new use classifications in this rule.

Exceedences Frequency: In a water quality criterion for aquatic life, EPA recommends an allowable frequency for excursions of the criteria. See 1985 Guidelines, pages 11–13. This allowable frequency provides an appropriate period of time during which the aquatic community can recover from the effect of an excursion and then function normally for a period of time before the next excursion. An excursion is defined as an occurrence of when the average concentration over the duration of the averaging period is above the CCC or the CMC. As ecological communities are naturally subjected to a series of stresses, the allowable frequency of pollutant stress may be set at a value that does not significantly increase the frequency or severity of all stresses combined. See also TSD, Appendix D. In addition, providing an allowable frequency for exceeding the criterion recognizes that it is not generally possible to assure that criteria are never exceeded. (TSD, page 36.)

Based on the available data, today's rule requires that the acute criterion for a pollutant be exceeded no more than once in three years on the average. EPA is also requiring that the chronic criterion for a pollutant be exceeded no more than once in three years on the average. EPA acknowledges that States may develop allowable frequencies that differ from these allowable frequencies, so long as they are scientifically supportable, but believes that these allowable frequencies are protective of the designated uses where EPA is promulgating criteria.

The use of aquatic life criteria for developing water quality-based effluent limits in permits requires the permitting official to use an appropriate wasteload allocation model. (TSD, Appendix D–6.) As discussed above, there are generally two methods for determining design flows, the hydrologically-based method and the biologically-based method.

The biologically-based method directly uses the averaging periods and frequencies specified in the aquatic life criteria for determining design flows. (TSD, Appendix. D–8.) Because the biologically-based method calculates the design flow directly from the duration and allowable frequency, it most accurately provides the allowed number of excursions. The hydrologically based method applies the CMC at a design flow equal to or equivalent to the 1Q10 design flow (i.e., the lowest one-day flow with an average recurrence frequency of once in ten years), and applies the CCC at the 7Q10 design flow (i.e., the lowest average seven consecutive day flow with a recurrence frequency of once in ten years).

EPA established a three year allowable frequency in the NTR. In settlement of the litigation on the NTR, EPA stated that it was in the midst of conducting, sponsoring, or planning research aimed at addressing scientific issues related to the basis for and application of water quality criteria and mentioned the issue of allowable frequency. See Partial Settlement Agreement in *American Forest and Paper Ass'n, Inc. et al.* v. *U.S. EPA* (Consolidated Case No. 93–0694 (RMU) D.D.C. To that end, EPA is reevaluating issues raised about allowable frequency as part of its work in revising the 1985 Guidelines.

EPA recognizes that additional data concerning (a) the probable frequency of lethal events for an assemblage of taxa covering a range of sensitivities to pollutants, (b) the probable frequency of sublethal effects for such taxa, (c) the differing effects of lethal and sublethal events in reducing populations of such taxa, and (d) the time needed to replace organisms lost as a result of toxicity, may lead to further refinement of the allowable frequency value. EPA has not yet completed this work. Until this work is complete, EPA believes that where EPA promulgates criteria, the three year allowable frequency represents a value in the reasonable range for this parameter.

3. Implementation

Once the applicable designated uses and water quality criteria for a water body are determined, under the National Pollutant Discharge Elimination System (NPDES) program discharges to the water body must be characterized and the permitting authority must determine the need for permit limits. If a discharge causes, has the reasonable potential to cause, or contributes to an excursion of a numeric or narrative water quality criteria, the permitting authority must develop permit limits as necessary to meet water quality standards. These permit limits are water quality-based effluent limitations or WQBELs. The terms "cause," "reasonable potential to cause," and "contribute to" are the terms in the NPDES regulations for conditions under which water quality-based permit limits are required. See 40 CFR 122.44(d)(1).

Since the publication of the proposed CTR, the State of California adopted procedures which detail how water quality criteria will be implemented through NPDES permits, waste discharge requirements, and other regulatory approaches. These procedures entitled, *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California* were adopted on March 2, 2000. Once these procedures are submitted for review under CWA section 303(c), EPA will review them as they relate to water quality standards, and approve or disapprove them.

Several commenters understood the language in the preamble to the proposed rule regarding implementation to mean that site-specific criteria, variances, and other actions would be prohibited or severely limited by the CTR. Site-specific criteria, variances and other actions modifying criteria are neither prohibited nor limited by the CTR. The State, if it so chooses, still can make these changes to its water quality standards, subject to EPA approval. However, with this Federal rule in effect, the State cannot implement any modifications that are less stringent than the CTR without an amendment to the CTR to reflect these modifications. EPA will make every effort to expeditiously accommodate Federal rulemaking of appropriate modifications to California's water quality standards. In the preamble to the proposed CTR, and here today, EPA is emphasizing that these efforts to amend the CTR on a case-by-case basis will generally increase the time before a modification can be implemented.

4. Wet Weather Flows

EPA has for a longtime maintained that CWA section 301(b)(1)(C) applies to NPDES permits for discharges from municipal separate storm sewer systems. Recently, the U.S. Court of Appeals for the Ninth Circuit upheld NPDES permits issued by EPA for five Arizona municipal separate storm sewer systems and addressed this issue specifically. *Defenders of Wildlife, et al.* v. *Browner,* No. 98–71080 (9th Cir., October 1999). The Court held that the CWA does not require ''strict compliance'' with State water quality standards for municipal storm sewer permits under section 301(b)(1)(C), but that at the same time, the CWA does give EPA discretion to incorporate appropriate water quality-based effluent limitations under another provision, CWA section 402(p)(3)(B)(iii).

The Court based its decision on the structure of section 402(p)(3), which contains distinct language for discharges of industrial storm water and municipal storm water. In section 402(p)(3)(A), Congress requires that ''dischargers associated with industrial activity shall meet all applicable provisions of [section 402] and section [301].'' 33 U.S.C. section 1342(p)(3)(A). The Court noted, therefore, that by incorporation, industrial storm water discharges need to achieve ''any more stringent limitation, including those necessary to meet water quality standards * * *'' The Court explained that industrial storm water discharges ''must comply strictly with State water quality standards'' but that Congress chose not to include a similar provision for municipal storm sewer discharges, including instead a requirement for controls to reduce pollutants to the maximum extent practicable or MEP standard in section 402(p)(3)(B). Reading the two related sections together, the Court concluded that section 402(p)(3)(B)(iii) does not require ''strict compliance'' by municipal storm sewer discharges according to section 301(b)(1)(C). At the same time, however, the Court found that the language in CWA section 402(p)(3)(B)(iii) which states that permits for discharges from municipal storm sewers shall require ''such other provisions as the Administrator of the state determines appropriate for the control of such pollutants'' provides EPA with discretion to incorporate provisions lending to ultimate compliance with water quality standards.

EPA believes that compliance with water quality standards through the use of Best Management Practices (BMPs) is appropriate. EPA articulated its position on the use of BMPs in storm water permits in the policy memorandum entitled, ''Interim Permitting Approach for Water Quality-Based Effluent Limitations In Storm Water Permits'' which was signed by the Assistant Administrator for Water, Robert Perciasepe on August 1, 1996 (61 FR 43761, August 9, 1996). A copy of this memorandum is contained in the administrative record for today's rule. The policy affirms the use of BMPs as a means to attain water quality standards in municipal storm water permits, and embraces BMPs as an interim permitting approach.

The interim permitting approach uses BMPs in first-round storm water permits, and expanded or better-tailored BMPs in subsequent permits, where necessary, to provide for the attainment of water quality standards. In cases where adequate information exists to develop more specific conditions or limitations to meet water quality standards, these conditions or limitations are to be incorporated into storm water permits, as necessary and appropriate.

This interim permitting approach, however, only applies to EPA. EPA encourages the State to adopt a similar policy for municipal storm water permits. This interim permitting approach provides time, where necessary, to more fully assess the range of issues and possible options for the control of storm water discharges for the protection of water quality. More information on this issue is included in the response to comment document in response to specific storm water issues raised by commenters.

5. Schedules of Compliance

A compliance schedule refers to an enforceable sequence of interim requirements in a permit leading to ultimate compliance with water quality-based effluent limitations or WQBELs in accordance with the CWA. The authorizing compliance schedule provision authorizes, but does not require, the permit issuing authority in the State of California to include such compliance schedules in permits under appropriate circumstances. The State of California is authorized to administer the National Pollutant Discharge Elimination System (NPDES) program and may exercise its discretion when deciding if a compliance schedule is justified because of the technical or financial (or other) infeasibility of immediate compliance. An authorizing compliance schedule provision is included in today's rule because of the potential for existing dischargers to have new or more stringent effluent limitations for which immediate compliance would not be possible or practicable.

New and Existing Dischargers: The provision allows compliance schedules only for an ''existing discharger'' which is defined as any discharger which is not a ''new California discharger.'' A ''new California discharger'' includes ''any building, structure, facility, or installation from which there is, or may be, a 'discharge of pollutants', the construction of which commences after the effective date of this regulation.'' These definitions are modeled after the existing 40 CFR 122.2 definitions for parallel terms, but with a cut-off date modified to reflect this rule. Only ''new California dischargers'' are required to comply immediately upon commencement of discharge with effluent limitations derived from the criteria in this rule. For ''existing dischargers'' whose permits are reissued or modified to contain new or more stringent limitations based upon certain water quality requirements, the permit could allow up to five years, or up to the length of a permit, to comply with such limitations. The provision applies to new or more stringent effluent limitations based on the criteria in this EPA rule.

EPA has included ''increasing dischargers'' within the category of ''existing dischargers'' since ''increasing dischargers'' are existing facilities with a change—an increase—in their discharge. Such facilities may include those with seasonal variations. ''Increasing dischargers'' will already have treatment systems in place for their current discharge, thus, they have less opportunity than a new discharger does to design and build a new treatment system which will meet new water quality-based requirements for their changed discharge. Allowing existing facilities with an increasing discharge a compliance schedule will avoid placing the discharger at a competitive disadvantage vis-a-vis other existing dischargers who are eligible for compliance schedules.

Today's rule does not prohibit the use of a short-term ''shake down period'' for new California dischargers as is provided for new sources or new dischargers in 40 CFR 122.29(d)(4). These regulations require that the owner or operator of (1) a new source; (2) a new discharger (as defined in 40 CFR 122.2) which commenced discharge after August 13, 1979; or (3) a recommencing discharger shall install and implement all pollution control equipment to meet the conditions of the permit before discharging. The facility must also meet all permit conditions in the shortest feasible time (not to exceed 90 days). This shake-down period is not a compliance schedule. This approach may be used to address violations which may occur during a new facility's start-up, especially where permit limits are water quality-based and biological treatment is involved.

The burden of proof to show the necessity of a compliance schedule is on the discharger, and the discharger must request approval from the permit issuing authority for a schedule of compliance. The discharger should submit a description of the minimum required actions or evaluations that must be undertaken in order to comply with the new or more restrictive discharge limits. Dates of completion for the required actions or evaluations should be included, and the proposed schedule should reflect the shortest practicable time to complete all minimum required actions.

Duration of Compliance Schedules: Today's rule provides that compliance schedules may provide for up to five years to meet new or more stringent effluent limitations in those limited circumstances where the permittee can demonstrate to the permit authority that an extended schedule is warranted. EPA's regulations at 122.47 require compliance with standards as soon as possible. This means that permit authorities should not allow compliance schedules where the permittee fails to demonstrate their necessity. This provision should not be considered a default compliance schedule duration for existing facilities.

In instances where dischargers wish to conduct toxicological studies, analyze results, and adopt and implement new or revised water quality-based effluent limitations, EPA believes that five years is sufficient time within which to complete this process. See the preamble to the proposed rule.

Under this rule, where a schedule of compliance exceeds one year, interim requirements are to be specified and interim progress reports are to be submitted at least annually to the permit issuing authority, in at least one-year time intervals.

The rule allows all compliance schedules to extend up to a maximum duration of five years, which is the maximum term of any NPDES permit. See 40 CFR 122.46. The discharger's opportunity to obtain a compliance schedule occurs when the existing permit for that discharge is issued, reissued or modified to contain more stringent limits based on the water quality criteria in today's rule. Such compliance schedules, however, cannot be extended to any indefinite point of time in the future because the compliance schedule provision in this rule will sunset on May 18, 2005. The sunset applies to the authorizing provision in today's rule (40 CFR 131.38(e)), not to individual schedules of compliance included in specific NPDES permits. Delays in reissuing expired permits (including those which continue in effect under applicable NPDES regulations) cannot indefinitely extend the period of time during which a compliance schedule is in effect. This would occur where the permit authority includes the single maximum five-year compliance schedule in a permit that is reissued just before the compliance schedule provision sunsets (having been previously issued without WQBELS using the rule's criteria on the eve of the effective date of this rule). Instead, the effect of the sunset provision is to limit the longest time period for compliance to ten years after the effective date of this rule.

EPA recognizes that where a permit is modified during the permit term, and the permittee needs the full five years to comply, the five-year schedule may extend beyond the term of the modified permit. In such cases, the rule allows for the modified permit to contain a compliance schedule with an interim limit by the end of the permit term. When the permit is reissued, the permit authority may extend the compliance schedule in the next permit, provided that, taking into account the amount of time allowed under the previous permit, the entire compliance schedule contained in the permit shall not exceed five years. Final permit limits and compliance dates will be included in the record for the permit. Final compliance dates must occur within five years from the date of permit issuance, reissuance, or modification, unless additional or less time is provided for by law.

EPA would prefer that the State adopt an authorizing compliance schedule provision but recognizes that the State may not be able to complete this action for some time after promulgation of the CTR. Thus, EPA has chosen to promulgate the rule with a sunset provision which states that the authorizing compliance schedule provision will cease or sunset on May 18, 2005. However, if the State Board adopts, and EPA approves, a statewide authorizing compliance schedule provision significantly prior to May 18, 2005, EPA will act to stay the authorizing compliance schedule provision in today's rule. Additionally, if a Regional Board adopts, and the State Board adopts and EPA approves, a Regional Board authorizing compliance schedule provision, EPA will act to stay today's provision for the appropriate or corresponding geographic region in California. At that time, the State Board's or Regional Board's authorizing compliance schedule provision will govern the ability of the State regulatory entity to allow a discharger to include a compliance schedule in a discharger's NPDES permit.

Antibacksliding: EPA wishes to address the potential concern over antibacksliding where revised permit limits based on new information are the result of the completion of additional studies. The Agency's interpretation of the CWA is that the antibacksliding requirements of section 402(o) of the CWA do not apply to revisions to effluent limitations made before the scheduled date of compliance for those limitations.

State Compliance Schedule Provisions: EPA supports the State in adopting a statewide provision independent of or as part of the effort to readopt statewide water quality control plans, or in adopting individual basin-wide compliance schedule provisions through its nine Regional Water Quality Control Boards (RWQCBs). The State and RWQCBs have broad discretion to adopt a provision, including discretion on reasonable lengths of time for final compliance with WQBELs. EPA recognizes that practical time frames within which to set interim goals may be necessary to achieve meaningful, long-term improvements in water quality in California.

At this time, two RWQCBs have adopted an authorizing compliance schedule provision as an amendment to their respective Basin Plans during the Boards' last triennial review process. The Basin Plans have been adopted by the State and have come to EPA for approval. Thus, the Basin Plans' provisions are effective for the respective Basins. If and when EPA approves of either Regional Basin Plan, EPA will expeditiously act to amend the CTR, staying its compliance schedule provision, for the appropriate geographic region.

6. Changes From Proposed Rule

A few changes were made in the final rule from the proposal both as a result of the Agency's consideration of issues raised in public comments and Endangered Species Act consultation with the U.S. Fish and Wildlife Service (FWS) and U.S. National Marine Fisheries Service (NMFS). The important changes include: reserving the mercury aquatic life criteria; reserving the selenium freshwater acute aquatic life criterion; reserving the chloroform human health criteria; and adding a sunset provision to the authorizing compliance schedule provision. EPA also clarified that the CTR will not replace priority toxic pollutant criteria which were adopted by the San Francisco Regional Water Quality Control Board in its 1986 Basin Plan, adopted by the State Board, and approved by EPA; specifying the harmonic mean for human health criteria for non-carcinogens and adding a provision which explicitly allows the State to adopt and implement an alternative averaging period, frequency, and design flow for a criterion after opportunity for public comment.

The first two changes, the reservation of mercury criteria and selenium criterion, are discussed in more detail below in Section L., The Endangered Species Act (ESA). The selenium criterion is also discussed in more detail above in Section E., Derivation of Criteria, in subsection 2.b., Freshwater Acute Selenium Criterion. EPA has also decided to reserve a decision on numeric criteria for chloroform and therefore not promulgate chloroform criteria in the final rule. As part of a large-scale regulation promulgated in December l998 under the Safe Drinking Water Act, EPA published a health-based goal for chloroform (the maximum contaminant level goal or MCLG) of zero, see 63 FR 69390, Dec. 16, 1998. EPA provided new data and analyses concerning chloroform for public review and comment, including a different, mode of action approach for estimating the cancer risk, 63 FR 15674, March 31, 1998, but did not reach a conclusion on how to use that new information in establishing the final MCLG, pending further review by the Science Advisory Board. EPA has now concluded that any further actions on water quality criteria should take into account the new data and analysis as reviewed by the SAB. This decision is consistent with a recent federal court decision vacating the MCLG for chloroform (*Chlorine Chemistry Council* v. *EPA,* No. 98–1627 (DC Cir., Mar. 31,2000)). EPA intends to reassess the human health 304(a) criteria recommendation for chloroform. For these reasons, EPA has decided to reserve a decision on numeric criteria for chloroform in the CTR and not promulgate water quality criteria as proposed. Permitting authorities in California should continue to rely on existing narrative criteria to establish effluent limitations as necessary for chloroform.

The sunset provision for the authorizing compliance schedule provision has been added to ease the transition from a Federal provision to the State's provision that was adopted in March 2000 as part of its' new statewide implementation plan. The sunset provision is discussed in more detail in Section G.5 of today's preamble. The CTR matrix at 40 CFR 131.38(b)(1) makes it explicit that the rule does not supplant priority toxic pollutant criteria which were adopted by the San Francisco Regional Water Quality Control Board in its 1986 Basin Plan, adopted by the State Board, and approved by EPA. This change is discussed more fully in Section D.4. of today's preamble. EPA modified the design flow for implementing human health criteria for non-carcinogens from a 30Q5 to a harmonic mean. Human health criteria for non-carcinogens are based on an RfD, which is an acceptable daily exposure over a lifetime. EPA matched the criteria for protection over a human lifetime with the longest stream flow averaging period, i.e., the harmonic mean. Lastly, the CTR now contains language which is intended to make it easier for the State to adopt and implement an alternative averaging period, frequency and related design flow, for situations where the default parameters are inappropriate. This language is found at 40 CFR 131.38(c)(2)(iv).

H. Economic Analysis

This final rule establishes ambient water quality criteria which, by themselves, do not directly impose economic impacts (see section K). These criteria combined with the State-adopted designated uses for inland surface waters, enclosed bays and estuaries, and implementation policies, will establish water quality standards. Until the State implements these water quality standards, there will be no effect of this rule on any entity. The State will implement these criteria by ensuring that NPDES permits result in discharges that will meet these criteria. In so doing, the State will have considerable discretion.

EPA has analyzed the indirect potential costs and benefits of this rule. In order to estimate the indirect costs and benefits of the rule, an appropriate baseline must be established. The baseline is the starting point for measuring incremental costs and benefits of a regulation. The baseline is established by assessing what would occur in the absence of the regulation. At present, State Basin Plans contain a narrative water quality criterion stating that all waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life. EPA's regulation at 40 CFR 122.44(d)(1)(vi) requires that where a discharge causes or has the reasonable potential to cause an excursion above a narrative criterion within a State water quality standard, the permitting authority must establish effluent limits but may determine limits using a number of options. These options include establishing ''effluent limits on a case-by-case basis, using EPA's water quality criteria published under section 304(a) of the CWA, supplemented where necessary by other relevant information'' (40 CFR 122.44(d)(1)(vi)(B)). Thus, to the extent that the State is implementing its narrative criteria by applying the CWA section 304(a) criteria, this rule does not impose any incremental costs because the criteria in this rule are identical to the CWA section 304(a) criteria. Alternatively, to the extent that the State is implementing its narrative criteria on a ''case-by-case basis'' using ''other relevant information'' in its permits this rule may impose incremental indirect costs because the criteria in these permits may not be based on CWA 304(a) criteria. Both of these approaches to establishing effluent limits are in full compliance with the CWA.

Because a specific basis for effluent limits in all existing permits in California is not known, it is not possible to determine a precise estimate of the indirect costs of this rule. The incremental costs of the rule may be as low as zero, or as high as $61 million. The high estimate of costs is based on the possibility that most of the effluent limits now in effect are not based on 304(a) criteria. EPA evaluated these indirect costs using two different approaches. The first approach uses existing discharge data and makes assumptions about future State NPDES permit limits. Actual discharge levels are usually lower than the level set by current NPDES permit limits. This approach, representing the low-end scenario, also assumes that some of the discretionary mechanisms that would enhance flexibility (*e.g.,* site specific criteria, mixing zones) would be granted by the State. The second approach uses a sample of existing permit limits and assumes that dischargers are actually discharging at the levels contained in their permits and makes assumptions about limits statewide that would be required under the rule. This approach, representing the high-end scenario, also assumes that none of the discretionary mechanisms that would enhance flexibility (*e.g.,* site specific criteria, mixing zones) would be granted by the State. These two approaches recognize that the State has significant flexibility and discretion in how it chooses to implement standards within the NPDES permit program, the EA by necessity includes many assumptions about how the State will implement the water quality standards. These assumptions are based on a combination of EPA guidance and current permit conditions for the facilities examined in this analysis. To account for the uncertainty of EPA's implementation assumptions, this analysis estimates a wide range of costs and benefits. By completing the EA, EPA intends to inform the public about how entities might be potentially affected by State implementation of water quality standards in the NPDES permit program. The costs and benefits sections that follow summarize the methodology and results of the analysis.

1. Costs

EPA assessed the potential compliance costs that facilities may incur to meet permit limits based on the criteria in today's rule. The analysis focused on direct compliance costs such as capital costs and operation and maintenance costs (O&M) for end-of-pipe pollution control, indirect source controls, pollution prevention, monitoring, and costs of pursuing alternative methods of compliance.

The population of facilities with NPDES permits that discharge into California's enclosed bays, estuaries and inland surface waters includes 184 major dischargers and 1,057 minor dischargers. Of the 184 major facilities, 128 are publicly owned treatment works (POTWs) and 56 are industrial facilities. Approximately 2,144 indirect dischargers designated as significant industrial users discharge wastewater to those POTWs. In the EA for the proposed CTR, EPA used a three-phased process to select a sample of facilities to represent California dischargers potentially affected by the State's implementation of permit limits based on the criteria contained in this rule.

The first phase consisted of choosing three case study areas for which data was thought to exist. The three case studies with a total of 5 facilities included: the South San Francisco Bay (the San Jose/Santa Clara Water Pollution Control Plant and Sunnyvale Water Pollution Control Plant); the Sacramento River (the Sacramento Regional Wastewater Treatment Plant); and the Santa Ana River (the City of Riverside Water Quality Control Plant and the City of Colton Municipal Wastewater Treatment Facility). The second phase consisted of selecting five additional major industrial dischargers to complement the case-study POTWs.

The third phase involved selecting 10 additional facilities to improve the basis for extrapolating the costs of the selected sample facilities to the entire population of potentially affected dischargers. The additional 10 facilities were selected such that the group examined: (1) Was divided between major POTWs and major industrial discharger categories in proportion to the numbers of facilities in the State; (2) gave greater proportionate representation to major facilities than minor facilities based on a presumption that the majority of compliance costs would be incurred by major facilities; (3) gave a proportionate representation to each of four principal conventional treatment processes typically used by facilities in specified industries in California; and (4) was representative of the proportionate facilities located within the different California Regional Water Quality Control Boards. Within these constraints, facilities were selected at random to complete the sample.

In the EA for today's final rule, EPA primarily used the same sample as the EA for the proposed rule with some modifications. EPA increased the number of minor POTWs and minor industrial facilities in the sample. EPA randomly selected four new minor POTW facilities and five new minor industrial facilities to add to the sample. The number of sample facilities selected in each area under the jurisdiction of a Regional Water Quality Control Board was roughly proportional to the universe of facilities in each area.

For those facilities that were projected to exceed permit limits based on the criteria, EPA estimated the incremental costs of compliance. Using a decision matrix or flow chart, costs were developed for two different scenarios—a ''low-end'' cost scenario and a ''high-end'' cost scenario—to account for a range of regulatory flexibility available to the State when implementing permit limits based on the water quality criteria. The assumptions for baseline loadings also vary over the two scenarios. The low-end scenario generally assumed that facilities were discharging at the maximum effluent concentrations taken from actual monitoring data, while the high-end scenario generally assumed that facilities were discharging at their current effluent limits. The decision matrix specified assumptions used for selection of control options, such as optimization of existing treatment processes and operations, in-plant pollutant minimization and prevention, and end-of-pipe treatment.

The annualized potential costs that direct and indirect dischargers may incur as a result of State implementation of permit limits based on water quality standards using today's criteria are estimated to be between $33.5 million and $61 million. EPA believes that the costs incurred as a result of State implementation of these permit limits will approach the low-end of the cost range. Costs are unlikely to reach the high-end of the range because State authorities are likely to choose implementation options that provide some degree of flexibility or relief to point source dischargers. Furthermore, cost estimates for both scenarios, but especially for the high-end scenario, may be overstated because the analysis tended to use conservative assumptions in calculating these permit limits and in establishing baseline loadings. The baseline loadings for the high-end were based on current effluent limits rather than actual pollutant discharge data. Most facilities discharge pollutants in concentrations well below current effluent limits. In addition, both the high-end and low-end cost estimates in the EA may be slightly overstated since potential costs incurred to reduce chloroform discharges were included in these estimates. EPA made a decision to reserve the chloroform human health criteria after the EA was completed.

Under the low-end cost scenario, major industrial facilities and POTWs would incur about 27 percent of the potential costs, indirect dischargers would incur about 70 percent of the potential costs, while minor dischargers would incur about 3 percent. Of the major direct dischargers, POTWs would incur the largest share of projected costs (87 percent). However, distributed among 128 major POTWs in the State, the average cost per plant would be $61,000 per year. Chemical and petroleum industries would incur the highest cost of the industrial categories (5.6 percent of the annual costs, with an annual average of $25,200 per plant). About 57 percent of the low-end costs would be associated with pollution prevention activities, while nearly 38 percent would be associated with pursuing alternative methods of compliance under the regulations.

Under the high-end cost scenario, major industrial facilities and POTWs would incur about 94 percent of the potential costs, indirect dischargers would incur about 17 percent of the potential costs, while minor dischargers would incur about 5 percent. Among the major, direct dischargers, two categories would incur the majority of potential costs—major POTWs (82 percent), Chemical/Petroleum Products (9 percent). The average annual per plant cost for different industry categories would ranges from zero to $324,000. The two highest average cost categories would be major POTWs ($324,000 per year) and Chemical/Petroleum Products ($221,264 per year). The shift in proportion of potential costs between direct and indirect dischargers is due to the assumption that more direct dischargers would use end-of-pipe treatment under the high-end scenario. Thus, a smaller proportion of indirect dischargers would be impacted under the high-end scenario, since some municipalities are projected to add end-of-pipe treatment which would reduce the need for controls from indirect discharges. Over 91 percent of the annual costs are for waste minimization and treatment optimization costs. Waste minimization would represent nearly 84% of the total annual costs. Capital and operation and maintenance costs would make up less than 9 percent of annual costs.

Cost-Effectiveness: Cost-effectiveness is estimated in terms of the cost of reducing the loadings of toxic pollutants from point sources. The cost-effectiveness is derived by dividing the projected annual costs of implementing permit limits based on water quality standards using today's criteria by the toxicity-weighted pounds (pound-equivalents) of pollutants removed. Pound-equivalents are calculated by multiplying pounds of each pollutant removed by the toxic weight (based on the toxicity of copper) for that pollutant.

Based on this analysis, State implementation of permit limits based on today's criteria would be responsible for the reduction of about 1.1 million to 2.7 million toxic pound-equivalents per year, or 15 to 50 percent of the toxic-weighted baseline loadings for the high- and low-end scenarios, respectively. The cost-effectiveness of the scenarios would range from $22 (high-end scenario) to $31 (low-end scenario) per pound-equivalent.

2. Benefits

The benefits analysis is intended to provide insight into both the types and potential magnitude of the economic benefits expected as a result of implementation of water quality standards based on today's criteria. To the extent feasible, empirical estimates of the potential magnitude of the benefits were developed and then compared to the estimated costs of implementing water quality standards based on today's criteria.

To perform a benefits analysis, the types or categories of benefits that apply need to be defined. EPA relied on a set of benefits categories that typically apply to changes in the water resource environment. Benefits were categorized as either use benefits or passive (nonuse) benefits depending on whether or not they involve direct use of, or contact with, the resource. The most prominent use benefit categories are those related to recreational fishing, boating, and swimming. Another use benefit category of significance is human health risk reduction. Human health risk reductions can be realized through actions that reduce human exposure to contaminants such as exposure through the consumption of fish containing elevated levels of pollutants. Passive use benefits are those improvements in environmental quality that are valued by individuals apart from any use of the resource in question.

Benefits estimates were derived in this study using an approach in which benefits of discrete large-scale changes in water quality beyond present day conditions were estimated wherever feasible. A share of those benefits was then apportioned to implementation of water quality standards based on today's criteria. The apportionment estimate was based on a three-stage process:

First, EPA assessed current total loadings from all sources that are contributing to the toxics-related water quality problems observed in the State. This defines the overall magnitude of loadings. Second, the share of total loadings that are attributable to sources that would be controlled through implementation of water quality standards based on today's criteria was estimated. Since this analysis was designed to focus only on those controls imposed on point sources, this stage of the process entailed estimating the portion of total loadings originating from point sources. Third, the percentage reduction in loadings expected due to implementation of today's criteria was estimated and then multiplied by the share of point source loadings to calculate the portion of benefits that could be attributed to implementation of water quality standards based on today's criteria.

Total monetized annual benefits were estimated in the range of $6.9 to $74.7 million. By category, annual benefits would be $1.3 to $4.6 million for avoided cancer risk, $2.2 to $15.2 million for recreational angling, and $3.4 to $54.9 million for passive use benefits.

There are numerous categories of potential or likely benefits that have been omitted from the quantified and monetized benefit estimates. In terms of potential magnitudes of benefit, the following are likely to be significant contributors to the underestimation of the monetized values presented above:

- Improvements in water-related (in-stream and near stream) recreation apart from fishing. The omission of potential motorized and nonmotorized boating, swimming, picnicking, and related in-stream and stream-side recreational activities from the benefits estimates could contribute to an appreciable underestimation of total benefits. Such recreational activities have been shown in empirical research to be highly valued, and even modest changes in participation and or user values could lead to sizable benefits statewide. Some of these activities can be closely associated with water quality attributes (notably, swimming). Other recreational activities may be less directly related to the water quality improvements, but might nonetheless increase due to their association with fishing, swimming, or other activities in which the participants might engage.
- Improvements in consumptive and nonconsumptive land-based recreation, such as hunting and wildlife observation. Improvements in aquatic habitats may lead (via food chain and related ecologic benefit mechanisms) to healthier, larger, and more diverse populations of avian and terrestrial species, such as waterfowl, eagles, and otters. Improvements in the populations for these species could manifest as improved hunting and wildlife viewing opportunities, which might in turn increase participation and user day values for such activities. Although the scope of the benefits analysis has not allowed a quantitative assessment of these values at either pre- or post-rule

conditions, it is conceivable that these benefits could be appreciable.

- Improvements in human health resulting from reduction of non-cancer risk. EPA estimated that implementation of water quality standards based on the criteria would result in a reduction of mercury concentrations in fish tissue and, thus, a reduction in the hazard from consumption of mercury contaminated fish. However, EPA was unable to monetize benefits due to reduced non-cancer health effects.
- Human health benefits for saltwater anglers outside of San Francisco Bay were not estimated. The number of saltwater anglers outside of San Francisco Bay is estimated to be 673,000 (based on Huppert, 1989, and U.S. FWS, 1993). The omission of other saltwater anglers may cause human health benefits to be underestimated. In addition, benefit estimates in the EA may be slightly overstated since potential benefits from reductions in chloroform discharges were included in these estimates. EPA made a decision to reserve the chloroform human health criteria after the EA was completed.

EPA received a number of comments which requested the Agency use the cost-benefit analysis in the EA as a factor in setting water quality criteria. EPA does not use the EA as a basis in determining protective water quality criteria. EPA's current regulations at 40 CFR 131.11 state that the criteria must be based on sound scientific rationale and must protect the designated use. From the outset of the water quality standards program, EPA has explained that while economic factors may be considered in designating uses, they may not be used to justify criteria that are not protective of those uses. 44 FR 25223–226, April 30, 1979. See e.g. *Mississippi Commission on Natural Resources* v. *Costle,* 625 F. 2d 1269, 1277 (5th Cir. 1980). EPA reiterated this interpretation of the CWA and its implementing regulations in discussing section 304(a) recommended criteria guidance stating that ''they are based solely on data and scientific judgments on the relationship between pollutant concentrations and environmental and human health effects and do not reflect consideration of economic impacts or the technological feasibility of meeting the chemical concentrations in ambient water.'' 63 FR 36742 and 36762, July 7, 1998.

I. Executive Order 12866, Regulatory Planning and Review

Under Executive Order 12866 (58 FR 51735, October 4, 1993), the Agency must determine whether the regulatory action is ''significant'' and therefore subject to Office of Management and Budget (OMB) review and the requirements of the Executive Order. The Order defines ''significant regulatory action'' as one that is likely to result in a rule that may:

(1) Have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or tribal governments or communities;

(2) Create a serious inconsistency or otherwise interfere with an action taken or planned by another Agency;

(3) Materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or

(4) Raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the Executive Order.

It has been determined that this rule is not a ''significant regulatory action'' under the terms of Executive Order 12866 and is therefore not subject to OMB review.

J. Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA), Public Law 104–4, establishes requirements for Federal agencies to assess the effects of their regulatory actions on State, local, and tribal governments and the private sector. Under section 202 of the UMRA, EPA generally must prepare a written statement, including a cost-benefit analysis, for proposed and final rules with ''Federal mandates'' that may result in expenditures to State, local, and tribal governments, in the aggregate, or to the private sector, of $100 million or more in any one year. Before promulgating any regulation for which a written statement is needed, section 205 of the UMRA generally requires EPA to identify and consider a reasonable number of regulatory alternatives and adopt the least costly, most cost-effective or least burdensome alternative that achieves the objectives of the rule. The provisions of section 205 do not apply when they are inconsistent with applicable law. Moreover, section 205 allows an Agency to adopt an alternative other than the least costly, most cost-effective or least burdensome alternative if the Administrator publishes with the final rule an explanation why that alternative was not adopted. Before EPA establishes any regulatory requirements that may significantly or uniquely affect small governments, including tribal governments, it must have developed under section 203 of the UMRA a small government Agency plan. The plan must provide for notifying potentially affected small governments, enabling officials of the affected small governments to have meaningful and timely input in the development of regulatory proposals with significant Federal intergovernmental mandates, and EPA informing, educating, and advising small governments on compliance with the regulatory requirements.

Today's rule contains no Federal mandates (under the regulatory provisions of Title II of the Unfunded Mandates Reform Act (UMRA)) for State, local, or tribal governments or the private sector. Today's rule imposes no enforceable duty on any State, local or Tribal governments or the private sector; rather, the CTR promulgates ambient water quality criteria which, when combined with State-adopted uses, will create water quality standards for those water bodies with adopted uses. The State will then use these resulting water quality standards in implementing its existing water quality control programs. Thus, today's rule is not subject to the requirements of sections 202 and 205 of the UMRA.

EPA has determined that this rule contains no regulatory requirements that might significantly or uniquely affect small governments. This rule establishes ambient water quality criteria which, by themselves do not directly impact any entity. The State will implement these criteria by ensuring that NPDES permits result in discharges that will meet these criteria. In so doing, the State will have considerable discretion. Until the State implements these water quality standards, there will be no effect of this rule on any entity. Thus, today's rule is not subject to the requirements of section 203 of UMRA.

K. Regulatory Flexibility Act

The Regulatory Flexibility Act generally requires Federal agencies to prepare a regulatory flexibility analysis of any rule subject to notice and comment rulemaking requirements under the Administrative Procedure Act or any other statute unless the Agency certifies that the rule will not have a significant economic impact of a substantial number of small entities. Small entities include small businesses, small organizations, and small governmental jurisdictions. For purposes of assessing the impacts of today's rule on small entities, small entity is defined as: (1) A small business according to RFA default definitions for small businesses (based on SBA size standards); (2) a small governmental jurisdiction that is a government of a city, county, town, school district or special district with a population of less than 50,000; and (3) a small organization that is any not-for-profit enterprise which is independently owned and operated and is not dominant in its field.

After considering the economic impacts of today's final rule on small entities, I certify that this action will not have a significant economic impact on a substantial number of small entities. This final rule will not impose any requirements on small entities.

Under the CWA water quality standards program, States must adopt water quality standards for their waters that must be submitted to EPA for approval. If the Agency disapproves a State standard and the State does not adopt appropriate revisions to address EPA's disapproval, EPA must promulgate standards consistent with the statutory requirements. EPA has authority to promulgate criteria or standards in any case where the Administrator determines that a revised or new standard is necessary to meet the requirements of the Act. These State standards (or EPA-promulgated standards) are implemented through various water quality control programs including the National Pollutant Discharge Elimination System (NPDES) program that limits discharges to navigable waters except in compliance with an EPA permit or permit issued under an approved State NPDES program. The CWA requires that all NPDES permits must include any limits on discharges that are necessary to meet State water quality standards.

Thus, under the CWA, EPA's promulgation of water quality criteria or standards establishes standards that the State, in turn, implements through the NPDES permit process. The State has considerable discretion in deciding how to meet the water quality standards and in developing discharge limits as needed to meet the standards. In circumstances where there is more than one discharger to a water body that is subject to water quality standards or criteria, a State also has discretion in deciding on the appropriate limits for the different dischargers. While the State's implementation of federally-promulgated water quality criteria or standards may result indirectly in new or revised discharge limits for small entities, the criteria or standards themselves do not apply to any discharger, including small entities.

Today's rule, as explained above, does not itself establish any requirements that are applicable to small entities. As a result of EPA's action here, the State of California will need to ensure that permits it issues include limits as necessary to meet the water quality standards established by the criteria in today's rule. In so doing, the State will have a number of discretionary choices associated with permit writing. While California's implementation of today's rule may ultimately result in some new or revised permit conditions for some dischargers, including small entities, EPA's action today does not impose any of these as yet unknown requirements on small entities.

The RFA requires analysis of the economic impact of a rule only on the small entities subject to the rule's requirements. Courts have consistently held that the RFA imposes no obligation on an Agency to prepare a small entity analysis of the effect of a rule on entities not regulated by the rule. *Motor & Equip. Mrfrs. Ass'n* v. *Nichols,* 142 F.3d 449, 467 & n.18 (D.C. Cir. 1998)(quoting *United States Distribution Companies* v. *FERC,* 88 F.3d 1105, 1170 (D.C. Cir. 1996); see also *American Trucking Association, Inc.* v. *EPA,* 175 F.3d 1027 (D.C. Cir. 1999). This final rule will have a direct effect only on the State of California which is not a small entity under the RFA. Thus, individual dischargers, including small entities, are not directly subject to the requirements of the rule. Moreover, because of California's discretion in implementing these standards, EPA cannot assess the extent to which the promulgation of this rule may subsequently affect any dischargers, including small entities. Consequently, certification under section 605(b) is appropriate. *State of Michigan, et al.* v. *U.S. Environmental Protection Agency,* No. 98–1497 (D.C. Cir. Mar. 3, 2000), slip op. at 41–42.

L. Paperwork Reduction Act

This action requires no new or additional information collection, reporting, or record keeping subject to the Paperwork Reduction Act, 44 U.S.C. 3501 *et seq.*

M. Endangered Species Act

Pursuant to section 7(a) of the Endangered Species Act (ESA), EPA has consulted with the U.S. Fish and Wildlife Service and the U.S. National Marine Fisheries Service (collectively, the Services) concerning EPA's rulemaking action for the State of California. EPA initiated informal consultation in early 1994, and completed formal consultation in April 2000. As a result of the consultation, EPA modified some of the provisions in the final rule.

As part of the consultation process, EPA submitted to the Services a Biological Evaluation for their review in October of 1997. This evaluation found that the proposed CTR was not likely to jeopardize the continued existence of any Federally listed species or result in the destruction or adverse modification of designated critical habitat. In April of 1998, the Services sent EPA a draft Biological Opinion which tentatively found that EPA's proposed rule would jeopardize the continued existence of several Federally listed species and result in the destruction or have adverse effect on designated critical habitat. After lengthy discussions with the Services, EPA agreed to several changes in the final rule and the Services in turn issued a final Biological Opinion finding that EPA's action would not likely jeopardize the continued existence of any Federally listed species or result in the destruction or adverse modification of designated critical habitat. EPA's Biological Evaluation and the Services' final Biological Opinion are contained in the administrative record for today's rule.

In order to ensure the continued protection of Federally listed threatened and endangered species and to protect their critical habitat, EPA agreed to reserve the aquatic life criteria for mercury and the acute freshwater aquatic life criterion for selenium. The Services believe that EPA's proposed criteria are not sufficiently protective of Federally listed species and should not be promulgated. EPA agreed that it would reevaluate these criteria in light of the Services concerns before promulgating them for the State of California. Other commitments made by EPA are described in a letter to the Services dated December 16, 1999; this letter is contained in the administrative record for today's rule.

N. Congressional Review Act

The Congressional Review Act, 5 U.S.C. 801 *et seq.*, as added by the Small Business Regulatory Enforcement Fairness Act of 1996, generally provides that before a rule may take effect, the Agency promulgating the rule must submit a rule report, which includes a copy of the rule, to each House of the Congress and to the Comptroller General of the United States. EPA will submit a report containing this rule and other required information to the U.S. Senate, the U.S. House of Representatives, and the Comptroller General of the United States prior to publication of the rule in the **Federal Register**. A major rule cannot take effect until 60 days after it is published in the **Federal Register**. This rule is not a major rule as defined by 5 U.S.C. 804(2). This rule will be effective May 18, 2000.

O. Executive Order 13084, Consultation and Coordination With Indian Tribal Governments

Under Executive Order 13084, EPA may not issue a regulation that is not required by statute, that significantly or uniquely affects the communities of Indian tribal governments, and that imposes substantial direct compliance costs on those communities, unless the Federal government provides the funds necessary to pay the direct compliance costs incurred by the tribal governments, or EPA consults with those governments. If EPA complies by consulting, Executive Order 13084 requires EPA to provide to the Office of Management and Budget, in a separately identified section of the preamble to the rule, a description of the extent of EPA's prior consultation with representatives of affected tribal governments, a summary of the nature of their concerns, and a statement supporting the need to issue the regulation. In addition, Executive Order 13084 requires EPA to develop an effective process permitting elected officials and other representatives of Indian tribal governments ''to provide meaningful and timely input in the development of regulatory policies on matters that significantly or uniquely affect their communities.''

Today's rule does not significantly or uniquely affect the communities of Indian tribal governments nor does it impose substantial direct compliance cots on them. Today's rule will only address priority toxic pollutant water quality criteria for the State of California and does not apply to waters in Indian country. Accordingly, the requirements of section 3(b) of Executive Order 13084 do not apply to this rule.

P. National Technology Transfer and Advancement Act

Section 12(d) of the National Technology Transfer and Advancement Act of 1995 (''NTTAA''), Public Law No. 104–113, section 12(d) (15 U.S.C. 272 note) directs EPA to use voluntary consensus standards in its regulatory activities unless to do so would be inconsistent with applicable law or otherwise impractical. Voluntary consensus standards are technical standards (e.g., materials specifications, test methods, sampling procedures, and business practices) that are developed or adopted by voluntary consensus standards bodies. The NTTAA directs EPA to provide Congress, through OMB, explanations when the Agency decides not to use available and applicable voluntary consensus standards.

This final rule does not involve technical standards. Therefore, EPA did not consider the use of any voluntary consensus standards.

Q. Executive Order 13132 on Federalism

Executive Order 13132, entitled ''Federalism'' (64 FR 43255, August 10, 1999), requires EPA to develop an accountable process to ensure ''meaningful and timely input by State and local officials in the development of regulatory policies that have federalism implications.'' ''Policies that have federalism implications'' is defined in the Executive Order to include regulations that have ''substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government.''

Under section 6 of Executive Order 13132, EPA may not issue a regulation that has federalism implications, that imposes substantial direct compliance costs, and that is not required by statute, unless the Federal government provides the funds necessary to pay the direct compliance costs incurred by State and local governments, or EPA consults with State and local officials early in the process of developing the proposed regulation. EPA also may not issue a regulation that has federalism implications and that preempts State law, unless the Agency consults with State and local officials early in the process of developing the proposed regulation.

This final rule does not have federalism implications. It will not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government, as specified in Executive Order 13132. The rule does not affect the nature of the relationship between EPA and States generally, for the rule only applies to water bodies in California. Further, the rule will not substantially affect the relationship of EPA and the State of California, or the distribution of power or responsibilities between EPA and the State. The rule does not alter the State's authority to issue NPDES permits or the State's considerable discretion in implementing these criteria. The rule simply implements Clean Water Act section 303(c)(2)(B) requiring numeric ambient water quality criteria for which EPA has issued section 304(a) recommended criteria in a manner that is consistent with previous regulatory guidance that the Agency has issued to implement CWA section 303(c)(2)(B). Further, this rule does not preclude the State from adopting water quality standards that meet the requirements of the CWA. Thus, the requirements of section 6 of the Executive Order do not apply to this rule.

Although section 6 of Executive Order 13132 does not apply to this rule, EPA did consult with State and local government representatives in developing this rule. EPA and the State reached an agreement that to best utilize its respective resources, EPA would promulgate water quality criteria and the State would concurrently work on a plan to implement the criteria. Since the proposal of this rule, EPA has kept State officials fully informed of changes to the proposal. EPA has continued to invite comment from the State on these changes. EPA believes that the final CTR incorporates comments from State officials and staff.

R. Executive Order 13045 on Protection of Children From Environmental Health Risks and Safety Risks

Executive Order 13045: ''Protection of Children from Environmental Health Risks and Safety Risks'' (62 FR 19885, April 23, 1997) applies to any rule that: (1) Is determined to be ''economically significant'' as defined under Executive Order 12866, and (2) concerns an environmental health or safety risk that EPA has reason to believe may have a disproportionate effect on children. If the regulatory action meets both criteria, the Agency must evaluate the environmental health or safety effects of the planned rule on children, and explain why the planned regulation is preferable to other potentially effective and reasonably feasible alternatives considered by the Agency.

While this final rule is not subject to the Executive Order because it is not economically significant as defined in Executive Order 12866, we nonetheless have reason to believe that the environmental health or safety risk addressed by this action may have a disproportionate effect on children. As a matter of EPA policy, we therefore have assessed the environmental health or safety effects of ambient water quality criteria on children. The results of this assessment are contained in section F.3., Human Health Criteria.

List of Subjects in 40 CFR Part 131

Environmental protection, Indians—lands, Intergovernmental relations, Reporting and recordkeeping requirements, Water pollution control.

Dated: April 27, 2000.

Carol Browner,

Administrator.

For the reasons set out in the preamble, part 131 of chapter I of title 40 of the Code of Federal Regulations is amended as follows:

PART 131—WATER QUALITY STANDARDS

1. The authority citation for part 131 continues to read as follows:

Authority: 33 U.S.C. 1251 *et seq.*

Subpart D—[Amended]

2. Section 131.38 is added to subpart D to read as follows:

§ 131.38 Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California.

(a) *Scope.* This section promulgates criteria for priority toxic pollutants in the State of California for inland surface waters and enclosed bays and estuaries. This section also contains a compliance schedule provision.

(b)(1) Criteria for Priority Toxic Pollutants in the State of California as described in the following table:

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A		B Freshwater		C Saltwater		D Human Health (10^{-6} risk for carcinogens) For consumption of:	
# Compound	CAS Number	Criterion Maximum Conc. [d] B1	Criterion Continuous Conc. [d] B2	Criterion Maximum Conc. [d] C1	Criterion Continuous Conc. [d] C2	Water & Organisms (µg/L) D1	Organisms Only (µg/L) D2
1. Antimony	7440360					14 a,s	4300 a,t
2. Arsenic [b]	7440382	340 i,m,w	150 i,m,w	69 i,m	36 i,m		
3. Beryllium	7440417					n	n
4. Cadmium [b]	7440439	4.3 e,i,m,w,x	2.2 e,i,m,w	42 i,m	9.3 i,m	n	n
5a. Chromium (III)	16065831	550 e,i,m,o	180 e,i,m,o			n	n
5b. Chromium (VI) [b]	18540299	16 i,m,w	11 i,m,w	1100 i,m	50 i,m	n	n
6. Copper [b]	7440508	13 e,i,m,w,x	9.0 e,i,m,w	4.8 i,m	3.1 i,m	1300	
7. Lead [b]	7439921	65 e,i,m	2.5 e,i,m	210 i,m	8.1 i,m	n	n
8. Mercury [b]	7439976	[Reserved]	[Reserved]	[Reserved]	[Reserved]	0.050 a	0.051 a
9. Nickel [b]	7440020	470 e,i,m,w	52 e,i,m,w	74 i,m	8.2 i,m	610 a	4600 a
10. Selenium [b]	7782492	[Reserved] p	5.0 q	290 i,m	71 i,m	n	n
11. Silver [b]	7440224	3.4 e,i,m		1.9 i,m			
12. Thallium	7440280					1.7 a,s	6.3 a,t
13. Zinc [b]	7440666	120 e,i,m,w,x	120 e,i,m,w	90 i,m	81 i,m		
14. Cyanide [b]	57125	22 o	5.2 o	1 r	1 r	700 a	220,000 a,j
15. Asbestos	1332214					7,000,000 fibers/L k,s	
16. 2,3,7,8-TCDD (Dioxin)	1746016					0.000000013 c	0.000000014 c
17. Acrolein	107028					320 s	780 t
18. Acrylonitrile	107131					0.059 a,c,s	0.66 a,c,t
19. Benzene	71432					1.2 a,c	71 a,c
20. Bromoform	75252					4.3 a,c	360 a,c
21. Carbon Tetrachloride	56235					0.25 a,c,s	4.4 a,c,t
22. Chlorobenzene	108907					680 a,s	21,000 a,j,t
23. Chlorodibromomethane	124481					0.401 a,c	34 a,c
24. Chloroethane	75003						
25. 2-Chloroethylvinyl Ether	110758						

26. Chloroform	67663					[Reserved]	[Reserved]
27. Dichlorobromomethane	75274					0.56 a,c	46 a,c
28. 1,1-Dichloroethane	75343						
29. 1,2-Dichloroethane	107062					0.38 a,c,s	99 a,c,t
30. 1,1-Dichloroethylene	75354					0.057 a,c,s	3.2 a,c,t
31. 1,2-Dichloropropane	78875					0.52 a	39 a
32. 1,3-Dichloropropylene	542756					10 a,s	1,700 a,t
33. Ethylbenzene	100414					3,100 a,s	29,000 a,t
34. Methyl Bromide	74839					48 a	4,000 a
35. Methyl Chloride	74873					n	n
36. Methylene Chloride	75092					4.7 a,c	1,600 a,c
37. 1,1,2,2-Tetrachloroethane	79345					0.17 a,c,s	11 a,c,t
38. Tetrachloroethylene	127184					0.8 c,s	8.85 c,t
39. Toluene	108883					6,800 a	200,000 a
40. 1,2-Trans-Dichloroethylene	156605					700 a	140,000 a
41. 1,1,1-Trichloroethane	71556					n	n
42. 1,1,2-Trichloroethane	79005					0.60 a,c,s	42 a,c,t
43. Trichloroethylene	79016					2.7 c,s	81 c,t
44. Vinyl Chloride	75014					2 c,s	525 c,t
45. 2-Chlorophenol	95578					120 a	400 a
46. 2,4-Dichlorophenol	120832					93 a,s	790 a,t
47. 2,4-Dimethylphenol	105679					540 a	2,300 a
48. 2-Methyl-4,6-Dinitrophenol	534521					13.4 s	765 t
49. 2,4-Dinitrophenol	51285					70 a,s	14,000 a,t
50. 2-Nitrophenol	88755						
51. 4-Nitrophenol	100027						
52. 3-Methyl-4-Chlorophenol	59507						
53. Pentachlorophenol	87865	19 f,w	15 f,w	13	7.9	0.28 a,c	8.2 a,c,j
54. Phenol	108952					21,000 a	4,600,000 a,j,t
55. 2,4,6-Trichlorophenol	88062					2.1 a,c	6.5 a,c
56. Acenaphthene	83329					1,200 a	2,700 a
57. Acenaphthylene	208968						
58. Anthracene	120127					9,600 a	110,000 a

59. Benzidine	92875					0.00012 a,c,s	0.00054 a,c,t
60. Benzo(a)Anthracene	56553					0.0044 a,c	0.049 a,c
61. Benzo(a)Pyrene	50328					0.0044 a,c	0.049 a,c
62. Benzo(b)Fluoranthene	205992					0.0044 a,c	0.049 a,c
63. Benzo(ghi)Perylene	191242						
64. Benzo(k)Fluoranthene	207089					0.0044 a,c	0.049 a,c
65. Bis(2-Chloroethoxy)Methane	111911						
66. Bis(2-Chloroethyl)Ether	111444					0.031 a,c,s	1.4 a,c,t
67. Bis(2-Chloroisopropyl)Ether	39638329					1,400 a	170,000 a,t
68. Bis(2-Ethylhexyl)Phthalate	117817					1.8 a,c,s	5.9 a,c,t
69. 4-Bromophenyl Phenyl Ether	101553						
70. Butylbenzyl Phthalate	85687					3,000 a	5,200 a
71. 2-Chloronaphthalene	91587					1,700 a	4,300 a
72. 4-Chlorophenyl Phenyl Ether	7005723						
73. Chrysene	218019					0.0044 a,c	0.049 a,c
74. Dibenzo(a,h)Anthracene	53703					0.0044 a,c	0.049 a,c
75. 1,2 Dichlorobenzene	95501					2,700 a	17,000 a
76. 1,3 Dichlorobenzene	541731					400	2,600
77. 1,4 Dichlorobenzene	106467					400	2,600
78. 3,3'-Dichlorobenzidine	91941					0.04 a,c,s	0.077 a,c,t
79. Diethyl Phthalate	84662					23,000 a,s	120,000 a,t
80. Dimethyl Phthalate	131113					313,000 s	2,900,000 t
81. Di-n-Butyl Phthalate	84742					2,700 a,s	12,000 a,t
82. 2,4-Dinitrotoluene	121142					0.11 c,s	9.1 c,t
83. 2,6-Dinitrotoluene	606202						
84 Di-n-Octyl Phthalate	117840						
85. 1,2-Diphenylhydrazine	122667					0.040 a,c,s	0.54 a,c,t
86. Fluoranthene	206440					300 a	370 a
87. Fluorene	86737					1,300 a	14,000 a
88. Hexachlorobenzene	118741					0.00075 a,c	0.00077 a,c
89. Hexachlorobutadiene	87683					0.44 a,c,s	50 a,c,t
90. Hexachlorocyclopentadiene	77474					240 a,s	17,000 a,j,t
91. Hexachloroethane	67721					1.9 a,c,s	8.9 a,c,t

92. Indeno(1,2,3-cd) Pyrene	193395					0.0044 a,c	0.049 a,c
93. Isophorone	78591					8.4 c,s	600 c,t
94. Naphthalene	91203						
95. Nitrobenzene	98953					17 a,s	1,900 a,j,t
96. N-Nitrosodimethylamine	62759					0.00069 a,c,s	8.1 a,c,t
97. N-Nitrosodi-n-Propylamine	621647					0.005 a	1.4 a
98. N-Nitrosodiphenylamine	86306					5.0 a,c,s	16 a,c,t
99. Phenanthrene	85018						
100. Pyrene	129000					960 a	11,000 a
101. 1,2,4-Trichlorobenzene	120821						
102. Aldrin	309002	3 g		1.3 g		0.00013 a,c	0.00014 a,c
103. alpha-BHC	319846					0.0039 a,c	0.013 a,c
104. beta-BHC	319857					0.014 a,c	0.046 a,c
105. gamma-BHC	58899	0.95 w		0.16 g		0.019 c	0.063 c
106. delta-BHC	319868						
107. Chlordane	57749	2.4 g	0.0043 g	0.09 g	0.004 g	0.00057 a,c	0.00059 a,c
108. 4,4'-DDT	50293	1.1 g	0.001 g	0.13 g	0.001 g	0.00059 a,c	0.00059 a,c
109. 4,4'-DDE	72559					0.00059 a,c	0.00059 a,c
110. 4,4'-DDD	72548					0.00083 a,c	0.00084 a,c
111. Dieldrin	60571	0.24 w	0.056 w	0.71 g	0.0019 g	0.00014 a,c	0.00014 a,c
112. alpha-Endosulfan	959988	0.22 g	0.056 g	0.034 g	0.0087 g	110 a	240 a
113. beta-Endosulfan	33213659	0.22 g	0.056 g	0.034 g	0.0087 g	110 a	240 a
114. Endosulfan Sulfate	1031078					110 a	240 a
115. Endrin	72208	0.086 w	0.036 w	0.037 g	0.0023 g	0.76 a	0.81 a,j
116. Endrin Aldehyde	7421934					0.76 a	0.81 a,j
117. Heptachlor	76448	0.52 g	0.0038 g	0.053 g	0.0036 g	0.00021 a,c	0.00021 a,c
118. Heptachlor Epoxide	1024573	0.52 g	0.0038 g	0.053 g	0.0036 g	0.00010 a,c	0.00011 a,c
119-125. Polychlorinated biphenyls (PCBs)			0.014 u		0.03 u	0.00017 c,v	0.00017 c,v
126. Toxaphene	8001352	0.73	0.0002	0.21	0.0002	0.00073 a,c	0.00075 a,c
Total Number of Criteria [h]		22	21	22	20	92	90

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Footnotes to Table in Parargraph (b)(1):

a. Criteria revised to reflect the Agency q1* or RfD, as contained in the Integrated Risk Information System (IRIS) as of October 1, 1996. The fish tissue bioconcentration factor (BCF) from the 1980 documents was retained in each case.

b. Criteria apply to California waters except for those waters subject to objectives in Tables III–2A and III–2B of the San Francisco Regional Water Quality Control Board's (SFRWQCB) 1986 Basin Plan, that were adopted by the SFRWQCB and the State Water Resources Control Board, approved by EPA, and which continue to apply.

c. Criteria are based on carcinogenicity of 10 (-6) risk.

d. Criteria Maximum Concentration (CMC) equals the highest concentration of a pollutant to which aquatic life can be exposed for a short period of time without deleterious effects. Criteria Continuous Concentration (CCC) equals the highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4 days) without deleterious effects. ug/L equals micrograms per liter.

e. Freshwater aquatic life criteria for metals are expressed as a function of total hardness (mg/L) in the water body. The equations are provided in matrix at paragraph (b)(2) of this section. Values displayed above in the matrix correspond to a total hardness of 100 mg/l.

f. Freshwater aquatic life criteria for pentachlorophenol are expressed as a function of pH, and are calculated as follows: Values displayed above in the matrix correspond to a pH of 7.8. CMC = exp(1.005(pH) − 4.869). CCC = exp(1.005(pH) − 5.134).

g. This criterion is based on 304(a) aquatic life criterion issued in 1980, and was issued in one of the following documents: Aldrin/Dieldrin (EPA 440/5–80–019), Chlordane (EPA 440/5–80–027), DDT (EPA 440/5–80–038), Endosulfan (EPA 440/5–80–046), Endrin (EPA 440/5–80–047), Heptachlor (440/5–80–052), Hexachlorocyclohexane (EPA 440/5–80–054), Silver (EPA 440/5–80–071). The Minimum Data Requirements and derivation procedures were different in the 1980 Guidelines than in the 1985 Guidelines. For example, a ''CMC'' derived using the 1980 Guidelines was derived to be used as an instantaneous maximum. If assessment is to be done using an averaging period, the values given should be divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines.

h. These totals simply sum the criteria in each column. For aquatic life, there are 23 priority toxic pollutants with some type of freshwater or saltwater, acute or chronic criteria. For human health, there are 92 priority toxic pollutants with either ''water + organism'' or ''organism only'' criteria. Note that these totals count chromium as one pollutant even though EPA has developed criteria based on two valence states. In the matrix, EPA has assigned numbers 5a and 5b to the criteria for chromium to reflect the fact that the list of 126 priority pollutants includes only a single listing for chromium.

i. Criteria for these metals are expressed as a function of the water-effect ratio, WER, as defined in paragraph (c) of this section. CMC = column B1 or C1 value x WER; CCC = column B2 or C2 value x WER.

j. No criterion for protection of human health from consumption of aquatic organisms (excluding water) was presented in the 1980 criteria document or in the 1986 Quality Criteria for Water. Nevertheless, sufficient information was presented in the 1980 document to allow a calculation of a criterion, even though the results of such a calculation were not shown in the document.

k. The CWA 304(a) criterion for asbestos is the MCL.

l. [Reserved]

m. These freshwater and saltwater criteria for metals are expressed in terms of the dissolved fraction of the metal in the water column. Criterion values were calculated by using EPA's Clean Water Act 304(a) guidance values (described in the total recoverable fraction) and then applying the conversion factors in § 131.36(b)(1) and (2).

n. EPA is not promulgating human health criteria for these contaminants. However, permit authorities should address these contaminants in NPDES permit actions using the State's existing narrative criteria for toxics.

o. These criteria were promulgated for specific waters in California in the National Toxics Rule (''NTR''), at § 131.36. The specific waters to which the NTR criteria apply include: Waters of the State defined as bays or estuaries and waters of the State defined as inland, i.e., all surface waters of the State not ocean waters. These waters specifically include the San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta. This section does not apply instead of the NTR for this criterion.

p. A criterion of 20 ug/l was promulgated for specific waters in California in the NTR and was promulgated in the total recoverable form. The specific waters to which the NTR criterion applies include: Waters of the San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta; and waters of Salt Slough, Mud Slough (north) and the San Joaquin River, Sack Dam to the mouth of the Merced River. This section does not apply instead of the NTR for this criterion. The State of California adopted and EPA approved a site specific criterion for the San Joaquin River, mouth of Merced to Vernalis; therefore, this section does not apply to these waters.

q. This criterion is expressed in the total recoverable form. This criterion was promulgated for specific waters in California in the NTR and was promulgated in the total recoverable form. The specific waters to which the NTR criterion applies include: Waters of the San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta; and waters of Salt Slough, Mud Slough (north) and the San Joaquin River, Sack Dam to Vernalis. This criterion does not apply instead of the NTR for these waters. This criterion applies to additional waters of the United States in the State of California pursuant to 40 CFR 131.38(c). The State of California adopted and EPA approved a site-specific criterion for the Grassland Water District, San Luis National Wildlife Refuge, and the Los Banos State Wildlife Refuge; therefore, this criterion does not apply to these waters.

r. These criteria were promulgated for specific waters in California in the NTR. The specific waters to which the NTR criteria apply include: Waters of the State defined as bays or estuaries including the San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta. This section does not apply instead of the NTR for these criteria.

s. These criteria were promulgated for specific waters in California in the NTR. The specific waters to which the NTR criteria apply include: Waters of the Sacramento-San Joaquin Delta and waters of the State defined as inland (*i.e.,* all surface waters of the State not bays or estuaries or ocean) that include a MUN use designation. This section does not apply instead of the NTR for these criteria.

t. These criteria were promulgated for specific waters in California in the NTR. The specific waters to which the NTR criteria apply include: Waters of the State defined as bays and estuaries including San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta; and waters of the State defined as inland (i.e., all surface waters of the State not bays or estuaries or ocean) without a MUN use designation. This section does not apply instead of the NTR for these criteria.

u. PCBs are a class of chemicals which include aroclors 1242, 1254, 1221, 1232, 1248, 1260, and 1016, CAS numbers 53469219, 11097691, 11104282, 11141165, 12672296, 11096825, and 12674112, respectively. The aquatic life criteria apply to the sum of this set of seven aroclors.

v. This criterion applies to total PCBs, e.g., the sum of all congener or isomer or homolog or aroclor analyses.

w. This criterion has been recalculated pursuant to the 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water, Office of Water, EPA–820-B–96–001, September 1996. See also Great Lakes Water Quality Initiative Criteria Documents for the Protection of Aquatic Life in Ambient Water, Office of Water, EPA–80–B–95–004, March 1995.

x. The State of California has adopted and EPA has approved site specific criteria for the Sacramento River (and tributaries) above Hamilton City; therefore, these criteria do not apply to these waters.

General Notes to Table in Paragraph (b)(1)

1. The table in this paragraph (b)(1) lists all of EPA's priority toxic pollutants whether or not criteria guidance are available. Blank spaces indicate the absence of national section 304(a) criteria guidance. Because of variations in chemical nomenclature systems, this listing of toxic pollutants does not duplicate the listing in Appendix A to 40 CFR Part 423–126 Priority Pollutants. EPA has added the Chemical Abstracts Service (CAS) registry numbers, which provide a unique identification for each chemical.

2. The following chemicals have organoleptic-based criteria recommendations that are not included on this chart: zinc, 3-methyl-4-chlorophenol.

3. Freshwater and saltwater aquatic life criteria apply as specified in paragraph (c)(3) of this section.

(2) Factors for Calculating Metals Criteria. Final CMC and CCC values should be rounded to two significant figures.

(i) *CMC = WER* × (*Acute Conversion Factor)* × (exp{m_A[1n (*hardness*)]+b_A})

(ii) *CCC = WER* × (*Acute Conversion Factor)* × (exp{m_C[1n (*hardness*)]+b_C})

(iii) Table 1 to paragraph (b)(2) of this section:

Metal	m_A	b_A	m_C	b_C
Cadmium	1.128	−3.6867	0.7852	−2.715
Copper	0.9422	−1.700	0.8545	−1.702
Chromium (III)	0.8190	3.688	0.8190	1.561
Lead	1.273	−1.460	1.273	−4.705
Nickel	0.8460	2.255	0.8460	0.0584
Silver	1.72	−6.52		
Zinc	0.8473	0.884	0.8473	0.884

Note to Table 1: The term ''exp'' represents the base e exponential function.

(iv) Table 2 to paragraph (b)(2) of this section:

Metal	Conversion factor (CF) for freshwater acute criteria	CF for freshwater chronic criteria	CF for saltwater acute criteria	CF [a] for saltwater chronic criteria
Antimony	([d])	([d])	([d])	([d])
Arsenic	1.000	1.000	1.000	1.000
Beryllium	([d])	([d])	([d])	([d])
Cadmium	[b] 0.944	[b] 0.909	0.994	0.994
Chromium (III)	0.316	0.860	([d])	([d])
Chromium (VI)	0.982	0.962	0.993	0.993
Copper	0.960	0.960	0.83	0.83
Lead	[b] 0.791	[b] 0.791	0.951	0.951
Mercury				
Nickel	0.998	0.997	0.990	0.990
Selenium		([c])	0.998	0.998
Silver	0.85	([d])	0.85	([d])
Thallium	([d])	([d])	([d])	([d])
Zinc	0.978	0.986	0.946	0.946

Footnotes to Table 2 of Paragraph (b)(2):

[a] Conversion Factors for chronic marine criteria are not currently available. Conversion Factors for acute marine criteria have been used for both acute and chronic marine criteria.

[b] Conversion Factors for these pollutants in freshwater are hardness dependent. CFs are based on a hardness of 100 mg/l as calcium carbonate ($CaCO_3$). Other hardness can be used; CFs should be recalculated using the equations in table 3 to paragraph (b)(2) of this section.

[c] Bioaccumulative compound and inappropriate to adjust to percent dissolved.

[d] EPA has not published an aquatic life criterion value.

Note to Table 2 of Paragraph (b)(2): The term ''Conversion Factor'' represents the recommended conversion factor for converting a metal criterion expressed as the total recoverable fraction in the water column to a criterion expressed as the dissolved fraction in the water column. See ''Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria'', October 1, 1993, by Martha G. Prothro, Acting Assistant Administrator for Water available from Water Resource Center, USEPA, Mailcode RC4100, M Street SW, Washington, DC, 20460 and the note to § 131.36(b)(1).

(v) Table 3 to paragraph (b)(2) of this section:

	Acute	Chronic
Cadmium	CF=1.136672—[(ln {hardness}) (0.041838)]	CF = 1.101672—[(ln {hardness})(0.041838)]
Lead	CF=1.46203—[(ln {hardness})(0.145712)]	CF = 1.46203—[(ln {hardness})(0.145712)]

(c) *Applicability.* (1) The criteria in paragraph (b) of this section apply to the State's designated uses cited in paragraph (d) of this section and apply concurrently with any criteria adopted by the State, except when State regulations contain criteria which are more stringent for a particular parameter and use, or except as provided in footnotes p, q, and x to the table in paragraph (b)(1) of this section.

(2) The criteria established in this section are subject to the State's general rules of applicability in the same way and to the same extent as are other Federally-adopted and State-adopted numeric toxics criteria when applied to the same use classifications including mixing zones, and low flow values below which numeric standards can be exceeded in flowing fresh waters.

(i) For all waters with mixing zone regulations or implementation procedures, the criteria apply at the appropriate locations within or at the boundary of the mixing zones; otherwise the criteria apply throughout the water body including at the point of discharge into the water body.

(ii) The State shall not use a low flow value below which numeric standards can be exceeded that is less stringent than the flows in Table 4 to paragraph (c)(2) of this section for streams and rivers.

(iii) Table 4 to paragraph (c)(2) of this section:

Criteria	Design flow
Aquatic Life Acute Criteria (CMC).	1 Q 10 or 1 B 3
Aquatic Life Chronic Criteria (CCC).	7 Q 10 or 4 B 3
Human Health Criteria.	Harmonic Mean Flow

Note to Table 4 of Paragraph (c)(2): 1. CMC (Criteria Maximum Concentration) is the water quality criteria to protect against acute effects in aquatic life and is the highest instream concentration of a priority toxic pollutant consisting of a short-term average not to be exceeded more than once every three years on the average.

2. CCC (Continuous Criteria Concentration) is the water quality criteria to protect against chronic effects in aquatic life and is the highest in stream concentration of a priority toxic pollutant consisting of a 4-day average not to be exceeded more than once every three years on the average.

3. 1 Q 10 is the lowest one day flow with an average recurrence frequency of once in 10 years determined hydrologically.

4. 1 B 3 is biologically based and indicates an allowable exceedence of once every 3 years. It is determined by EPA's computerized method (DFLOW model).

5. 7 Q 10 is the lowest average 7 consecutive day low flow with an average recurrence frequency of once in 10 years determined hydrologically.

6. 4 B 3 is biologically based and indicates an allowable exceedence for 4 consecutive days once every 3 years. It is determined by EPA's computerized method (DFLOW model).

(iv) If the State does not have such a low flow value below which numeric standards do not apply, then the criteria included in paragraph (d) of this section apply at all flows.

(v) If the CMC short-term averaging period, the CCC four-day averaging period, or once in three-year frequency is inappropriate for a criterion or the site to which a criterion applies, the State may apply to EPA for approval of an alternative averaging period, frequency, and related design flow. The State must submit to EPA the bases for any alternative averaging period, frequency, and related design flow. Before approving any change, EPA will publish for public comment, a document proposing the change.

(3) The freshwater and saltwater aquatic life criteria in the matrix in paragraph (b)(1) of this section apply as follows:

(i) For waters in which the salinity is equal to or less than 1 part per thousand 95% or more of the time, the applicable criteria are the freshwater criteria in Column B;

(ii) For waters in which the salinity is equal to or greater than 10 parts per thousand 95% or more of the time, the applicable criteria are the saltwater criteria in Column C except for selenium in the San Francisco Bay estuary where the applicable criteria are the freshwater criteria in Column B (refer to footnotes p and q to the table in paragraph (b)(1) of this section); and

(iii) For waters in which the salinity is between 1 and 10 parts per thousand as defined in paragraphs (c)(3)(i) and (ii) of this section, the applicable criteria are the more stringent of the freshwater or saltwater criteria. However, the Regional Administrator may approve the use of the alternative freshwater or saltwater criteria if scientifically defensible information and data demonstrate that on a site-specific basis the biology of the water body is dominated by freshwater aquatic life and that freshwater criteria are more appropriate; or conversely, the biology of the water body is dominated by saltwater aquatic life and that saltwater criteria are more appropriate. Before approving any change, EPA will publish for public comment a document proposing the change.

(4) *Application of metals criteria.* (i) For purposes of calculating freshwater aquatic life criteria for metals from the equations in paragraph (b)(2) of this section, for waters with a hardness of 400 mg/l or less as calcium carbonate, the actual ambient hardness of the surface water shall be used in those equations. For waters with a hardness of over 400 mg/l as calcium carbonate, a hardness of 400 mg/l as calcium carbonate shall be used with a default Water-Effect Ratio (WER) of 1, or the actual hardness of the ambient surface water shall be used with a WER. The same provisions apply for calculating the metals criteria for the comparisons provided for in paragraph (c)(3)(iii) of this section.

(ii) The hardness values used shall be consistent with the design discharge conditions established in paragraph (c)(2) of this section for design flows and mixing zones.

(iii) The criteria for metals (compounds #1—#13 in the table in paragraph (b)(1) of this section) are expressed as dissolved except where otherwise noted. For purposes of calculating aquatic life criteria for metals from the equations in footnote i to the table in paragraph (b)(1) of this section and the equations in paragraph (b)(2) of this section, the water effect ratio is generally computed as a specific pollutant's acute or chronic toxicity value measured in water from the site covered by the standard, divided by the respective acute or chronic toxicity value in laboratory dilution water. To use a water effect ratio other than the default of 1, the WER must be determined as set forth in Interim Guidance on Determination and Use of Water Effect Ratios, U.S. EPA Office of Water, EPA–823–B–94–001, February 1994, or alternatively, other scientifically defensible methods adopted by the State as part of its water quality standards program and approved by EPA. For calculation of criteria using site-specific values for both the hardness and the water effect ratio, the hardness used in the equations in paragraph (b)(2) of this section must be determined as required in paragraph (c)(4)(ii) of this section. Water hardness must be calculated from the measured calcium and magnesium ions present, and the ratio of calcium to magnesium should be approximately the same in standard laboratory toxicity testing water as in the site water.

(d)(1) Except as specified in paragraph (d)(3) of this section, all waters assigned any aquatic life or human health use classifications in the Water Quality Control Plans for the various Basins of the State (''Basin Plans'') adopted by the California State Water Resources Control Board (''SWRCB''), except for ocean waters covered by the Water Quality Control Plan for Ocean Waters of California (''Ocean Plan'') adopted by the SWRCB with resolution Number 90–27 on March 22, 1990, are subject to the criteria in paragraph (d)(2) of this section, without exception. These criteria apply to waters identified in the Basin Plans. More particularly, these criteria apply to waters identified in the Basin Plan chapters designating beneficial uses for waters within the region. Although the State has adopted several use designations for each of these waters, for purposes of this action, the specific standards to be applied in paragraph (d)(2) of this section are based on the presence in all waters of some aquatic life designation and the presence or absence of the MUN use designation (municipal and domestic supply). (See Basin Plans for more detailed use definitions.)

(2) The criteria from the table in paragraph (b)(1) of this section apply to the water and use classifications defined in paragraph (d)(1) of this section as follows:

Water and use classification	Applicable criteria
(i) All inland waters of the United States or enclosed bays and estuaries that are waters of the United States that include a MUN use designation.	(A) Columns B1 and B2—all pollutants (B) Columns C1 and C2—all pollutants (C) Column D1—all pollutants
(ii) All inland waters of the United States or enclosed bays and estuaries that are waters of the United States that do not include a MUN use designation.	(A) Columns B1 and B2—all pollutants (B) Columns C1 and C2—all pollutants (C) Column D2—all pollutants

(3) Nothing in this section is intended to apply instead of specific criteria, including specific criteria for the San Francisco Bay estuary, promulgated for California in the National Toxics Rule at § 131.36.

(4) The human health criteria shall be applied at the State-adopted 10 (−6) risk level.

(5) Nothing in this section applies to waters located in Indian Country.

(e) *Schedules of compliance.* (1) It is presumed that new and existing point source dischargers will promptly comply with any new or more restrictive water quality-based effluent limitations (''WQBELs'') based on the water quality criteria set forth in this section.

(2) When a permit issued on or after May 18, 2000 to a new discharger contains a WQBEL based on water quality criteria set forth in paragraph (b) of this section, the permittee shall comply with such WQBEL upon the commencement of the discharge. A new discharger is defined as any building, structure, facility, or installation from which there is or may be a ''discharge of pollutants'' (as defined in 40 CFR 122.2) to the State of California's inland surface waters or enclosed bays and estuaries, the construction of which commences after May 18, 2000.

(3) Where an existing discharger reasonably believes that it will be infeasible to promptly comply with a new or more restrictive WQBEL based on the water quality criteria set forth in this section, the discharger may request approval from the permit issuing authority for a schedule of compliance.

(4) A compliance schedule shall require compliance with WQBELs based on water quality criteria set forth in paragraph (b) of this section as soon as possible, taking into account the dischargers' technical ability to achieve compliance with such WQBEL.

(5) If the schedule of compliance exceeds one year from the date of permit issuance, reissuance or modification, the schedule shall set forth interim requirements and dates for their achievement. The dates of completion between each requirement may not exceed one year. If the time necessary for completion of any requirement is more than one year and is not readily divisible into stages for completion, the permit shall require, at a minimum, specified dates for annual submission of progress reports on the status of interim requirements.

(6) In no event shall the permit issuing authority approve a schedule of compliance for a point source discharge which exceeds five years from the date of permit issuance, reissuance, or modification, whichever is sooner. Where shorter schedules of compliance are prescribed or schedules of compliance are prohibited by law, those provisions shall govern.

(7) If a schedule of compliance exceeds the term of a permit, interim permit limits effective during the permit shall be included in the permit and addressed in the permit's fact sheet or statement of basis. The administrative record for the permit shall reflect final permit limits and final compliance dates. Final compliance dates for final permit limits, which do not occur during the term of the permit, must occur within five years from the date of issuance, reissuance or modification of the permit which initiates the compliance schedule. Where shorter schedules of compliance are prescribed or schedules of compliance are prohibited by law, those provisions shall govern.

(8) The provisions in this paragraph (e), Schedules of compliance, shall expire on May 18, 2005.

[FR Doc. 00–11106 Filed 5–17–00; 8:45 am]
BILLING CODE 6560–50–P

records. Appellate determinations, including extensions of time on appeal, with respect to records of the United States Secret Service will be made by the Deputy Director, United States Secret Service. Appeals may be mailed or delivered personally to: Privacy Act Amendment Appeal, Deputy Director, United States Secret Service, 950 H Street, NW., Suite 8300, Washington, DC 20373–5802.

* * * * *

5. Amend 31 CFR part 1, subpart C, appendix D—UNITED STATES SECRET SERVICE, paragraph 6, by removing ''Room 843, 1800 G Street NW., Washington, DC 20223,'' and adding in its place, ''Suite 8300, 950 H Street, NW., Washington, DC 20373–5802.''

Date: February 6, 2001.

W. Earl Wright, Jr.,

Chief Management and Administrative Programs Officer.

[FR Doc. 01–3634 Filed 2–12–01; 8:45 am]

BILLING CODE 4810–42–P

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 131

[FRL –6941–1]

RIN 2040–AC44

Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California; Correction

AGENCY: Environmental Protection Agency.

ACTION: Final Rule; correction.

SUMMARY: This document contains corrections to a final rule, *Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California,* also know as the California Toxics Rule, which was published in the **Federal Register** on Thursday, May 18, 2000 (65 FR 31682). The California Toxics Rule promulgated numeric aquatic life and human health criteria for priority toxic pollutants and a compliance schedule provision which authorizes the State to issue schedules of compliance for new or revised National Pollutant Discharge Elimination System permit limits based on the federal criteria when certain conditions are met.

EFFECTIVE DATE: This action is effective February 13, 2001.

ADDRESSES: The administrative record for the final rule is available for public inspection at the U.S. Environmental Protection Agency, Region 9, Water Division, 75 Hawthorne Street, San Francisco, California 94105, between the hours of 8 a.m. and 4:30 p.m. For access to the administrative record, call Diane E. Fleck, P.E., Esq. at (415) 744–1997 for an appointment. A reasonable fee will be charged for photocopies.

FOR FURTHER INFORMATION CONTACT: Diane E. Fleck, P.E., Esq. or Philip Woods, U.S. Environmental Protection Agency, Region 9, Water Division, 75 Hawthorne Street, San Francisco, California 94105, (415) 744–1984 or (415) 744–1997, respectively.

SUPPLEMENTARY INFORMATION: On May 18, 2000, EPA published a final rule in the **Federal Register** titled *Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California* (see 65 FR 31682) that contained typographical errors. These typographical errors consisted of omission of units in the column headings to a table, inadvertent placement of a zero in one of the numeric criteria values, an oversight in the correct CAS number for a pollutant, and the incorrect placement of a parameter in a formula. This action corrects those typographical errors. These corrections are all minor in nature and do not substantively alter the final rule.

Section 553 of the Administrative Procedure Act, 5 U.S.C. 553(b)(B), provides that, when an agency for good cause finds that notice and public procedure are impracticable, unnecessary or contrary to the public interest, the agency may issue a rule without providing notice and an opportunity for public comment. EPA has determined that there is good cause for making today's rule final without prior proposal and opportunity for comment because this action merely corrects typographical errors in a rule that already went through public notice and comment. Furthermore, the corrections in today's rule are all minor in nature and do not substantively alter the final rule. Thus, notice and public procedure are unnecessary. EPA finds that this constitutes good cause under 5 U.S.C. 553(b)(B).

Under Executive Order 12866 (58 FR 51735, October 4, 1993), this action is not a ''significant regulatory action'' and is therefore not subject to review by the Office of Management and Budget. Because the agency has made a ''good cause'' finding that this action is not subject to notice-and-comment requirements under the Administrative Procedure Act or any other statute, it is not subject to the regulatory flexibility provisions of the Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*), or to sections 202 and 205 of the Unfunded Mandates Reform Act of 1995 (UMRA) (Pub. L. 104–4). In addition, this action does not significantly or uniquely affect small governments or impose a significant intergovernmental mandate, as described in sections 203 and 204 of UMRA. This rule also does not significantly or uniquely affect the communities of tribal governments, as specified by Executive Order 13084 (63 FR 27655, May 10, 1998). This rule will not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government, as specified in Executive Order 13132 (64 FR 43255, August 10, 1999). This rule also is not subject to Executive Order 13045 (62 FR 19885, April 23, 1997), because it is not economically significant. This technical correction action does not involve technical standards; thus, the requirements of section 12(d) of the National Technology Transfer and Advancement Act of 1995 (15 U.S.C. 272 note) do not apply. This rule does not impose an information collection burden under the provisions of the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 *et seq.*). EPA's compliance with these statutes and Executive Orders for the underlying rule is discussed in the May 18, 2000, **Federal Register** notice (65 FR 31682).

The Congressional Review Act (5 U.S.C. 801 *et seq.*), as added by the Small Business Regulatory Enforcement Fairness Act of 1996, generally provides that before a rule may take effect, the agency promulgating the rule must submit a rule report, which includes a copy of the rule, to each House of the Congress and to the Comptroller General of the United States. Section 808 allows the issuing agency to make a rule effective sooner than otherwise provided by the CRA if the agency makes a good cause finding that notice and public procedure is impracticable, unnecessary or contrary to the public interest. This determination must be supported by a brief statement. 5 U.S.C. 808(2). As stated previously, EPA has made such a good cause finding, including the reasons therefor, and established an effective date of February 13, 2001. EPA will submit a report containing this rule and other required information to the U.S. Senate, the U.S. House of Representatives, and the Comptroller General of the United States prior to publication of the rule in the **Federal Register**. This action is not a ''major rule'' as defined by 5 U.S.C. 804(2).

List of Subjects in 40 CFR Part 131

Environmental protection, Intergovernmental relations, Reporting and recordkeeping requirements, water pollution control.

Dated: January 19, 2001.

J. Charles Fox,

Assistant Administrator, Office of Water.

For the reasons set out in the preamble, part 131 of chapter 1 of title 40 of the Code of Federal Regulations is amended as follows:

PART 131—WATER QUALITY STANDARDS

1. The authority citation for part 131 continues to read as follows:

Authority: 33 U.S.C. 1251 *et seq.*

Subpart D—[Amended]

2. Section 131.38 is amended:

a. In the table to paragraph (b)(1) under the column heading for ''B Freshwater'' by revising the column headings for ''Criterion Maximum Concentration'' and ''Criterion Continuous Concentration''.

b. In the table to paragraph (b)(1) under the column heading for ''C Saltwater'' by revising the column headings for ''Criterion Maximum Concentration'' and ''Criterion Continuous Concentration''.

c. Revising entry ''23.'' to the table in paragraph (b)(1).

d. Revising entry ''67.'' to the table in paragraph (b)(1).

e. Revising paragraph (b)(2)(ii).

The revisions read as follows:

§ 131.38 Establishment of Numeric Criteria for priority toxic pollutants for the State of California.

* * * * *

(b)(1) * * *

A		B Freshwater		C Saltwater		D Human health (10^{-6}) risk for carcinogens) For consumption of:	
# Compound	CAS number	Criterion maximum conc. (µg/L)[d] B1	Criterion continous conc. (µg/L)[d] B2	Criterion maximum conc. (µg/L)[d] C1	Criterion continious conc. (µg/L)[d] C2	Water & organisms (µg/L) D1	Organisms only (µg/L) D2
* * *		*	*	*		*	
23. Chlorodibromomethane	124481					[a,c] 0.41	[a,c] 34
* * *		*	*	*		*	
67. Bis(2-Chloroisopropyl)Ether	108601					[a] 1,400	[a,t] 170,000
* * *		*	*	*		*	

Footnotes to table in Paragraph (b)(1):

* * * * * * *

[a] Criteria revised to reflect the Agency q1* or RfD, as contained in the Integrated Risk Information System (IRIS) as of October 1, 1996. The fish tissue bioconcentration factor (BCF) from the 1980 documents was retained in each case.

[c] Criteria are based on carcinogenicity of 10^{-6} risk.

[d] Criteria Maximum Concentration (CMC) equals the highest concentration of a pollutant to which aquatic life can be exposed for a short period of time without deleterious effects. Criteria Continuous Concentration (CCC) equals the highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4 days) without deleterious effects. µg/L equals micrograms per liter.

* * * * * * *

[t] These criteria were promulgated for specific waters in California in the NTR. The specific waters to which the NTR criteria apply include: Waters of the State defined as bays and estuaries including San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta; and waters of the State defined as inland (i.e., all surface waters of the State not bays or estuaries or ocean) without a MUN use designation. This section does not apply instead of the NTR for these criteria.

* * * * *

(2) * * *

(ii) CCC = WER x (Chronic Conversion Factor) x $(\exp\{m_c[\ln(hardness)]+b_c\})$

* * * * *

[FR Doc. 01–3617 Filed 2–12–01; 8:45 am]

BILLING CODE 6560–50–P

FEDERAL COMMUNICATIONS COMMISSION

47 CFR Parts 21, 73, and 76

[MM Docket Nos. 94–150, 92–51, and 87–154; FCC 00–438]

[RIN 3060–AF82]

Attribution Rules

AGENCY: Federal Communications Commission.

ACTION: Final rule; petition for reconsideration.

SUMMARY: This document concerns rules and policies for attributing cognizable interests in applying the broadcast multiple ownership rules, the broadcast-cable cross-ownership rule, and the cable-Multipoint Distribution Service cross-ownership rule. The intended effect of this action is to clarify and resolve issues raised in petitions for reconsideration pertaining to the application of the Commission's attribution rules.

DATES: Effective April 16, 2001. Written comments by the public on the proposed information collections are due April 16, 2001. Written comments must be submitted by the Office of Management and Budget (OMB) on the proposed information collection(s) on or before April 16, 2001.

ADDRESSES: Federal Communications Commission, 445 Twelfth Street, SW, Washington DC 20554. A copy of any comments on the information collections contained herein should be submitted to Judy Boley, Federal Communications Commission, Room 1–C804, 445 12th Street, SW, Washington, DC 20554, or via the Internet to *jboley@fcc.gov,* and the Edward C. Springer, OMB Desk Officer, Room 10236 NEOB, 725 17th Street, NW., Washington, DC 20503 or via the Internet to *edward.springer@omb.eop.gov.*

FOR FURTHER INFORMATION CONTACT: Cyndi Thomas or Mania Baghdadi, Policy and Rules Division, Mass Media Bureau, at (202) 418–2120. For additional information concerning the information collection(s) contained in this document, contact Judy Boley at 202–418–0214, or via the Internet at *jboley@fcc.gov.*

SUPPLEMENTARY INFORMATION: This is a summary of the *Memorandum Opinion and Order on Reconsideration ("MO&O")* in MM Docket Nos. 94–150, 92–51, and 87–154, FCC 00–438, adopted on December 14, 2000, and released on January 19, 2001. The full text of this decision is available for inspection and copying during regular business hours in the FCC Reference Center, 445 Twelfth Street, SW, Room CY–A257, Washington DC, and also may be purchased from the Commission's copy contractor, International Transcription Service, (202) 857–3800, 445 Twelfth Street, SW, Room CY–B402, Washington DC. The complete text is also available under the file name fcc00438.doc on the Commission's Internet site at *www.fcc.gov.*

This MO&O contains either new or modified information collection(s) subject to the Paperwork Reduction Act of 1995 (PRA). The general public and other Federal agencies are invited to comment on the proposed information collections contained in this proceeding.

Paperwork Reduction Act

This *MO&O* contains either new or modified information collections. The Commission, therefore, as part of its continuing effort to reduce paperwork burdens, invites the general public and the Office of Management and Budget to comment on the information collections contained in this *MO&O* as required by the Paperwork Reduction Act of 1995, Public Law 104–13. Public and agency comments are due 60 days from date of publication of this *MO&O* in the **Federal Register**. Comments should address: (a) Whether the new or modified collection of information is necessary for the proper performance of the functions of the Commission, including whether the information shall have practical utility; (b) the accuracy of the Commission's burden estimates; (c) ways to enhance the quality, utility, and clarity of the information collected; and (d) ways to minimize the burden of the collection of information on the respondents, including the use of automated collection techniques or other forms of information technology.

OMB Approval Number: 3060–XXXX

Title: Reconsideration of Mass Media Attribution Rules, MM Docket Nos. 94–150, 92–51, and 87–154.

APPENDIX D: Water Quality Technical Memo (TM)

TECHNICAL MEMORANDUM

North City Pure Water Facility (Miramar Reservoir)
30% Pre-Design
City of San Diego Pure Water Program

Date: November 29, 2016

Authors: Mitchel Bartolo, Eileen Idica, (Trussell Technologies, Inc.)

Reviewers: Fred Gerringer, Celine Trussell, David Hokanson, Aleks Pisarenko, Shane Trussell (Trussell Technologies, Inc.)
Madhavan Jayakumar (Brown and Caldwell)
Michael Priest, James Borchardt (MWH)
Bill Pearce (City of San Diego)

Subject: **Concentration of Key Water Quality Parameters in NCPWF (Miramar Reservoir) Process Streams**

1 - INTRODUCTION

As part of the City of San Diego (City) Pure Water Program, the City and its consulting team are developing a preliminary design for the North City Pure Water Facility (NCPWF). The NCPWF has the capacity to produce 34.0 mgd of Pure Water through a treatment train consisting of the following processes: ozonation, biological activated carbon (BAC) filtration, membrane filtration (MF) using either microfiltration or ultrafiltration, reverse osmosis (RO), ultraviolet light with advanced oxidation (UV/AOP), stabilization using lime and carbon dioxide, treated effluent chlorine disinfection, and finally dechlorination prior to discharging into the Miramar Reservoir (MR). This technical memorandum (TM) addresses the changes in key water quality parameters in each process effluent stream, and provides the basis for estimation of their concentration.

2 - CONCENTRATION OF KEY WATER QUALITY PARAMETERS IN EACH PROCESS STREAM

Table 2.1 presents the estimated change in selected water quality parameters as water flows through the NCPWF. Water quality in the NCPWF feed and individual process streams shown here generally correspond to values presented in the NCPWF (formerly North City Advanced Water Purification Facility) (MR) Pre-Design 10% Engineering

Design Report submitted to the City under Task 3 of Task Order 2 (10% Engineering Design Report) in November of 2015.

Feed water quality parameters were predicted using various sources including:

- Results from historical data at the North City Water Reclamation Plant (NCWRP),
- Data and sampling results from the Advanced Water Purification Facility Demonstration Project (Demonstration Project),
- Water quality measurements from four new sewer sources that are expected to be added to the NCWRP influent and taken as part of the Task 6 project (NCWRP Expansion Pre-Design), and
- BioWin modeling under Task 6.

Appendix A-2 of the 10% Engineering Design Report contains a detailed explanation of the feed water quality estimation.

Table 2.1 - Concentration of Key Parameters in NCPWF Process Effluent Streams

Quality at 34.0 mgd Treated Water Production		NCPWF Feed Water		Ozone Effluent		BAC Filtrate		MF Feed		MF Filtrate		RO Cartridge Filter Effluent	
		Stream 1 [a]		Stream 3		Stream 4		Stream 6		Stream 11		Stream 13	
Parameter	Units	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median
pH [b]	-	6.7 - 7.7	7.3	6.7 - 7.7	7.3	6.6 – 7.6	7.2	6.7 – 7.7	7.3	6.7 - 7.7	7.3	6.2 – 6.7	6.5
Alkalinity [c]	mg/L as $CaCO_3$	143 – 197	173	143 - 197	173	139 - 196	171	143 - 205	178	143 - 205	178	41 - 174	111
Turbidity [d]	NTU	0.1 – 1.0	0.2	0.1 – 1.0	0.2	0.06 – 0.75	0.12	0.06 – 0.75	0.12	0.01 - 0.08	0.03	0.01 - 0.08	0.03
Calcium [b]	mg/L as $CaCO_3$	238 – 263	250	238 - 263	250	238 – 263	250	238 – 263	250	187 - 206	197	187 - 206	197
Sodium [b]	mg/L	187 – 238	198	188 - 239	199	188 – 239	199	188 – 239	199	189 - 242	202	189 - 242	202
TOC [e]	mg/L	6.2 - 8.6	7.2	5.1 – 9.1	7.2	3.9 – 7.0	4.5	3.9 – 7.0	4.5	3.9 – 7.0	4.5	3.9 – 7.0	4.5
TDS [f]	mg/L	700 – 1320	1170	700 - 1320	1170	700 - 1320	1170	700 - 1320	1170	700 - 1320	1170	700 - 1320	1170
LSI [g]	-	-0.6 – 0.6	0.1	-0.6 – 0.6	0.1	-0.6 – 0.6	0.1	-0.6 – 0.6	0.1	-0.7 – 0.5	0.0	-1.9 – -0.5	-1.0
Free Chlorine [h]	mg/L as Cl_2	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)
Chloramines [h]	mg/L as Cl_2	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	2.0 - 5.0	3.0	2.0 - 5.0	3.0	2.0 - 5.0	3.0
Total Chlorine [h]	mg/L as Cl_2	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	ND (0.03)	2.0 - 5.0	3.0	2.0 - 5.0	3.0	2.0 - 5.0	3.0
Bromide [i]	mg/L	0.2 – 0.5	0.3	0.1 – 0.4	0.2	0.1 – 0.4	0.2	0.1 – 0.4	0.2	0.1 – 0.4	0.2	0.1 – 0.4	0.2
Bromate [j]	µg/L	ND (5)	ND (5)	130 – 165	138	130 – 165	138	130 – 165	138	130 – 165	138	130 – 165	138
HAA5 [k]	µg/L	1 – 20	2.2	1 – 31	6.5	ND (2)	ND (2)	1.0 – 5.6	4.4	1.0 – 5.6	4.4	1.0 – 5.6	4.4
TTHM [k]	µg/L	1.1 – 6.4	2.6	0.7 – 16	2.1	1.7 – 4.7	2.8	2.7 – 13	10	2.7 – 13	10	2.7 – 13	10
NDMA [l]	ng/L	2 – 41	3.8	18 – 55	31	2 – 24	2	2 – 28	2	2 – 28	2	2 – 28	2
1,4-dioxane [m]	µg/L	1	1	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)
Nitrate [c]	mg/L as N	5.4 – 11.2	7.7	5.4 – 11.2	7.7	5.5 – 11.8	7.9	5.5 – 11.8	7.9	5.5 – 11.8	7.9	5.5 – 11.8	7.9
Ammonia [c]	mg/L as N	0.1 – 0.5	0.15	0.1 – 0.5	0.15	ND (0.03)	ND (0.03)	0.7 – 1.6	0.8	0.7 – 1.6	0.8	0.7 – 1.6	0.8
Total N [c]	mg/L	7.8 – 13.9	10.4	7.8 – 13.9	10.4	7.8 – 13.9	10.4	8.5 – 15.5	11.2	8.5 – 15.5	11.2	8.5 – 15.5	11.2
Total P [c]	mg/L	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78

Table 2.1 - Concentration of Key Parameters in NCPWF Process Effluent Streams (contd.)

		RO Permeate		UV/AOP Feed After NaOCl Addition		UV/AOP Effluent		Finished Water			
Parameter	Units	Stream 17		Not defined		Stream 19		Post-CO_2	Post-Lime	Post-Chlorination	Post-Dechlorination
		Range	Median	Range	Median	Range	Median				
pH [b]	-	4.8 - 5.7	5.0	5.0 – 5.9	5.2	4.1 – 5.0	4.3	4.0 – 5.0	7.5 - 8.5	7.5 - 8.5	7.5 - 8.5
Alkalinity [c]	mg/L as $CaCO_3$	0 – 13	6	2 – 15	8	2 – 15	8	2 - 15	>100	>100	>100
Turbidity [d]	NTU	0.01 - 0.08	0.03	0.01 - 0.08	0.03	0.01 - 0.08	0.03	0.04	2.0	0.60	0.60
Calcium [b]	mg/L as $CaCO_3$	4 – 4.4	4.2	4 – 4.4	4.2	4 – 4.4	4.2	4.2	92 - 146	92 - 146	92 - 146
Sodium [b]	mg/L	5 - 20	9	7 – 22	11	7 – 22	11	7 - 22	7 - 22	9 - 24	10 - 25
TOC [e]	mg/L	0.02 – 0.07	0.03	0.02 – 0.07	0.03	0.02 – 0.07	0.03	0.03	0.03	0.03	0.03
TDS [f]	mg/L	14 – 69	36	14 – 69	36	14 – 69	36	14 – 69	50 - 195	50 - 195	50 - 195
LSI [g]	-	-6.2 – -4.3	-5.4	-5.5 – -3.5	-4.7	-5.5 – -3.5	-4.7	-5.7 – -4.6	0 – 0.5	0 – 0.5	0 – 0.5
Free Chlorine[h]	mg/L as Cl_2	ND (0.03)	ND (0.03)	2.0	2.0	1.0	1.0	1.0	1.0	1.5 – 4.0	ND (0.03)
Chloramines[h]	mg/L as Cl_2	1.5 - 3.0	2.0	1.5 - 3.0	2.0	0.7 – 1.5	1.0	1.0	1.0	1.0	ND (0.03)
Total Chlorine[h]	mg/L	1.5 - 3.0	2.0	3.5 – 5.0	4.0	1.7 – 2.5	2.0	2.0	2.0	2.5 – 5.0 [n]	ND (0.03) [n]
Bromide [i]	mg/L	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Bromate [j]	µg/L	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)
HAA5 [k]	µg/L	ND (2)	ND (2)	ND (2)	ND (2)	1.5 - 5.3	3.3	3.3	3.3	3.3	3.3
TTHM [k]	µg/L	1.4 – 5.3	2.7	1.4 – 5.3	2.7	2 – 5	3.8	3.8	3.8	3.8	3.8
NDMA [l]	ng/L	2 – 29	2	2 – 29	2	2 – 12	ND (2)	ND (2)	ND (2)	ND (2)	ND (2)
1,4-dioxane [m]	µg/L	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)
Nitrate [c]	mg/L as N	0.71 – 1.52	1.02	0.71 – 1.52	1.02	0.52 – 1.12	0.75	0.75	0.75	0.75	0.75
Ammonia [c]	mg/L as N	0.27 – 0.62	0.31	0.27 – 0.62	0.31	0.27 – 0.62	0.31	0.31	0.31	0.31	ND (0.03)
Total N [c]	mg/L	1.0 – 2.1	1.3	1.0 – 2.1	1.3	0.8 – 1.7	1.1	1.1	1.1	1.1	0.8
Total P [c]	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

[a] Stream numbers are consistent with the process flow diagram (PFD) provided in Appendix A of this TM

[b] Feed water ranges provided for pH, calcium, and sodium represent operating conditions at the Demonstration Project from September 2013 to June 2014 and daily samples of new sewer sources for two weeks in June 2015. Subsequent ranges result from calculations after each treatment process.

[c] Feed water ranges provided for alkalinity, nitrate, ammonia, total N, and total P represent BioWin wastewater treatment plant modeling predictions. Subsequent ranges result from calculations after each treatment process.

[d] The feed water range and BAC effluent range provided for turbidity represent operating conditions at the Demonstration Project from an online turbidimeter sampling daily from August 2014 to September 2015. The upper limit is set by the NCWRP tertiary effluent goal of 1.0 NTU or less. The BAC filtrate upper limit is from a conservative estimate of 25% removal, as informed by Demonstration Project data. The MF filtrate turbidity range is taken from 500 samples in 2014 and 2015.

[e] The feed water range provided for TOC represents tertiary filtered effluent samples collected by the City of San Diego in November and December 2014. Ozone effluent and filtrate TOC ranges are taken from Demonstration Project samples between April 2015 and March 2016. RO permeate ranges result from measurements taken at the Demonstration Project from October 2014 to November 2015.

[f] The feed water range provided for TDS represents NCWRP raw influent data from January to June 2015 taken by the City of San Diego and daily samples of new sewer sources for two weeks in June 2015. Subsequent ranges result from calculations after each treatment process.

[g] Ranges provided for LSI represent calculations using Standard Method 2330 B with a modification for errors at high pH (Kenny et al., 2015).

[h] Ranges provided for chlorine species represent calculations made along each step of the treatment process including expected NaOCl design doses and reactions in the treatment train.

[i] The feed water range provided for bromide represents tertiary effluent data from 33 samples ranging from 2013 to 2016, as well as daily samples of new sewer sources for two weeks in June 2015. The expected Ozone effluent range of bromide is taken from 14 samples at the Demonstration Project in November and December of 2014. The expected BAC effluent range of bromide is taken from 19 samples in November and December of 2014 and various months throughout 2015 and 2016. The RO permeate value comes from 5 of 5 non-detects from November to December of 2015.

[j] Feed water values provided for bromate represent 20 of 20 non-detect samples of filtered tertiary effluent taken from 2013 to 2016. The Ozone effluent range is provided from 6 samples at the Demonstration Project in November and December of 2014 (not including non-detects). The RO permeate value comes from 11 of 11 non-detects from November 2014 to September 2015.

[k] The feed water HAA5 and TTHM ranges come from 21 NCPWF feed samples from 2014 to 2016 (and conservatively do not reflect 5 non-detect measurements for HAA5). The Ozone effluent ranges come from 20 Demonstration Project samples throughout 2014 to 2016. The BAC filtrate values come from 19 samples throughout 2014 to 2016. The MF filtrate ranges were provided by 18 samples throughout 2014 to 2016. The RO permeate and UV/AOP effluent ranges were taken throughout 2014 to 2015 from 19 and 20 samples, respectively.

[l] The feed water NDMA range comes from 14 NCPWF feed samples from 2014 to 2016. The Ozone effluent and effluent ranges come from 13 Demonstration Project samples throughout 2014 to 2016. The MF filtrate range was provided by 9 samples throughout 2014 to 2016. The RO permeate and UV/AOP effluent ranges were taken throughout 2014 to 2015 from 17 and 20 samples, respectively.

[m] The feed water 1,4-dioxane range comes from 8 non-detect samples and a single 1 µg/L sample from NCPWF feed in November and December of 2014. The Ozone effluent and effluent ranges come from 6 Demonstration Project samples during November and December of 2014. The MF filtrate and RO permeate ranges were provided by 5 samples in November and December of 2014. The UV/AOP effluent ranges was from 6 non-detects in November and December of 2014

[n] Total chlorine residual (present as free chlorine) is expected to be around 2.5 mg/L as Cl_2 just prior to the dechlorination facility after complete chloramine breakpoint and chlorine decay through the product water pipeline to Miramar Reservoir.

2.1 pH

For estimation of pH in the projected NCPWF feed water, coordination was performed with the Task 6 project (NCWRP Expansion Pre-Design) to assess if future upgrades to the NCWRP would significantly change the pH of the existing NCWRP tertiary filtered effluent. It was determined that future plant operations would not differ greatly from the existing operations, and that historical pH data would be appropriate to use in approximating the NCPWF feed pH. Therefore, the projected tertiary effluent discharge from the NCWRP is expected to have a pH between 6.7 and 7.7, with a median of 7.3.

Feed water is first injected with ozone and then flows into the ozone contactors, followed by filtration through BAC. No significant change in pH is expected during the ozonation process. A pH decrease of 0.1 is expected due to biological activity in the BAC filters and occurs in concert with the alkalinity drop across this process. Both predictions are based on observations at the Demonstration Project. Sodium hypochlorite and ammonium hydroxide are added to the feed water prior to MF to form chloramines, which aid in controlling biofouling of the RO membranes. The formation of chloramines will increase the pH due to their alkaline nature, and the pH is expected to be within the 6.7 to 7.7 range again.

Before the water flows into the RO membranes, the pH needs to be adjusted to control mineral deposition and scale formation. Addition of sulfuric acid is planned in order to reduce the pH in RO feed to a range of 6.2 to 6.7 to control calcium phosphate scaling. Section 4.5.6 of the 10% Engineering Design Report explains pretreatment and scaling control in further detail. RO modeling performed with the projected feed water for two extreme cases (highest rejection and lowest rejection) indicated that the permeate will likely have a pH of 4.8 to 5.7; a median pH of 5.0 is assumed for the RO permeate. Details of the RO modeling are provided in Appendix A-7 of the 10% Engineering Design Report, with an update in Appendix B-5 of the 30% Engineering Design Report.

The NCPWF design uses chlorine as an oxidant for the UV/AOP system. At a pH of 6.5 and below, hypochlorous acid (HOCl) is the dominant species in water, and is the species primarily responsible for generation of hydroxyl radicals. It is very likely, based on the RO permeate pH projection modeling, that the UV/AOP feed water will have a pH less than 6.5. Addition of sodium hypochlorite (to provide HOCl) will increase the pH slightly, with an assumed average pH increase of 0.2 based on UV testing done for the City of San Diego at the Demonstration Project (UV Testing Report). The RO permeate water is stripped of alkalinity and may be sensitive to slight pH changes by base addition (i.e. sodium hypochlorite) due to its low buffering capacity. Therefore, an acid dosing system to the RO permeate has been added to the design as a provision to ensure that, even under various pre-RO and post-RO chemical dosing schemes, the pH entering the UV/AOP process will be sufficiently low to allow an effective process that meets the regulatory goals. The UV Testing Report revealed a drop in pH after exposure to UV/HOCl, with an average pH drop of 0.9 units through the reactor at the 849 mJ/cm^2 UV dose. The result is an expected pH range of 4.1 to 5.0 with a median pH assumed to be 4.3, through the UV/AOP process.

After RO and UV/AOP, the low TDS and low pH water is stabilized using carbon dioxide followed by lime addition to reduce its corrosive nature before it is conveyed to the reservoir. The target pH range of the water discharged to the reservoir is 7.5 to 8.5, per requirements from the Regional Water Quality Control Board. Accounting for the regime of possible CO_2 doses based on RO permeate water quality, the post-CO_2 pH is expected to be in the range of 4.0 to 5.0. Low acidity water from the RO permeate will require the dose of up to 90 mg/L CO_2 to buffer against extreme pH changes upon lime addition. Water with sufficient acidity (and carbonates to achieve the target LSI) requires no CO_2 addition. Addition of lime will then bring the pH to compliance within the range of 7.5 to 8.5. Sodium hypochlorite at a dose of 0.5 to 3 mg/L as Cl_2 is expected to be added to the product water to provide residual chlorine in the transmission pipeline, and the pH is expected to remain in the 7.5 to 8.5 range due to the buffering capacity of the product water. Just before water is discharged to the reservoir, all chlorine is expected to be quenched by adding sodium bisulfite. The addition of sodium bisulfite at the expected concentrations necessary for quenching is not expected to change the pH beyond the required 7.5 to 8.5 range, also due to the buffering capacity of the product water.

2.2 Alkalinity

For estimation of alkalinity in the NCPWF feed water, results from BioWin wastewater treatment plant modeling under Task 6 project (NCWRP Expansion Pre-Design) were used. The expected alkalinity in the feed water ranges from 143 to 197 mg/L as $CaCO_3$, with a median value of 173 mg/L as $CaCO_3$. After ozonation, sodium bisulfite is dosed at a concentration of 1 to 3 mg/L which adds 0.5 to 1.6 mg/L of alkalinity as $CaCO_3$. However, this alkalinity addition is expected to be offset by the oxidation of organics to alcohols and carboxylic acids in the ozone reactor resulting in a net alkalinity change near zero. This is supported by Demonstration Project data.

The polishing of ammonia via nitrification in the BAC filter is expected to decrease the alkalinity in the range of 0.7 to 4 mg/L as $CaCO_3$, assuming 8.64 mg/L of bicarbonate alkalinity consumed for every 1 mg/L of ammonia-N oxidized (USEPA, 2002). Ammonium hydroxide and sodium hypochlorite are added before the MF system at concentrations of 0.7 to 1.6 mg/L as N and 2 to 5 mg/L as Cl_2, respectively. Together, these add between 4 and 9 mg/L of alkalinity as $CaCO_3$.

The RO feed is supplemented with antiscalant and sulfuric acid for scaling control at doses of 1-5 mg/L and 30-100 mg/L, respectively. Based on projections from antiscalant manufacturers, water quality is not expected to change significantly. Sulfuric acid is expected to decrease alkalinity by 31 to 102 mg/L as $CaCO_3$. RO membranes remove most of the ions in solution, and alkalinity is reduced to low levels in this process. RO modeling performed on MF filtrate resulted in low levels of alkalinity ranging from 0 to 13 mg/L as $CaCO_3$ with a median of 6 mg/L as $CaCO_3$ in the RO permeate. During the UV/AOP process, approximately 1.5 mg/L as $CaCO_3$ of alkalinity will be added due to the addition of NaOCl at a dose of 2 mg/L as Cl_2.

Carbon dioxide added during post stabilization forms carbonic acid which will not change carbonate alkalinity. Lime addition at a design dose of 65 to 105 mg/L as $Ca(OH)_2$ is expected to increase alkalinity to the target for the product water of greater than 100 mg/L as $CaCO_3$. Chlorination of product water using NaOCl at a dose of 0.5 to 3 mg/L as Cl_2 is expected to increase the alkalinity by 0.4 to 2.1 mg/L as $CaCO_3$. After dechlorination, the alkalinity is expected to decrease about 1 mg/L as CaCO3, which is a net calculation assuming a decrease of alkalinity due to oxidation of HOCl at 2.5 mg/L as Cl_2 concentration and an increase of alkalinity due to sodium bisulfite addition at a dose of 5 mg/L. However, these chemical doses are not expected to significantly impact the final alkalinity goal achieved during lime dosing.

2.3 Turbidity

The NCPWF feed water turbidity is expected to range from 0.1 NTU to 1.0 NTU, with a median of 0.2 NTU, based on Demonstration Project data and the NCWRP tertiary effluent goal of 1.0 NTU or less. After ozonation, turbidity is expected to remain similar to that of the NCPWF feed water, therefore BAC influent turbidity values are analogous to those in the NCPWF feed. BAC influent turbidity values taken at the Demonstration Project from August 2014 to September 2015 are shown in the probability plot in Figure 1. Greater than 99% of feed turbidity values are expected to fall at or below 1.0 NTU, confirming the expected upper limit of 1.0 NTU for NCPWF feed and ozone effluent. Turbidity is expected to decrease after BAC filtration, with an expected range of 0.06 NTU to 0.75 NTU and a median value of 0.12 NTU, also based on the Demonstration Project data. The upper limit for BAC effluent turbidity was calculated from a conservative removal efficiency of 25%, as informed by Demonstration Project performance.

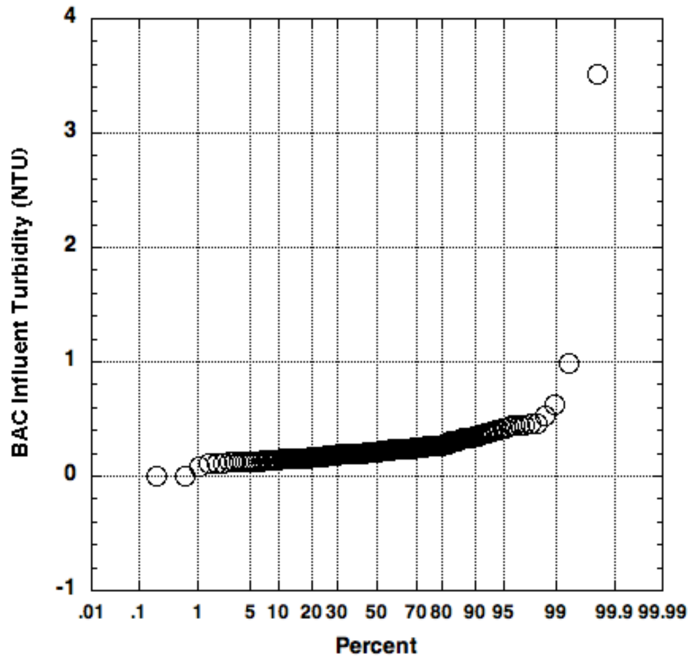

Figure 1: Probability plot of BAC influent turbidity taken from the Demonstration Project daily from 08/24/14 to 09/25/15 (N = 238 samples)

Maximum turbidity removal is achieved through MF. The design goal for MF is to achieve filtrate turbidity less than 0.15 NTU, and is based on the indirect integrity-monitoring requirement for filtration from the State and Federal Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) (EPA, 2010). The MF facilities at the Demonstration Project (ultrafiltration and microfiltration) have shown filtrate turbidity ranging from 0.01 to 0.08 NTU, with a median of 0.03 NTU. RO also reduces turbidity but is generally not designed for turbidity removal and hence not monitored for turbidity. As there are no processes that add turbidity through the RO and UV/AOP processes, the UV/AOP effluent is expected to have the same turbidity as the RO permeate.

Post-stabilization includes addition of lime, which may contribute turbidity to the finished water before reservoir discharge. A high-density (30% solids by weight or greater) lime slurry made from hydrated lime will be injected into the lime mixing boxes at the required dose of 65 to 105 mg/L as $Ca(OH)_2$. The effect of lime injection from this system was estimated from bench-scale testing conducted for the Los Angeles Department of Water and Power (LADWP). In the study, hydrated lime obtained from the Terminal Island Water Reclamation Plant was dosed directly into laboratory distilled water at a concentration of approximately 60 mg/L as $Ca(OH)_2$, resulting in a product water turbidity of 1.33 NTU. To account for the higher doses that will be used at the NCPWF, the bench-scale turbidity was increased by a factor of 1.5 to obtain an estimate of 2 NTU directly after lime addition. The lime mixing boxes and product water tank are expected to function as saturators in which the lime will dissolve (or settle), resulting in a decrease in turbidity. In the same study, lime water obtained from saturators at the Orange County Water District was dosed at 30 mg/L as $Ca(OH)_2$ which resulted in a turbidity of 0.20 NTU. After scaling up this dose to be consistent with the lime mixing tank estimate, a turbidity value of 0.60 NTU was calculated as an estimate of turbidity downstream of the lime mixing tanks. Turbidity is not expected to pose any issues in the final product water. Chlorination for residual disinfection in the pipeline and subsequent dechlorination are not expected to change the turbidity of water being discharged to the reservoir.

2.4 Calcium

Calcium in the NCPWF feed water is estimated to be in a range of 238 to 263 mg/L as $CaCO_3$ (95 to 105 mg/L as Ca) with a median concentration of 250 mg/L as $CaCO_3$ (100 mg/L as Ca).

Calcium concentrations are expected to fall within the range of the NCPWF feed water as Demonstration Project data from July 2014 to April 2015 shows negligible calcium removal through the ozonation and BAC processes. A calcium removal efficiency of about 21.4% through the MF system has been exhibited by the Demonstration Project, based on MF filtrate sampled from September 2013 to June 2014. Therefore, the estimated calcium concentration in the MF filtrate is expected to be about 187 to 206 mg/L as $CaCO_3$ (75 to 83 mg/L as Ca). Most calcium removal is achieved in RO, and RO modeling performed for the 10% Engineering Design Report showed an average calcium removal percentage of 97.9%. Using this removal percentage results in an RO permeate concentration of about 4 to 4.4 mg/L as $CaCO_3$ (1.6 to 1.8 mg/L as Ca). The calcium concentration is not expected to change through UV/AOP.

Lime is the remaining process that will have an effect on calcium concentration. Lime is added at a design dose of 65 to 105 mg/L as $Ca(OH)_2$. At this dose, it is anticipated to increase the calcium concentration in the product water to the range between 92 and 146 mg/L as $CaCO_3$ (37 to 58 mg/L as Ca).

2.5 Sodium

Sodium in the feed water is projected to be at concentrations of 187 mg/L to 238 mg/L with a median of 198 mg/L. Sodium bisulfite (SBS) is added as a quenching agent for oxidants at multiple points in the treatment train. SBS is expected to be applied at concentrations of 1 to 3 mg/L after the ozone contactors which will add approximately 0.2 to 0.7 mg/L of sodium; therefore, 1 mg/L of sodium addition is assumed. A slight addition of sodium from sodium hypochlorite before the MF system is expected in the range of 1 to 4 mg/L, corresponding to the dose range of 2 to 5 mg/L as Cl_2.

There is not much removal expected through the treatment train until the RO system, which achieves around 95% overall removal of sodium resulting in a permeate concentration of 5 to 14 mg/L, with a median of 9 mg/L. Sodium rejection by the RO will vary slightly with feed water temperature, and will decrease as the membrane elements age. For example, overall sodium removal with seven-year-old membrane elements may decrease to 90%, at which point around 20 mg/L of sodium would be expected in the RO permeate. Sodium hypochlorite addition at the UV/AOP will increase sodium levels by about 1 to 2 mg/L corresponding to the dosing range of 2 to 5 mg/L as Cl_2. The last sodium hypochlorite addition point is for pipeline disinfection at 0.5 to 3 mg/L as Cl_2, and corresponds to a sodium increase of around 1 to 2 mg/L.

SBS is added as a quenching agent for chlorine at 1 to 2.5 mg/L just before reservoir discharge. Based on this dosing, SBS adds 0.4 to 1.1 mg/L of sodium to the product water; therefore, 1mg/L of sodium addition is assumed.

2.6 Total Organic Carbon

The total organic carbon (TOC) content in the NCPWF feed is projected to be 6.2 to 8.6 mg/L with a median of 7.2 mg/L. During ozonation, organic carbon is not significantly decreased but rather transformed into more simple organic molecules that can be more readily utilized by microorganisms in the BAC filter (von Gunten, 2003; Rattier et al., 2012). After BAC filtration, TOC (often in the form of organic micropollutants) is expected to decrease to a concentration range between 3.9 and 7.0 mg/L with a median of 4.5 mg/L from mechanisms of adsorption to the activated carbon and utilization by microorganisms (Rattier et al., 2012). These TOC concentrations were observed in the Demonstration Project between April 2015 and March 2016.

Filtration through MF is not expected to have a significant effect on TOC. RO membranes are expected to reduce TOC levels to below 0.5 mg/L, in accordance with California Division of Drinking Water's (DDW) 2014 Groundwater Replenishment using Recycled Water Regulations (2014 GRR). Demonstration Project performance from October 2014 to November 2015 shows reduction in TOC concentrations to the range between 0.02 and 0.07 mg/L with a median of 0.03 mg/L in the RO permeate. Although the water quality of the RO concentrate is not discussed at length in this TM, the addition of ozone and BAC filtration to the treatment train have shown significant improvements in TOC and Contaminant of Concern (CEC) concentrations in the RO concentrate of the Demonstration Project. Table 5-13 of the San Diego AWPF Extended Testing Report shows CEC removal for many compounds on the order of 80-90% which significantly reduces the mass loading (lb/d) of these compounds to wastewater management.

UV/AOP is not expected to remove TOC at the current power and dose levels. Post-stabilization via lime and CO_2 addition, chlorination and subsequent dechlorination are also not expected to change TOC levels.

2.7 Total Dissolved Solids

The NCPWF feed water total dissolved solids (TDS) is expected to range from 700 to 1320 mg/L with a median or average value of 1170 mg/L. Section 4.1 of the 10% Engineering Design Report provides more information on estimation of TDS in the feed water.

No substantial TDS reduction is expected to occur in processes upstream of RO. RO modeling results for the projected feed water quality (provided in A-7 of 10% Engineering Design Report) suggested that TDS in RO permeate is expected to be in the range of 14 to 69 mg/L with a median value of 36 mg/L. UV/AOP is not expected to show TDS reduction.

As discussed above, finished water will be stabilized to avoid pipeline corrosion and allow for effective treatment at downstream drinking water treatment facilities. The design prescribes maintaining the Langelier Saturation Index (LSI) between 0 and +0.5, which requires addition of both calcium and carbonates. CO_2 added during post stabilization forms carbonic acid which will contribute to TDS upon conversion to bicarbonate at higher pH values. Lime addition in the range of 65 to 105 mg/L as $Ca(OH)_2$ together with CO_2 in the range of 0 to 90 mg/L will contribute to a TDS concentration in the range of 50 to 195 mg/L.

2.8 Langelier Saturation Index (LSI)

LSI is an important parameter to determine the corrosive potential of water. A positive LSI indicates a tendency toward calcium carbonate precipitation while a negative LSI indicates a tendency toward calcium carbonate dissolution. LSI in the product water is calculated using Standard Method 2330 B with a modification to account for error at higher pH values (Kenny et al., 2015). The calculation takes calcium concentration, alkalinity, pH, TDS concentration, and temperature as inputs.

The LSI of the NCPWF feed is expected to range from -0.55 to 0.55 with a median of 0.09. LSI does not change significantly until the MF filtrate where an LSI range of -0.65 to 0.46 is predicted due to the reduction in calcium concentration. LSI decreases further after sulfuric acid addition to the RO feed to the range between -1.85 and -0.51.

In the RO permeate stream, an LSI range of -6.23 to -4.34 is expected due to the removal of calcium, alkalinity, and the lowering of pH in the RO process. The increased pH in the UV/AOP feed stream after sodium hypochlorite addition increases the LSI to a range of -5.54 to -3.45. This LSI remains constant through the UV/AOP process and is slightly decreased by the addition of carbon dioxide during stabilization. The addition of lime during stabilization targets the promotion of alkalinity to greater than 100 mg/L as $CaCO_3$ and a positive LSI between 0 and 0.5 for protection of the pipeline. SBS addition at the dechlorination facility is not expected to significantly impact the LSI of the product water.

2.9 Free Chlorine/Chloramines/Total Chlorine

The NCPWF feed is made up of the NCWRP tertiary filtered effluent, prior to chlorination. Therefore, the NCPWF feed is expected to be free of any chlorine, barring trace amounts (< 0.3 mg/L) that may be present temporarily following a filter backwash cycle.

Just before MF membranes, chloramines are added to the process stream to protect downstream membranes against biofouling. The dose of sodium hypochlorite is expected to range from 2 to 5 mg/L as Cl_2 and that of ammonium hydroxide from 0.7 to 1.6 mg/L as N[1]. The total chlorine (present as chloramines) in the MF filtrate is expected to be in the range of 2 to 5 mg/L as Cl_2. Some chlorine is rejected by the RO membranes, and the RO permeate is expected to show total chlorine levels in the range of 1.5 to 3 mg/L as Cl_2, present as chloramines.

Sodium hypochlorite, added as the oxidant for UV/AOP, is used for providing free chlorine, and is injected at a design dose of 2.0 mg/L as Cl_2 [2]. Total chlorine residual in the UV/AOP effluent will be reduced under two simultaneous mechanisms: 1) free chlorine oxidation of chloramines (partial completion of the breakpoint reactions), and 2) photolysis of chlorine through UV. The remaining total chlorine residual in the UV/AOP effluent is expected to be approximately 2.2 to 3 mg/L as Cl_2, as a combination of chloramines and free chlorine and assuming approximately 50% destruction through the UV reactor. Breakpoint reactions are insignificant during the timescale of a UV reactor (seconds to a few minutes) and will not complete until the pipeline.

To provide residual disinfectant in the pipeline, chlorine at a dose of 0.5 to 3 mg/L of Cl_2 will be added during the stabilization processes. Total chlorine residual just after chlorination is expected to range between 3.5 to 4.5 mg/L as Cl_2. However, the oxidation of chloramines to breakpoint and chlorine decay in the pipeline will result in the predominance of free chlorine at a concentration of approximately 2.5 mg/L just before reservoir discharge. All chlorine will be quenched before discharge to the reservoir by dosing sodium bisulfite.

2.10 Bromide/Bromate

Bromate is a disinfection byproduct (DBP) of concern and is formed when bromide combines with ozone. Bromate is regulated by the DDW at a maximum contaminant

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[1] These doses result in a Cl_2: NH_3-N weight ratio of 2.9 to 3.1 which reach a metastable equilibrium on the order of seconds to a few minutes and monochloramine is the dominant species formed. This species is expected to predominate until the RO system where some dichloramine and trace trichloramine are possible due to the acidic pH values encountered.

[2] The addition of more sodium hypochlorite through the UV/AOP process will promote a higher speciation of dichloramine, but also results in the oxidation of all chloramines. However, roughly 50% of the free chlorine is expected to be destroyed by UV.

level (MCL) of 10 μg/L. Bromide in the projected feed water was assumed to be in the range of 0.2 to 0.5 mg/L, with an average of 0.3 mg/L from 33 Demonstration Project samples collected from various times between 2013 and 2016.

The NCPWF ozone system is designed to deliver an ozone dose of 14 mg/L, and has been replicated during testing at the Demonstration Project. However, the concentration-time (CT) design value has been lowered by half (from 8 to 4 mg-min/L) since the 10% Engineering Design Report. In the 30% design of the NCPWF, this will be accomplished by decreasing the ozone contactor volume and keeping the ozone dose at 14 mg/L. Owing to the similar water quality conditions and ozone dose, results for bromate formation from the Demonstration Project were referenced to estimate the projected bromate formation in the NCPWF ozone effluent stream. Estimated concentrations of bromate in the ozone effluent are in a range of 130 to 165 μg/L with a median value of 138 μg/L. The Demonstration Project has recently revised the ozonation parameters to accomplish the new CT design value by decreasing ozone dose. Future bromate concentrations in the ozone system effluent will be informed by this new data. The new CT value will likely result in decreased bromate concentrations.

As bromate is not biodegraded in biological filters (von Gunten, 2003), there is no removal expected in the BAC process. Bromate is also not removed by MF membranes. RO membranes, however, do reject both bromide and bromate. RO shows up to 85% removal of bromide and up to 98% removal of bromate (von Gunten, 2003), resulting in concentrations of both parameters in the RO permeate at non-detectable levels. Data from the Demonstration Project supports the removal of bromide and bromate to non-detect levels in the RO permeate at detection limits of 0.1 mg/L for bromide and 5 μg/L for bromate. Processes downstream of RO are not expected to alter bromide and bromate concentrations.

2.11 Chlorination Byproducts

Chlorination byproducts like haloacetic acids (HAA5) and total trihalomethanes (TTHM) are formed when TOC combines with chlorine. The DDW regulates HAA5 and TTHM at maximum contaminant levels (MCLs) of 60 μg/L and 80 μg/L, respectively. Location-based Running Annual Averages (LRAAs) of HAA5 and TTHM are not to exceed these levels.

For estimation of HAA5 and TTHM concentrations in each effluent stream (ozone, BAC, MF, RO), Demonstration Project data from November 2014 through October 2015 was used. The feed water (NCWRP tertiary filtered effluent) had trace amounts of HAA5 and TTHM at median values of 2.2 μg/L and 2.6 μg/L, respectively.

HAA5 and TTHM concentrations were observed to be constant through the ozonation process since these contaminants are primarily chlorination DBPs and are not expected to be removed by ozonation. The slight differences in the reported HAA5 and TTHM concentration range and median after ozonation are attributed to variability in sampling time. The Demonstration Project showed that the BAC filters achieved greater removal of HAA5 (non-detect with a method detection limit of 2 μg/L) compared to TTHM (median value of 2.8 μg/L).

The addition of sodium hypochlorite for chloramine formation before MF results in an increased concentration of these DBPs. HAA5 in the MF filtrate was measured at a median of 4.6 μg/L, whereas TTHM was measured at a median of 10 μg/L. However, RO serves as an effective barrier to their passage, and was seen to reduce concentration of HAA5 to non-detectable levels and TTHM to a median of 2.7 μg/L.

The use of chlorine as an oxidant in UV/AOP (hereafter referred to as UV/HOCl) raises concern about DBPs that may be present in the finished water. Currently, there is limited data available for chlorination DBPs formed due to UV/HOCl at the Demonstration Project. Due to the short travel time from sodium hypochlorite dosing to the UV/AOP reactor, no DBP formation is assumed in the UV/AOP feed. Any DBPs that are formed are attributed to reactions occurring in the UV/AOP. The limited samples from the Demonstration Project taken in January and March of 2016 include 5 non-detects for HAA5 and a range of 1.3 to 2.4 μg/L with a median of 2.4 μg/L for TTHM at the UV/HOCl effluent. To supplement this report, a similar project carried out at Terminal Island was referenced. The Terminal Island project investigated a similar process train to that of NCPWF, namely treating tertiary effluent from Terminal Island Water Reclamation Plant (TIWRP) via MF, RO and UV/HOCl.

Bench scale testing was performed for UV/HOCl and samples were taken to study HAA5 and TTHM formation potential (LABOS, 2014). TOC content in RO permeate of the 12 mgd Terminal Island Water Reclamation Facility (TIWRF) ranged from 0.055 mg/L to 0.354 mg/L, and averaged at 0.19 mg/L. This TOC range and average are generally higher than those expected for the NCPWF (based on RO permeate data from the Demonstration Project). Table 2.2 summarizes results of bench testing conducted for UV using low pressure lamps (LPUV) and medium pressure lamps (MPUV) at a NaOCl dose of 2 mg/L as Cl_2. It can be seen that the levels of HAA5 and TTHM formed were far below their respective MCLs, when either LPUV or MPUV technologies was applied. Specifically, the range of HAA5 in the UV/HOCl effluent was 1.5 to 5.3 μg/L with a median of 3.3 μg/L and the range of TTHM in the UV/HOCl effluent was 2 to 5 μg/L with a median of 3.8 μg/L.

Table 2.2: Formation potential of HAA5 and TTHM during UV/HOCl bench testing (UV + 2mg/L as Cl_2 of NaOCl) at Terminal Island Water Reclamation Plant (LABOS, 2014)

Analyte	750mJ/cm² LPUV (µg/L of analyte)				800 mJ/cm² MPUV (µg/L of analyte)			
	Test 1		Test 2		Test 1		Test 2	
	Raw	LPUV-Treated	Raw	LPUV-Treated	Raw	MPUV-Treated	Raw	MPUV-Treated
HAA5	ND	1.5	ND	2.2	16	4.4	ND	5.3
TTHM	2.1	3.4	1.4	2	6.2	4.2	7.3	5

The next chlorination process is the addition of free chlorine at a dose of 0.5 to 3 mg/L as Cl_2 to provide a disinfection residual in the pipeline. Owing to the low levels of TOC in this finished water, concentrations of additional chlorination DBPs formed are expected to be negligible.

2.12 N-Nitrosodimethylamine

N-Nitrosodimethylamine (NDMA) is a DBP and a known carcinogen, and is regulated at a limit of 0.69 ng/L as per the California Toxics Rule. The DDW has a public notification level of 10 ng/L for NDMA. The current method detection limit for NDMA is 2.0 ng/L.

The NDMA levels expected in the NCPWF feed water are in the range of the method reporting limit at 2 ng/L to 41 ng/L with a median value of 3.8 ng/L (all non-detect values in the NDMA statistical analysis were assumed 2 ng/L). This estimate was based on tertiary filtered effluent samples collected by the City of San Diego from November 2014 to March 2016. During this same time period, Ozone effluent NDMA concentrations were observed from 18 to 55 ng/L with a median value of 31 ng/L due to NDMA formation in the ozonation process. NDMA concentrations decreased to a range between 2 and 24 ng/L with a median of 2 ng/L after BAC filtration (11 of 13 samples were reported as non-detect), which is similar or better than the water quality observed in the NCPWF feed. The NDMA concentrations remain relatively constant through the MF (5 of 9 samples reported as non-detect) and RO processes (12 of 17 samples reported as non-detect). UV/AOP is a technology that has been proven to be effective in NDMA removal at the elevated UV doses used for the advanced treatment of wastewater. Based on this known treatment efficiency and the data (17 of 20 samples reported as non-detect), the assumed median concentration of NDMA in the UV/AOP effluent is non-detect at the detection limit of 2 ng/L. No change in NDMA levels is expected during post-stabilization processes. Appendix A-3 of the 10% Engineering Design Report has more information on finished water goals for NDMA.

2.13 1,4 – Dioxane

The DDW has a public notification level of 1 µg/L for 1,4-dioxane. From the samples taken at the Demonstration Project in November and December 2014 of the filtered NCWRP tertiary filtered effluent, only one 1,4-dioxane measurement was detected at 1 µg/L. The remaining samples were non-detect with a MRL of 1 µg/L. Samples taken at subsequent process effluent streams showed non-detect levels of 1,4-dioxane. It is not expected that the future NCPWF will have significant levels of 1,4-dioxane during typical conditions in the feed or other downstream process effluents.

The NCPWF is designed to achieve 0.5-log removal of 1,4-dioxane through UV/AOP, per the 2014 GRR. Further discussion on the effectiveness of UV/AOP is provided in Appendix A-8 of the 10% Engineering Design Report submitted to the City.

2.14 Nitrate/Ammonia/Total Nitrogen

Total nitrogen in the NCPWF feed is determined by the BioWin modeling as part of Task 6 (NCWRP Expansion Pre-Design), which assumed a 10-day sludge retention time. Assumptions were provided for ammonia, nitrate, nitrite, and total nitrogen. Organic nitrogen was assumed to be the difference between total nitrogen and the sum of ammonia, nitrate, and nitrite. Total nitrogen in the NCPWF feed is expected to range from 7.8 to 13.9 mg/L, with an average of 10.4 mg/L. For the purpose of this TM, the average is assumed to be reasonably representative of the median, as shown on Table 2.1.

In the ozonation and BAC processes, total nitrogen levels are not expected to change significantly, as supported by Demonstration Project data. However, changes in nitrogen speciation are expected to occur. Ozone is known to rapidly oxidize nitrite to nitrate, therefore it is assumed that all nitrite will be converted to nitrate in this process (von Gunten, 2003). Demonstration Project data shows that ozone consistently diminished nitrite to non-detect levels. In the BAC filters it is predicted that any remaining ammonia will be polished to non-detect levels by nitrification, through which microbes convert ammonia to nitrate (Yapsakli et al., 2010).

Nitrogen is added in the form of ammonium hydroxide to form chloramines after sodium hypochlorite addition. The design dose of ammonium hydroxide is expected to be approximately 0.7 to 1.6 mg/L as N. The resulting total nitrogen concentration is expected to range from 8.5 to 15.5 mg/L as N until the RO permeate. Based on RO modeling performed for the 10% Engineering Design Report, the average nitrate removal through the RO system is approximately 87%. Based on Demonstration Project data, the expected ammonia removal through the RO, when the ammonia is in the chloramine form, is 61.5%. Additionally, based on Demonstration Project data, all organic nitrogen was assumed to be removed through the RO. The resulting total nitrogen concentration in the RO permeate ranges from 0.98 to 2.13 mg/L, with an average of 1.32 mg/L.

Prior to UV/AOP, sodium hypochlorite is added as the AOP oxidant and begins the breakpoint chlorination process, which ultimately contributes to ammonia removal. The detention time through the UV/AOP process is on the order of seconds to a few minutes, which is not enough time to complete the breakpoint chlorination process. As a result, ammonia concentrations are estimated to remain the same through the UV/AOP. However, breakpoint chlorination will be complete by the time the product water reaches the Miramar Reservoir. The estimated travel time from the NCPWF to the reservoir is about 1.8 hours. As a result, it is estimated that ammonia concentrations will be non-detect at the discharge to the reservoir.

Total nitrogen concentrations are typically reduced through UV/AOP based on sampling done at the Demonstration Facility. From this data it was assumed that nitrate removal through UV/AOP is 26.5%. Nitrate is expected to remain the same through the subsequent treatment processes. As a result, the total nitrogen concentration of water delivered to the reservoir is expected to range from 0.52 to 1.12 mg/L, with an average of 0.75 mg/L.

Table 2.3: Total nitrogen by species

	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)
NCPWF Feed			
Ammonia-N	0.1	0.5	0.15
Nitrate-N	5.4	11.2	7.7
Nitrite-N	0.01	0.06	0.02
Organic N	2.3	2.1	2.5
Total N	7.8	13.9	10.4
Ozone Effluent			
Ammonia-N	0.1	0.5	0.15
Nitrate-N	5.41	11.26	7.72
Nitrite-N	0	0	0
Organic N	2.3	2.1	2.5
Total N	7.8	13.9	10.4
BAC Effluent			
Ammonia-N	ND (0.03)	ND (0.03)	ND (0.03)
Nitrate-N	5.51	11.76	7.87
Nitrite-N	ND (0.05)	ND (0.05)	ND (0.05)
Organic N	2.3	2.1	2.5
Total N	7.8	13.9	10.4
After NH4OH Addition (0.7 to 1.6 mg/L-N design dose)			
Ammonia-N	0.7	1.6	0.8
Nitrate-N	5.51	11.76	7.87
Nitrite-N	ND (0.05)	ND (0.05)	ND (0.05)
Organic N	2.3	2.1	2.5
Total N	8.5	15.5	11.2
RO Permeate			
Ammonia-N	0.27	0.62	0.31
Nitrate-N	0.71	1.52	1.02
Nitrite-N	ND (0.05)	ND (0.05)	ND (0.05)
Organic N	0	0	0
Total N	0.98	2.13	1.32
After UV/AOP			
Ammonia-N	0.27	0.62	0.31
Nitrate-N	0.52	1.12	0.75
Nitrite-N	ND (0.05)	ND (0.05)	ND (0.05)
Organic N	0	0	0
Total N	0.79	1.73	1.05
After Pipeline and Dechlorination			
Ammonia-N	ND (0.03)	ND (0.03)	ND (0.03)
Nitrate-N	0.52	1.12	0.75
Nitrite-N	ND (0.05)	ND (0.05)	ND (0.05)
Organic N	0	0	0
Total N	0.52	1.12	0.75

2.15 Total Phosphorus

The NCPWF feed total phosphorus is assumed to be 0.78 mg/L, based on Task 6, which plans to add ferric chloride addition to the NCWRP tertiary filters. This ferric chloride addition was evaluated against the costs and benefits of adding sufficient sulfuric acid upstream of RO to control for calcium phosphate scaling, and it was found more cost effective to dose coagulant at the tertiary filters.

Significant removal of phosphorus is not projected to occur until the RO process. RO modeling performed for the 10% Engineering Design Report shows phosphorus removal at about 99.0% to 99.6%, resulting in an RO permeate concentration of 0.01 mg/L as P. The model results are consistent with the phosphorus removal seen during the Demonstration Project.

After the RO process, there are no remaining processes in the treatment train that will affect phosphorus concentrations. The finished water quality goal for total phosphorus to the reservoir is less than 0.025 mg/L as P, based on the Basin Plan. Maintaining compliance with the Basin Plan for total phosphorus is not expected to be an issue.

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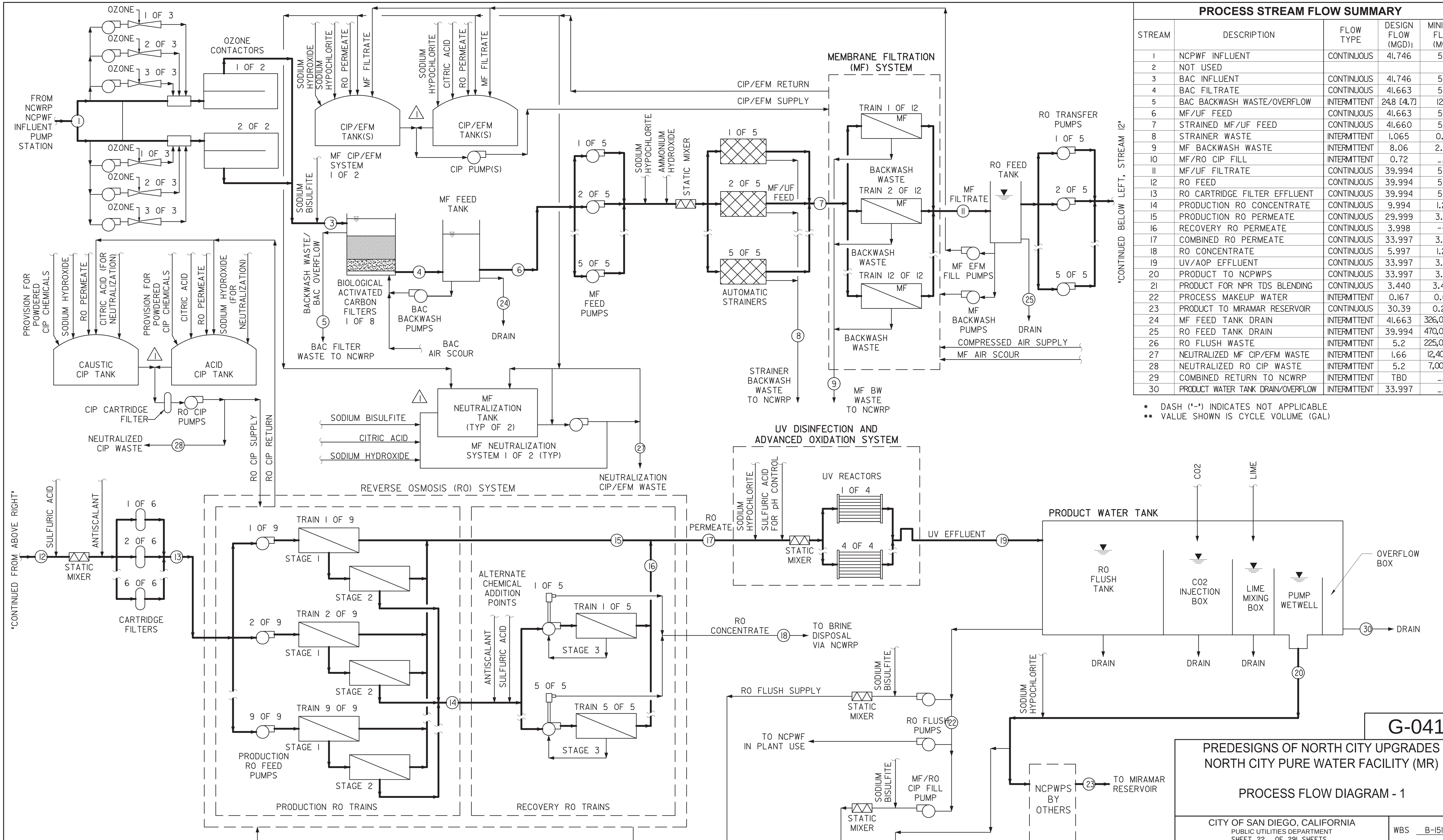
APPENDIX A – NCPWF (MR) PROCESS FLOW DIAGRAM



PROCESS STREAM FLOW SUMMARY

STREAM	DESCRIPTION	FLOW TYPE	DESIGN FLOW (MGD)1	MINIMUM FLOW (MGD)
1	NCPWF INFLUENT	CONTINUOUS	41.746	5.2
2	NOT USED			
3	BAC INFLUENT	CONTINUOUS	41.746	5.2
4	BAC FILTRATE	CONTINUOUS	41.663	5.2
5	BAC BACKWASH WASTE/OVERFLOW	INTERMITTENT	24.8 [41.7]	12.4
6	MF/UF FEED	CONTINUOUS	41.663	5.2
7	STRAINED MF/UF FEED	CONTINUOUS	41.660	5.2
8	STRAINER WASTE	INTERMITTENT	1.065	0.511
9	MF BACKWASH WASTE	INTERMITTENT	8.06	2.07
10	MF/RO CIP FILL	INTERMITTENT	0.72	---
11	MF/UF FILTRATE	CONTINUOUS	39.994	5.0
12	RO FEED	CONTINUOUS	39.994	5.0
13	RO CARTRIDGE FILTER EFFLUENT	CONTINUOUS	39.994	5.0
14	PRODUCTION RO CONCENTRATE	CONTINUOUS	9.994	1.25
15	PRODUCTION RO PERMEATE	CONTINUOUS	29.999	3.75
16	RECOVERY RO PERMEATE	CONTINUOUS	3.998	---
17	COMBINED RO PERMEATE	CONTINUOUS	33.997	3.75
18	RO CONCENTRATE	CONTINUOUS	5.997	1.25
19	UV/AOP EFFLUENT	CONTINUOUS	33.997	3.75
20	PRODUCT TO NCPWPS	CONTINUOUS	33.997	3.75
21	PRODUCT FOR NPR TDS BLENDING	CONTINUOUS	3.440	3.440
22	PROCESS MAKEUP WATER	INTERMITTENT	0.167	0.071
23	PRODUCT TO MIRAMAR RESERVOIR	CONTINUOUS	30.39	0.239
24	MF FEED TANK DRAIN	INTERMITTENT	41.663	326,000 **
25	RO FEED TANK DRAIN	INTERMITTENT	39.994	470,000 **
26	RO FLUSH WASTE	INTERMITTENT	5.2	225,000 **
27	NEUTRALIZED MF CIP/EFM WASTE	INTERMITTENT	1.66	12,400 **
28	NEUTRALIZED RO CIP WASTE	INTERMITTENT	5.2	7,000 **
29	COMBINED RETURN TO NCWRP	INTERMITTENT	TBD	---
30	PRODUCT WATER TANK DRAIN/OVERFLOW	INTERMITTENT	33.997	---

* DASH ("-") INDICATES NOT APPLICABLE
** VALUE SHOWN IS CYCLE VOLUME (GAL)

⚠ INCOMPATIBLE CHEMICALS WILL NOT BE ADDED TO TANKS AT THE SAME TIME. PLEASE REFER TO THE ENGINEERING DESIGN REPORT AND P&ID DRAWINGS FOR DETAILS ON EFM, CIP, AND NEUTRALIZATION PROCEDURES.

PROCESS FLOW DIAGRAM - 1

G-041

PREDESIGNS OF NORTH CITY UPGRADES
NORTH CITY PURE WATER FACILITY (MR)

PROCESS FLOW DIAGRAM - 1

CITY OF SAN DIEGO, CALIFORNIA
PUBLIC UTILITIES DEPARTMENT
SHEET 22 OF 291 SHEETS

WBS B-15139

CONSULTANT

MWH. Brown AND Caldwell Trussell B&P Beyaz & Patel

APPROVED:		SUBMITTED BY:
FOR CITY ENGINEER	DATE	PROJECT MANAGER
PRINT NAME	RCE#	CHECKED BY: PROJECT ENGINEER

DESCRIPTION	BY	APPROVED	DATE	FILMED
ORIGINAL	XX/XX			

258-1707
CCS27 COORDINATE
6268407-1898444
CCS83 COORDINATE
39636-022-D

CONTRACTOR ____ DATE STARTED ____
INSPECTOR ____ DATE COMPLETED ____

30% SUBMITTAL

Filename: NC03B-G-041 Plot date: Nov. 29, 2016 01:41PM CAD User: Rasa Kulnys
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APPENDIX B – RESPONSES TO SVR DRAFT SUBMITTAL COMMENTS RELEVANT TO MR TM

NO	REFERENCE	CITY COMMENT	REVIEWER	ACTION	DESIGNER RESPONSE TO CITY COMMENTS	RESPONSE BY
265	Water Quality Tech Memo	Technical Memorandum, subject: Concentration of Key Water Quality Parameters in NCAWPF (San Vicente Reservoir) Process Streams – this memo details expected water quality parameters for the SV plant design, thus does not include ozone and BAC. These added treatment steps are likely to influence some of the parameters detailed.	DC	Ensure MR Report has updated information	Comment noted for MR version of WQ memo.	TT/Eileen
266	Water Quality Tech Memo: 1- Introduction	Line 4 is missing "of" between consisting and membrane.	DC		Revised as noted	TT/Eileen
267	Water Quality Tech Memo: Pg. 3	Table 2.1 - Add rows for: nitrate, ammonia, chloramines, free chlorine, and LSI. Add columns for: MF feed with NaOCl and ammonium addition, RO feed with acid and antiscalant addition, and AOP feed with NaOCl addition. If uncertain add more rows and columns.	BP		Rows have been added	TT/Eileen

268	Water Quality Tech Memo	Table 2.1 – Define in footnote basis of ranges given (example: Ranges provided represents operating conditions expected at least 99% of the time.)	BP		Footnotes have been added detailing data source and date range.	TT/Eileen
269	Water Quality Tech memo Section 2.2 Pg. 5	3rd paragraph, first sentence – Consider replacing sentence with, "Carbon dioxide added during post stabilization mainly turns to carbonic acid with a negligible increase in bicarbonate alkalinity." If sentence is not more accurate, explain in your comments why.	BP		Revised as noted	TT/Eileen
270	Water Quality Tech Memo: 2.7 – Total Dissolved Solids Pg. 7	In paragraph 3 LSI is mentioned; it would be a good idea to establish from the start, and state explicitly, which LSI calculator will be use – there are several out there. Carlsbad Desal Plant uses the more sophisticated AWWA RTW LSI modeling calculator, which at Pure Water water quality parameters gives slightly higher LSI calculations than the traditional calculation.	DC		LSI calculator description added in memo: Section 2.8- Langelier Saturation Index	TT/Eileen
271	Water Quality Tech Memo: 2.8 – Total Chlorine, Pg. 8	Paragraph 1, line 3 – should be (<0.3 mg/L)?	DC		Revised as noted	TT/Eileen
272	Water Quality Tech Memo:	Lots of different forms of chlorine are being used in the plant – chloramines, hypochlorite,	DC		Footnotes have been added to discuss different chloramine	TT/Eileen

	2.8 – Total Chlorine	chlorine(?) in the pipeline. There is some talk about the different species that will be formed – mono-, di-, and trichloramines, etc, but I wonder if this has been studied extensively to ensure proper residual will be maintained in the pipeline.			species. Text has been added to the report to clarify assumptions for pipeline residual.	
273	Water Quality Tech Memo: 2.9 – Chlorination Byproducts Pg. 8	Paragraph 1 – Not that it really matters here, but MCLs for TTHM and HAA5 are set as LRAAs (Location-based Running Annual Averages) in the distribution system; temporary exceedances are allowed as long as the LRAA remains under 80 and 60 ppb, respectively.	DC		Note added to memo.	TT/Eileen
274	Water Quality Tech Memo	Memo does not discuss expected water quality parameters of RO Concentrate, which may be important to wastewater system management. Addition of O3 and BAC result in a significant improvement in RO concentrate water quality and might be beneficial to note that in the MR Report.	DC		Brief discussion added in memo: Section 2.6- Total Organic Carbon	TT/Eileen

APPENDIX C – RESPONSES TO CITY OF SAN DIEGO COMMENTS

NO	REFERENCE	CITY COMMENT	REVIEWER	ACTION	DESIGNER RESPONSE TO CITY COMMENTS (FROM TRUSSELL TECH)
1	General	Good job incorporating the last set of comments	BP		Thank you.
2	Page 6, Table 2.1, note n	Good note. Put the "n" in box where Total Chlorine row and Post Chlorination column intersect.	BP		Revised as noted
3	Page 7, Section 2.1, last paragraph, 6th sentence	Sentence makes it appear that NaOCl is added before lime. The draft 30% NCPWF design (SVR) in section 4.5.6 says "NaOCl is injected over the lime mixing boxes." Please verify, and revise if needed.	BP		Correct, NaOCl will be injected after the lime mixing boxes. The sentence prior to the one you noted will be removed.
4	Page 7, Section 2.1, last paragraph, 8th sentence	Replace 'distribution pipeline" with transmission pipeline".	BP		Revised as noted
5	Page 8, Section 2.2, Last Paragraph, 3rd sentence	"a minor increase in alkalinity to the order of 0.7 to 1.4 mg/L…" seems like a mixing of terms – the reader can go back and forth on if this is the amount of the increase or the amount of alkalinity after the increase.	DC		Sentence has been revised to read: "…expected to increase the alkalinity by 0.7 to 1.4 mg/L…"
6	Page 8, Section 2.3, paragraph 2, 3rd sentence	MF filtrate turbidity is described with range of 0.01 to 0.08 NTU, median 0.03. This data is for both UF and Microfilters; there is a real (but maybe not significant) difference between the turbidities produced by the different membrane filters. In other words, actual turbidity may vary depending on which is chosen for the NCPWF.	DC		Yes, we agree that UF and MF produce different turbidities. The 0.01 to 0.08 NTU range accounts for both of these systems
7	Page 8, section 2.3, 3rd paragraph, 5th sentence	Text says 2 NTU where table 2.1 says 2.6 NTU. Revise one or other.	BP		Table 2.1 value changed to 2.0 NTU

NO	REFERENCE	CITY COMMENT	REVIEWER	ACTION	DESIGNER RESPONSE TO CITY COMMENTS (FROM TRUSSELL TECH)
8	Page 8, section 2.3, 3rd paragraph, 6th sentence	Text says, "lime will dissolve (or settle), resulting in decreased turbidity." This indicates either the Ca(OH)2 reduces in turbidity as it dissolves and/or Ca(OH)2 is settling. Settling implies scale formation on the lime mixing boxes. Which is true?	BP		The vast majority of lime solids from the high density slurry are expected to dissolve in the product water tank given adequate mixing, thus reducing turbidity. "(or settle)" has been removed. Provisions have been made in the design for two parallel lime mixing boxes to allow for cleaning, should it be necessary.
9	Page 9, section 2.4, 2nd paragraph, 2nd sentence	Replace with clearer sentence, "MF/UF removes approximately 21.4% of calcium, based on tertiary effluent sampled November and December of 2014 and MF filtrate sampled September 2013 to June 2014."	BP		Sentence has been revised for clarity
10	Page 9, section 2.4, 2nd paragraph, last sentence	Insert "CO3" after "4.4 mg/l as Ca"	BP		Revised as noted
	Page 10, Section 2.6, Second paragraph, last two sentences	Thanks for including info about improved RO Concentrate water quality with ozone and BAC – it's a very important component in my book and should be emphasized whenever possible.	DC		Glad the revision is well-received.
11	Page 11, section 2.7, last sentence	Text says "50" but table 2.1 says "55". Revise one or other.	BP		Table has been revised
12	Page 11, section 2.8 3rd paragraph. 1st sentence.	Decreasing TDS has an effect of raising the LSI. I recommend removing "TDS" from sentence or adding an additional sentence to explain.	BP		Revised as noted
13	Page 12, section 2.9, 2nd paragraph, 1st sentence	Replace "downstream RO membranes" with just "downstream membranes" because both MF/UF and RO are protected.	BP		Revised as noted

NO	REFERENCE	CITY COMMENT	REVIEWER	ACTION	DESIGNER RESPONSE TO CITY COMMENTS (FROM TRUSSELL TECH)
14	Page 12, section 2.9, last paragraph, 2nd sentence	Delete word "maximum" to make statement true or also provide the minimum range and include that in table 2.1.	BP		"Maximum" has been deleted
15	Page 12, bottom of page, footnote 2	As 50% of the chlorine is "destroyed" in the UV, will there be any chlorine gas bubbles that need to be consciously contained and treated before release?	BP		The major chlorine end product through the UV will be chloride with a small amount of chlorate also formed. For a dose of 2 mg/L free chlorine, only ~30 µg/L results as chlorate with the majority of what is "destroyed" forming chloride. For this reason, chlorine gas bubbles are not expected to be an issue.
16	Page 13, section 2.10, 2nd paragraph, 3rd sentence	Replace the word "reactor" with "ozone contactor"	BP		Revised as noted
17	Page 14, Section 2.11 (all)	Units for HAA5 and TTHM are changing throughout this section, and may even be wrong in some cases. At the end of the second to last paragraph we have a median THM of 2.4 mg/L; this likely is supposed to be ug/L. Other instances of same in this paragraph.	DC		All DBP "mg/L" units changed to "µg/L"
18	Page 18, table 2.3	Add units, "mg/l" somewhere obvious	BP		Units added
19	Page 18, table 2.3	After NH4OH ammonia –N is at 0.8 mg/l. Can we keep excess ammonia in the 0.3 to 0.5 range? I understand safety factor to protect RO. Question is, does the savings of reduced ammonia and NaOCl cost off set cost of more precise control of ammonia?	BP		At this point in the design, an emphasis has been placed on the protection of the RO system corresponding to our 30% design parameter of a 0.7 to 1.6 mg/L ammonia dose. A 0.8 mg/L ammonia-N addition would result in a 0.4 mg/L ammonia-N excess assuming a 2.0 mg/L as Cl2 free

NO	REFERENCE	CITY COMMENT	REVIEWER	ACTION	DESIGNER RESPONSE TO CITY COMMENTS (FROM TRUSSELL TECH)
					chlorine dose. That excess could combine with an additional 2.0 mg/L as Cl2 if a feed chlorine spike occurred. A cost-benefit calculation could be formally performed to document the estimated cost savings associated with reducing the ammonia dose versus the potential risk of decreased RO protection. We will verify with you separately if you'd like this analysis included for the RO Protection Design Pilot Study (2016-2017), and to what extent and detail the analysis could be performed given the study's scope.
20	Figure 4-1	This drawing indicates that lime, NaOCl, and possibly CO2 are added into a pipeline rather than the product water tank that has weirs. Revise with 30% design submittal.	BP		The updated PFD will be included in the 30% design submittal

APPENDIX E: Water Quality and Treatability Study Technical Memo (TM)

Technical Memorandum

Water Quality and Treatability Study

Memo Information

To: John Helminski, Amy Dorman, Mike Williams, Joseph Quicho

CC: Julie L. Labonte, Peggy Umphres, Jaime Brown

From: James Borchardt, Michael Adelman, Mia Smith, Maysoon Sharif

Date: 2/4/16

Task Order/Number: TO4 T4 and T6

City Task Lead Name: Joseph Quicho

Consultant Task Lead Name: James Borchardt

Introduction and Overview

This Technical Memorandum discusses bench-scale studies to determine the potential impacts of the Pure Water Program on existing water treatment and distribution infrastructure. Under the Pure Water Program, the new North City Advanced Water Purification Facility (NCAWPF) will produce about 30 million gallons per day (MGD) of high-purity reuse water, hereinafter referred to as Pure Water. One proposed alternative for this program includes the discharge of Pure Water into Miramar Reservoir for treatment at the existing Miramar Water Treatment Plant, and potential future Pure Water discharge into Lake Murray for treatment at the existing Alvarado Water Treatment Plant.

The addition of Pure Water into the raw water supply at these Water Treatment Plants (WTPs) would change the existing water quality and water chemistry, and potentially affect the existing treatment processes at these WTPs. Therefore, bench-scale studies were conducted as described below, to determine the specific water quality implications of augmenting the WTP influent with Pure Water.

The bench-scale testing demonstrated that blends up to 100% Pure Water could be coagulated and made filterable under conditions similar to those at the existing WTPs. Treatability broke down only at high blending ratios with insufficiently conditioned and stabilized Pure Water. Ensuring chemical stability of the Pure Water entering the Lakes is necessary to ensure treatability, as well as for avoiding potentially corrosive water reaching the distribution system. The findings of this study indicate that adding calcium and alkalinity to Pure Water at the NCAWPF, along with accurate coagulant dosing and pH control at the WTP, will allow the WTPs to continue to meet performance goals and protect the distribution system.

Background

The treatment processes at the NCAWPF will produce Pure Water that is very low in suspended solids, dissolved solids, hardness, and alkalinity. The water will need to be stabilized prior to reuse, but the amount of stabilization (i.e. calcium and alkalinity addition) is uncertain. Left unstabilized, the addition of this "leaner" water at the Miramar and Alvarado WTPs may affect the existing treatment processes and reduce treatability. Leaner water may also be less chemically stable and create the potential for chemical or biological upset.

Effects on Treatability

Leaner water is difficult to treat for two reasons. First, it is harder to control the pH of leaner water because of its low alkalinity and reduced buffering capacity. This is an issue because coagulants must precipitate in order to function, and each metal salt coagulant requires a specific pH range (Kawamura, 2000). For example, ferric chloride, the coagulant currently used at the WTPs, has its minimum solubility at a pH around 8.0, as shown in the solubility diagram for Fe^{3+} in Figure 1. When the pH is less than about 5.5, ferric chloride will no longer be sufficiently insoluble to coat the suspended solids in the water and make them "sticky" as is required for particle growth through flocculation.

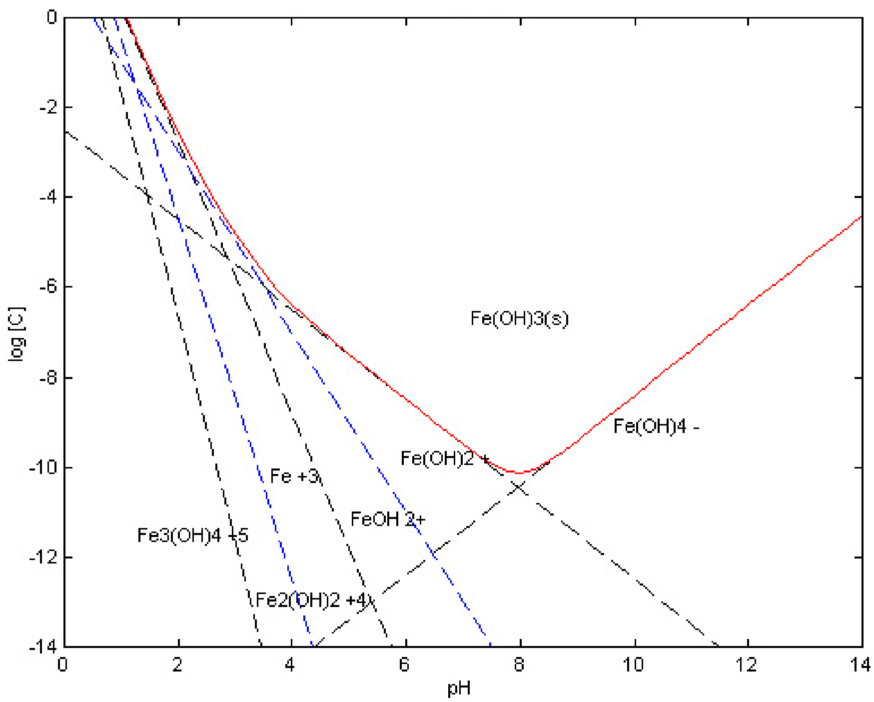

Figure 1. Solubility Diagram for Iron (III) Hydroxide.

Secondly, floc formation is inhibited in leaner water. Due to the low concentration of suspended solids, the average distance between individual particles is larger. This large mean distance between suspended particles makes collisions between them less likely (Weber-Shirk and Lion, 2012). Similarly, particles of the added coagulant are also less likely to coat the suspended particles. Instead, coagulant particles are more likely to collide with each other and self-aggregate (Swetland et al., 2013). Fewer collosions between suspended particles and increased coagulant self-aggregation both inhibit the formation of flocs.

Both low alkalinity and low suspended solids concentrations may make raw water blends containing unstabilized Pure Water less treatable by the existing WTPs. The first major objective of these bench-scale studies was to experimentally assess the treatability of Pure Water blends.

For the reasons described above, turbidity removal from Pure Water-augmented supplies could become more difficult even if the raw water concentration goes down. However, removal of total organic carbon (TOC) is not subject to the same effect. The current raw water at the Miramar and Alvarado WTPs has TOC levels around 2-3 mg/L, while the effluent TOC at the NCAWPF Demonstration Plant is below the detection limit of 0.3 mg/L. If the WTPs are performing adequately for TOC with their current raw water, they will if anything peform better with lower raw water TOC under Pure Water operation. Therefore, this study focused on turbidity removal rather than TOC treatment.

Chemical Stability and Upsets

In addition to these treatment challenges, leaner water is more likely to be chemically unstable and cause chemical or biological upsets in the WTPs and distribution system. The Pure Water itself is prone to chemical instability – the treatment processes at the NCAWPF will remove hardness and alkalinity, and if the effluent is not conditioned it will be very low in dissolved ions such as calcium and bicarbonate. Such water will be aggressive and prone to large changes in pH.

In addition to becoming corrosive itself, the Pure Water could potentially change the water chemistry in the distribution system without proper conditioning. Changes in the chemical composition of water may destabilize the chemical equilibrium in the distribution system, which can cause corrosion of pipes, degradation of mortar linings, and mobilization of metals in home plumbing. Unwanted corrosion and leaching of metals are familiar operational problems that have recently afflicted several U.S. cities (like Flint, MI) following a change in water supply, and they can cause taste, odor, and toxicity issues. Water chemistry may have biological implications as well. Biofilms exist in long-run equilibrium with any water distribution system, and recent research has found that this equilibrium depends more heavily on water source than on any particular treatment method (Shaw et al., 2014). Changing the water supply has been observed to lead to shifts in the biolfilm community (Li et al., 2016). These shifts may affect pathogen shielding by the biofilms, as well as the metabolic pathways of the biofilm community and therefore the water quality impacts of the biofilms interacting with the water.

The stability of water is influenced by several factors, including pH, dissolved ions, alkalinity, and organic carbon. There is no perfect single measure of stability, but the Langelier Saturation Index (LSI) is probably the most common proxy for chemical stability. The LSI characterizes saturation with respect to calcium carbonate solubility, and it is widely used in environmental engineering practice because of the prevalence of both calcium and the carbonate system. Water with negative LSI is below saturation with respect to $CaCO_3$, and a water with highly negative LSI will tend to be aggressive – it may attack materials such as concrete or mobilize metals in the distribution system. On the other hand, water with a slightly positive LSI will tend to deposit a protective layer of scale on piping, without causing clogging or corrosion. Maintaining a slightly positive LSI is a common operational target in water systems.

The NCAWPF will provide some form of post-conditioning of the product water, including lime addition and/or carbon dioxide injection. The second major objective of these bench-scale studies is to test the chemical stability of Pure Water during treatment by coagulation/flocculation, and determine the post-conditioning requirements for the NCAWPF to mitigate chemical instability and prevent upsets.

Materials and Methods

Experimental Setup and Raw Water Conditioning

Bench-scale testing was conducted to determine how existing treatment processes would respond to Pure Water augmentation of the WTP influent. The NCAWPF Demonstration Plant served as the source of Pure Water for testing, and this Pure Water was blended with Alvarado WTP influent for testing. This result applies to Miramar WTP as well, as raw water quality at this plant is very similar.

Reagents were added to the NCAWPF Demo Plant effluent to simulate various possible Pure Water conditioning scenarios. Conditioning categories included three extreme cases and one design case:

- *Unconditioned:* Extreme lean water case. Demonstration Plant effluent with no additional reagents added.
- *Lime:* Extreme high hardness / low alkalinity case. Saturated lime solution, approximately 4 mg/L, added to Unconditioned Pure Water to reach a pH of 9.0.
- *Lime/Soda:* Extreme high pH / high alkalinity case. 35 mg/L of Na_2CO_3 added to the above Lime Conditioned Pure Water to reach a pH of 10.0.
- *Design:* Simulation of full-scale lime and CO_2 conditioning to comply with NCAWPF design targets and pH limitations within the reservoirs (Target values: hardness of 115 mg/L as $CaCO_3$, alkalinity of 86 mg/L as $CaCO_3$, pH of 7.9). Unconditioned Pure Water dosed with 130 mg/L of $NaHCO_3$, then with saturated lime solution to reach pH 10.8, and finally with HCl to reach pH around 8.0.

Samples of the NCAWPF Demo Plant effluent and Alvarado WTP influent were taken for UV254 and major ion analyses, so that a major ion profile could be developed and used for calculation of the stability indices. Samples of the Design Pure Water were analyzed for hardness and alkalinity to verify that the conditioning process had met the NCAWPF design targets.

The four types of conditioned Pure Water were mixed with Alvarado WTP influent at varying blending ratios from 0% to 100%. The blends were jar tested across a range of water treatment conditions, including varying doses of two coagulants – ferric chloride ($FeCl_3$) and polyaluminum chloride (PACl). The following table summarizes the parameters of each experiment.

Table 1. Parameters for Jar-Testing Experiments.

Exp. ID	Pure Water Conditioning	Raw Water Type	Blend (Pure Water %)	Coagulant	Coagulant Doses (mg/L)
001	Unconditioned	El Capitan Reservoir	25%, 75%	$FeCl_3$	2, 5, 10
002	-	Alvarado Influent	0%	$FeCl_3$	1, 2, 5, 10, 15
003	Lime	Alvarado Influent	25%, 75%	$FeCl_3$	2, 5, 10
004	Lime/Soda	Alvarado Influent	25%, 75%	$FeCl_3$	2, 5, 10
005	Unconditioned	Alvarado Influent	25%, 75%	$FeCl_3$	2, 5, 10
102	-	Alvarado Influent	0%	PACl	2, 4, 6, 8, 10, 12
103	Lime	Alvarado Influent	25%, 75%	PACl	2, 5,10
104	Lime/Soda	Alvarado Influent	25%, 75%	PACl	2, 5,10
105	Unconditioned	Alvarado Influent	25%, 75%	PACl	2, 5,10
014	Design, Unconditioned	Alvarado Influent	90%	$FeCl_3$	2, 5,10
024	Design, Unconditioned	-	100%	$FeCl_3$	2, 5,10

Jar Testing

A jar testing apparatus was set up to simulate the coagulation, flocculation, and sedimentation treatment steps at the existing Alvarado WTP. Figure 2 shows a typical jar test apparatus. A paddle speed gauge controls the rotational speed of paddles that mix several individual jars of water. By controlling the mixing speed and duration, the mixing conditions of successive treatment steps can be simulated.

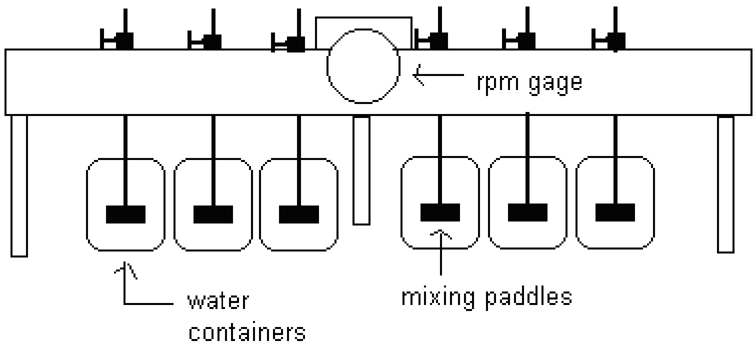

Figure 2. Jar Testing Apparatus.

In this experiment, the jars were filled with the blends of waters as described in Table 1 above. The pH and turbidity of the jars were measured and samples were taken for UV254 analysis. Next, the coagulant dose was added and rapidly mixed into the solution by setting the speed to 300 rpm for 30 seconds. After rapid mixing, pH measurements were taken again. Next, the mixing speed was set to 80 rpm for 35 minutes to simulate full-scale flocculation. Finally, the mixing paddles were turned off for 60 minutes to simulate full-scale sedimentation. Turbidity samples were taken 30 minutes and 60 minutes into sedimentation. Table **2** provides a summary of the parameters for each step of the jar test experiments.

Table 2. Jar Testing Parameters.

Parameter	Unit	Value
Rapid Mix Step		
Mixing Speed	rpm	300
Duration	sec	30
Flocculation Step		
Mixing Speed	rpm	80
Duration	min	35
Fluid Shear (G)	s^{-1}	63
Avg. Energy Dissipation Rate	mW/kg	3.5
Max. Energy Dissipation Rate	mW/kg	16
Sedimentation Step		
Mixing Speed	rpm	0
Duration	min	60

These operating parameters were selected based on current operation at the Alvarado WTP, but they are a reasonable bench-scale representation of the Miramar WTP as well. The rotational speed and paddle size of the Alvarado WTP flocculation tanks were used to calculate an energy dissipation rate, which was translated into a rotational speed for jar testing based on the dimensions of the jar-test paddles. Energy dissipation rate was selected as the scaling parameter because of it has been shown to govern floc size in previous laboratory studies (Tse et al., 2013). Jar test design calculations are shown in **Attachment 1.**

Filterability Testing

After jar testing, full-scale filtration was simulated in the lab as the key measure of treatability. Ultimately, the purpose of the coagulation and flocculation steps is to combine suspended particles into agglomerations large enough to be removed by settling or filtration. Therefore, passing the settled jar-test water through a proxy for the filtration process serves as an indicator of the overall success of the treatment process. Full-scale filtration was simulated in the lab by passing the settled water from the jar tests through 5 µm filter cartridges attached to the tips of plastic syringes. The filtered water was collected and measurements of pH and turbidity were taken. Samples of the filtered water were also sent to the lab for UV 254 analysis.

This filtration test was intended to determine whether the coagulation and flocculation processes had effectively increased the size of the suspended solids from the primary particle size, which is approximately 1 µm for suspended clay particles. Sedimentation works well for particles that are many orders of magnitude larger than primary particle size, but even a small increase in size makes a large difference in performance for a media filter. **Figure 3** shows the projected log removal (pC*) by the filters at the Alvarado WTP as a function of particle size, based on a depth filtration performance model that predicts particle capture by the mechanisms of Brownian motion, interception, and gravity transport (Tufenkji and Elimelech, 2004). The different removal mechanisms are classified by the driving force that causes a suspended particle to collide with a grain of filter media. For Brownian motion, it is the random movement of smaller particles suspended in the liquid. For interception, it is the particle's streamline. For gravity transport, it is gravitational settling of the suspended particle in the space between media grains.

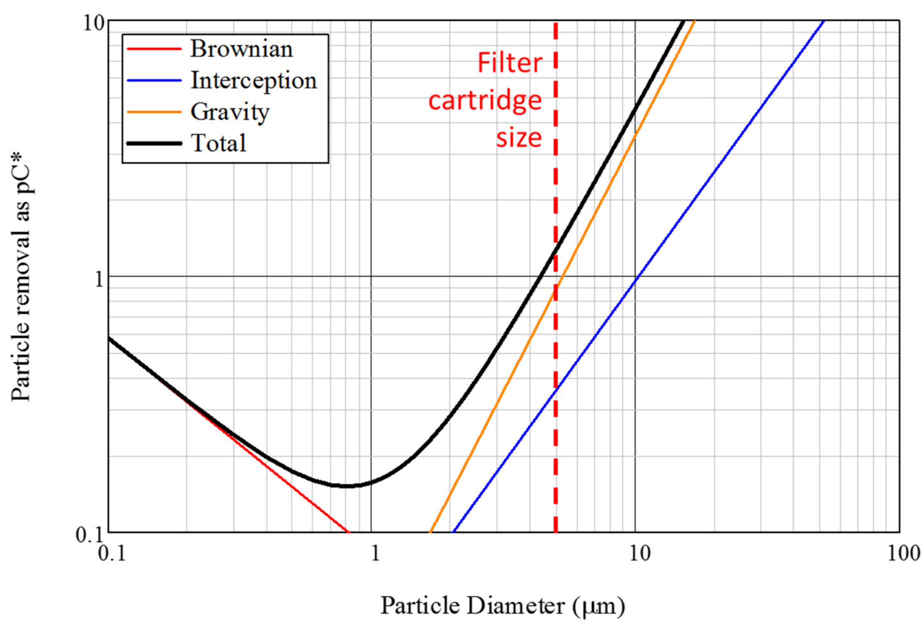

Figure 3. Projected Filter Performance vs. Particle Size at Alvarado WTP.

This concept provides the rationale for the syringe filter test – the filters would be expected to remove particles around 1 µm relatively poorly, but would achieve greater than 1 log (90%) removal of particles 5 µm and above. Therefore, even though the filter cartridges are a size exclusion process and not a depth removal process, they should serve as a good qualitative indicator of whether a coagulated suspension is filterable. This concept was validated with a test on the raw and settled water from the Alvarado WTP, both of which had turbidity around 0.3 NTU during the test. After passing through the syringe filter, the raw water turbidity was still high (0.16 NTU), while the settled water had dropped to 0.08 NTU – similar to the full-scale filter effluent. This confirmed that the 5 µm filter cartridges could serve as a screening method for filterability. Filter model calculations and filterability test results are shown in **Attachment 2.**

Analytical Methods

Table 3 summarizes the analytical methods used in this study.

Table 3. Summary of Analytical Methods.

Parameter	Analytical Method	Time of Analysis
pH	Method 4500-H^+ (*Standard Methods* 2012)	Immediately after collection by laboratory instrument[1]
Turbidity	Method 2130B (*Standard Methods* 2012)	Immediately after collection by laboratory instrument
UV 254	Method 5910B (*Standard Methods* 2012)	Within 24 hours of collection
Major Ions	Ion Chromatography in Environmental Analysis (Jackson, 2000)	Within 24 hours of collection
Hardness	Method 2340C (*Standard Methods* 2012)	Within 24 hours of collection
Alkalinity	Method 2320 (*Standard Methods* 2012)	Within 24 hours of collection

Results and Discussion

Water Chemistry and LSI Calculations

Measured water quality parameters for both the Demonstration Plant water and Alvarado WTP influent are summarized in **Attachment 3.** Based on this analytical data, representative raw water profiles were developed for the Alvarado WTP influent and the various categories of conditioned Pure Water. The TDS, calcium, and total carbonate concentration in each jar were then calculated based on the blend ratios for that jar. The representative raw water profiles and blending calculations are shown in **Attachment 4**.

The above analytical results and blending calculations were used to calculate the LSI values from the measured pH during each jar test. LSI was calculated using Equation (1) below, after the method presented by Tchobanoglous et al. (2003):

$$LSI = pH - pH_S \qquad (1)$$

Where pH = solution pH
pH_S = saturation pH for calcium carbonate

The saturation pH was calculated in turn from Equation (2):

$$pH_S = -\log\left(\frac{K_{a2} \times \gamma_{Ca}[Ca] \times \gamma_{HCO_3}[HCO_3]}{K_{sp}}\right) \qquad (2)$$

Where K_{a2} = second ionization constant for the carbonate system = 4.7×10^{-11}
γ_{Ca} = activity coefficient for calcium

[1] IntelliCAL™ PHC281Ultra Refillable pH Electrode, Hach Company, Loveland, CO.

[*Ca*] = calcium concentration, mol/L
γ_{HCO3} = activity coefficient for bicarbonate
[HCO_3] = bicarbonate concentration, mol/L
K_{sp} = solubility product constant for $CaCO_3$ = 5.0 × 10^{-9}

Activity coefficients in Equation (2) used the Guntelberg approximation, where the ionic strength is estimated from the TDS concentration and the activity coefficient is then estimated as a function of ion charge and total ionic strength. The bicarbonate concentration was estimated by calculating the bicarbonate fraction of the carbonate system at the measured pH, based on the known equilibrium constants for the carbonate system and the calculated total carbonate concentration in each blend.

Treatability Results

Datasheets for all jar tests, along with tabular summaries of all jar test and filterability test data, are found in **Attachment 5.**

Treatability was remarkably robust in the 25% and 75% Pure Water blends, and successful treatment with visible floc formation was achieved under every blending and conditioning scenario. **Table 4** shows the results of the most successful jar test that produced the lowest filtered water turbidity for each blending ratio, conditioning category, and coagulant type. It is important to note that the filtered water test data is only an indication of filterability, and is not intended to be a precise projection of full-scale granular media filter performance.

Table 4. Results of Most Successful Jar Tests under Each Condition.

Pure Water	Conditioning	Coagulant		Turbidity (NTU)		
(%)	Category	Type	Dose (mg/L)	Raw	Settled	Filtered
25%	Unconditioned	$FeCl_3$	2	0.34	0.46	0.100
75%	Unconditioned	$FeCl_3$	5	0.25	0.19	0.074
25%	Lime	$FeCl_3$	2	0.51	0.80	0.140
75%	Lime	$FeCl_3$	10	0.20	0.22	0.091
25%	Lime/Soda	$FeCl_3$	10	0.70	0.43	0.088
75%	Lime/Soda	$FeCl_3$	10	0.29	0.16	0.066
25%	Unconditioned	PACl	10	0.26	0.23	0.109
75%	Unconditioned	PACl	5	0.16	0.20	0.070
25%	Lime	PACl	10	0.25	0.31	0.100
75%	Lime	PACl	5	0.19	0.22	0.076
25%	Lime/Soda	PACl	10	0.26	0.19	0.105
75%	Lime/Soda	PACl	5	0.18	0.12	0.090

As shown in **Figure 4** and **Figure 5**, there was no clear trend in the filtered water turbidity across the range of coagulant doses, coagulant types, conditioning methods, and measured pH values. At the 25% and 75% Pure Water blending ratios, filterable water with low turbidity could be produced under any set of conditions tested with both ferric chloride and PACl.

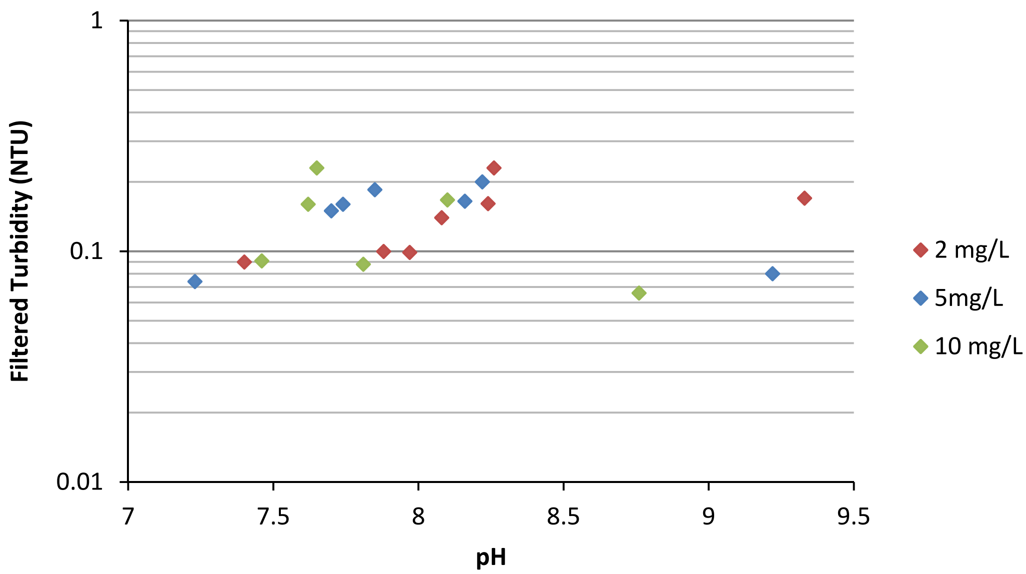

Figure 4. Filtered Water Turbidity Data for $FeCl_3$ Tests.

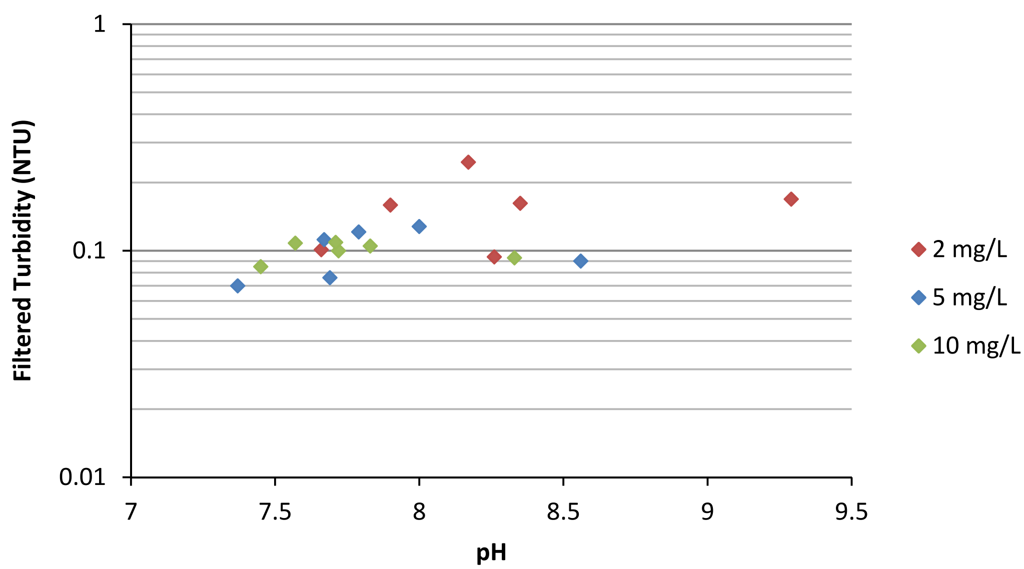

Figure 5. Filtered Water Turbidity Data for PACl Tests.

While the filtered water turbidity at 25% and 75% Pure Water did not vary as a function of conditioning, the settled water turbidity and turbidity removal by sedimentation did vary widely. However, the resultant filtered water was similar regardless of the blend ratio, conditioning method, and settled water turbidity. **Figure 6** and **Figure 7** illustrate this phenomenon across the the range of Pure Water blending and conditioning cases. This suggests that, while different operating conditions may cause more or less of the suspended solids to be removed by the sedimentation process, the finished water will come out approximately the same. Solids removal that is not achieved by the sedimentation tanks under some conditions will simply shift to the filters. At full scale, this would change the filter backwash interval and the sedimentation tank cleaning frequency.

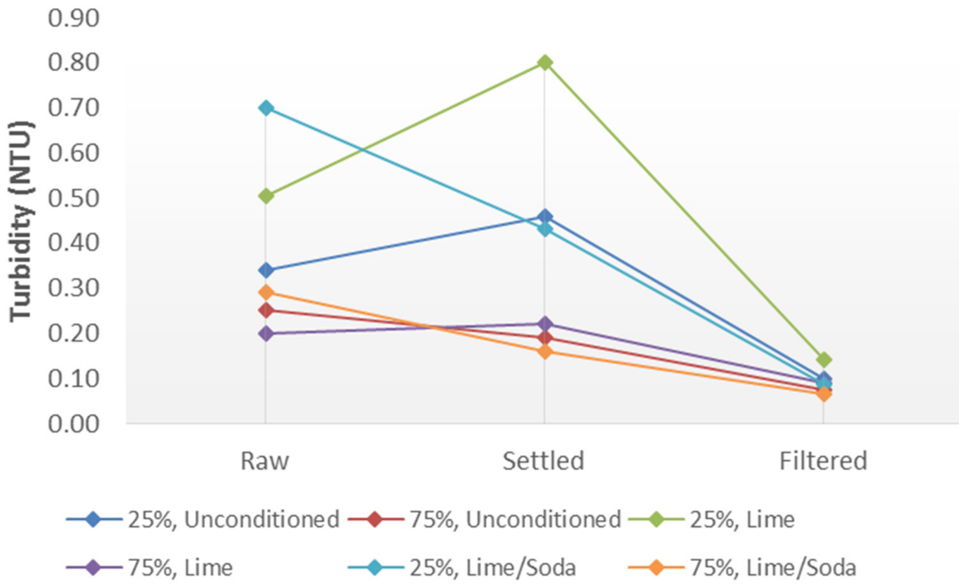

Figure 6. Raw, Settled, and Filtered Turbidity from Most Successful $FeCl_3$ Jars.

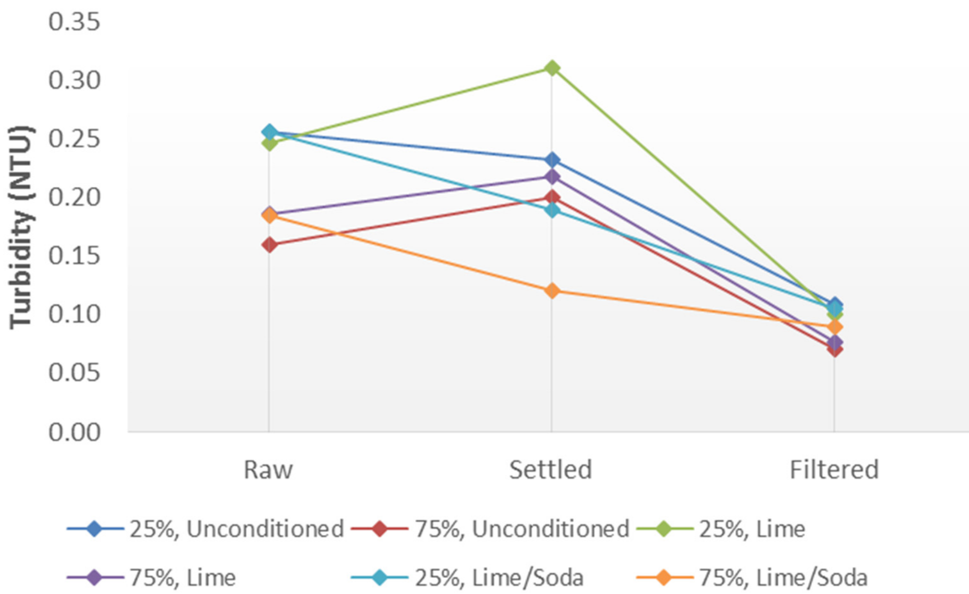

Figure 7. Raw, Settled, and Filtered Turbidity from Most Successful PACl Jars.

Treatability did break down at very high Pure Water ratios with insufficient conditioning. With unconditioned Pure Water, removal by the filtration step dropped to essentially zero in the 100% blend. However, the filtered water turbidity was still <0.1 NTU for blends with 90% to 100% Design Pure Water and filterability was achieved under these conditions. High blend data is summarized in **Table 5**.

Table 5. Results of Most Successful Jar Tests at High Blend Ratios.

Pure Water (%)	Conditioning Category	Coagulant Type	Coagulant Dose (mg/L)	Turbidity (NTU) Raw	Turbidity (NTU) Settled	Turbidity (NTU) Filtered
90%	Design	$FeCl_3$	2	0.307	0.182	0.079
100%	Design	$FeCl_3$	2	0.265	0.226	0.072
90%	Unconditioned	$FeCl_3$	5	0.305	0.236	0.087
100%	Unconditioned	$FeCl_3$	2	0.177	0.077	0.080

The jar tests successfully and consistently treated Pure Water blends with coagulation and flocculation settings similar to the existing plants. Provided the Pure Water was chemically conditioned, it could be treated at blend ratios as high as 100%. It appears that the coagulation and flocculation step is sufficient to produce filterable particles, even if sedimentation performance may vary widely. Based on these results, the treatment plants would be expected to produce low-turbidity finished water when properly-conditioned Pure Water is blended with their current raw water.

Treated Water pH Results

As expected, the chemical conditioning of the Pure Water had a clear effect on the final pH. The effect of each conditioning scenario is clear in **Figure 8** and **Figure 9** for the 25% and 75% Pure Water blends, respectively.

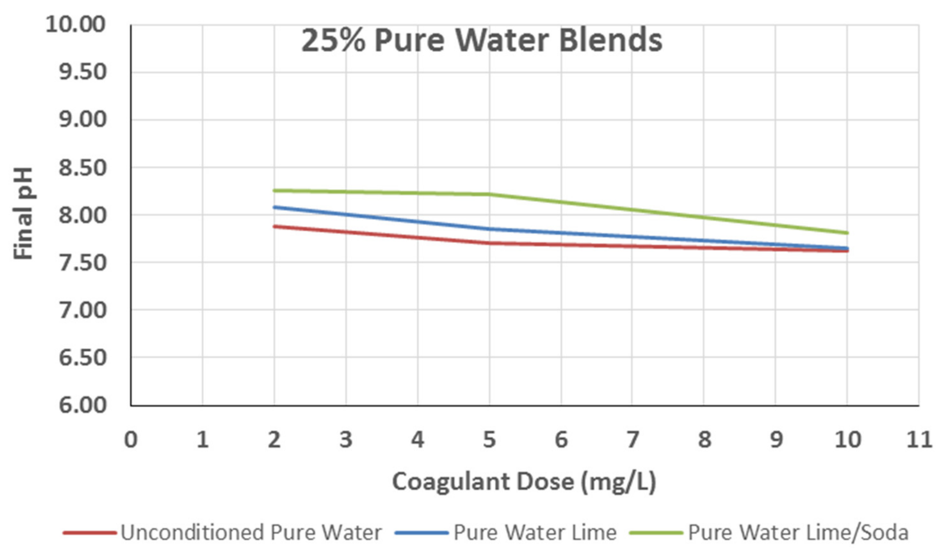

Figure 8. pH Data for 25% Pure Water Blends with $FeCl_3$.

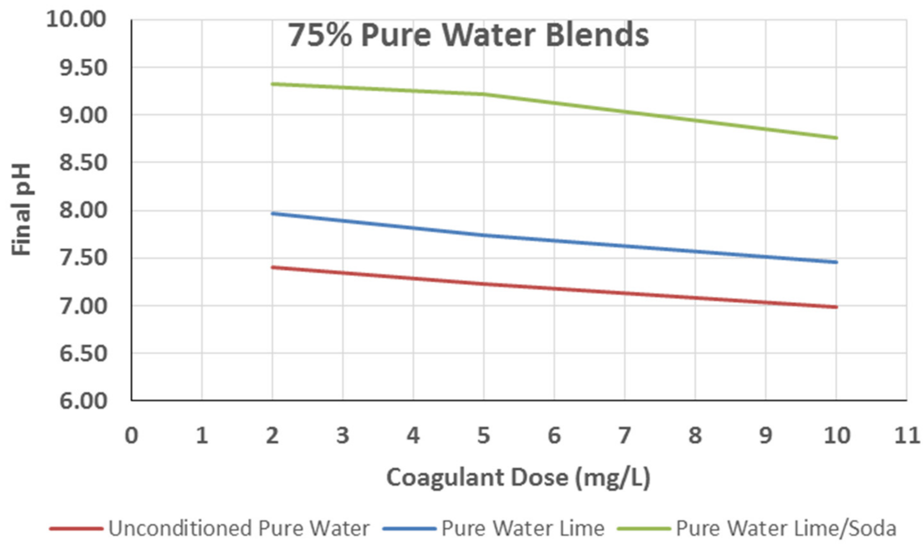

Figure 9. pH Data for 75% Pure Water Blends with $FeCl_3$.

The data shown in **Figure 8** and **Figure 9** is for the ferric chloride tests. In terms of the magnitude of pH change, the results were similar with PACl. The latter coagulant did not demonstrate a clear advantage over ferric chloride in these tests, likely because even the 25% Pure Water blends contained enough alkalinity from the raw water to buffer against extreme shifts in pH. In general, the pH in these tests remained within both the buffered range of PACl and the range in which ferric chloride is effective.

The effect of conditioning on pH was particularly extreme for the 90% and 100% Pure Water blends. **Figure 10** and **Figure 11** compare the raw, coagulated, and final pH for the 90% and 100% blends of both Unconditioned Pure Water and Design Pure Water. The Design Pure Water proved to be much more effectively buffered against pH changes due to coagulant addition. The Unconditioned Pure Water, with almost no acid neutralizing capacity, saw pH decreases well outside the effective range of the coagulant. This extreme pH drop appears to explain the breakdown in treatability (**Table 5**).

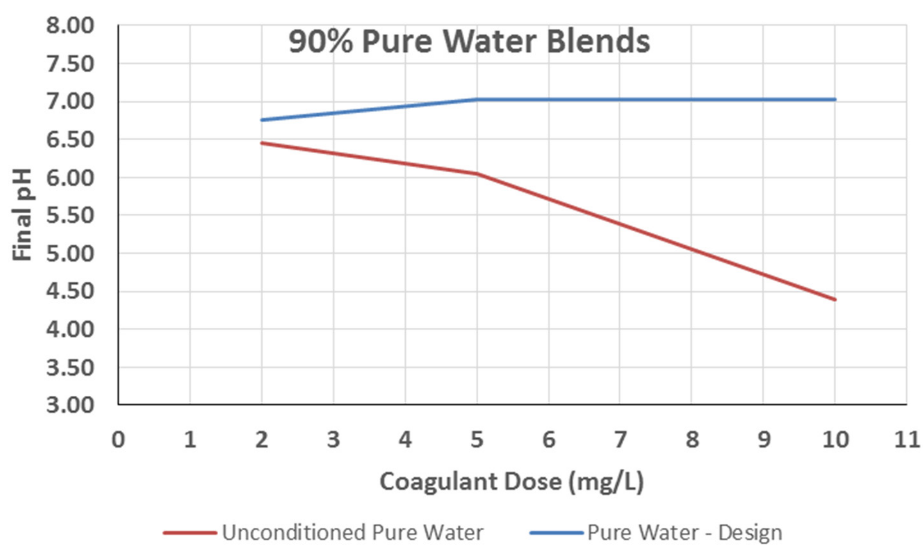

Figure 10. pH Data for 90% Pure Water Blends.

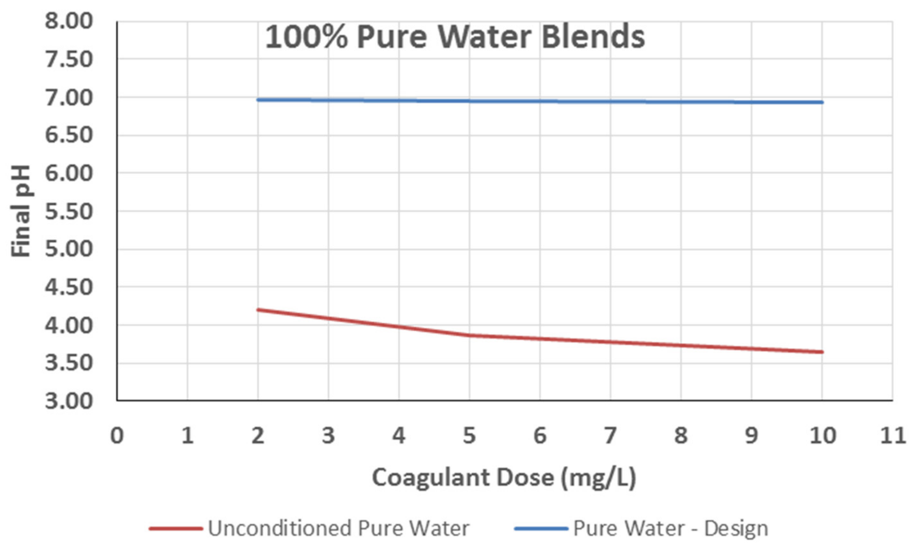

Figure 11. pH Data for 100% Pure Water Blends.

Chemical Stability Results

LSI values were calculated for the initial, coagulated, and final pH using the method described above. The LSI calculations from the jar test data are shown in **Attachment 6.**

Both the chemical conditioning of the Pure Water and the coagulant dose had a clear effect on the LSI of the finished water, as shown in **Figure 12** and **Figure 13**. It is notable that positive LSI values were achieved only when the Pure Water was conditioned with both lime and added alkalinity. Both the Unconditioned Pure Water and Lime Pure Water yielded negative LSI values in every blend at every coagulant dose.

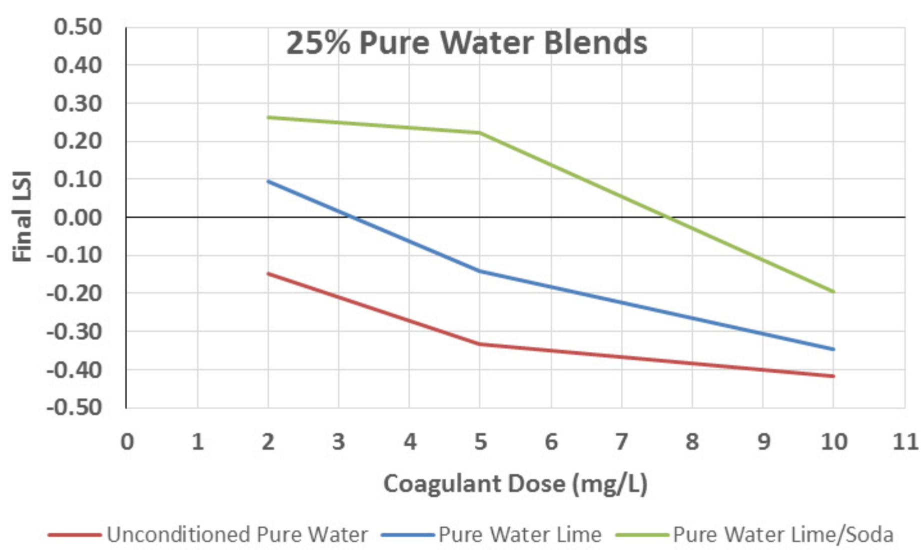

Figure 12. Final LSI Values in 25% Blends for $FeCl_3$ Test Data.

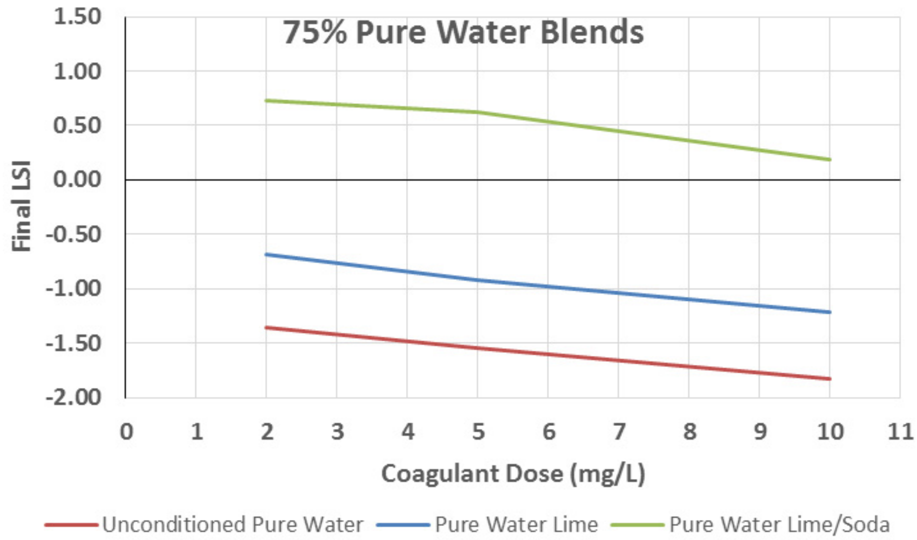

Figure 13. Final LSI Values in 75% Blends for $FeCl_3$ Test Data.

The Design Pure Water performed much better than the Unconditioned Pure Water for the 90% and 100% blends (**Figure 14**). The finished LSI of the Unconditioned Pure Water was highly negative, indicating a water that is quite unstable. While this Design Pure Water ended up with slightly negative LSI, post-treatment with sodium hydroxide to increase the pH to 8.2 or higher would match existing practice and achieve a positive LSI value for this water.

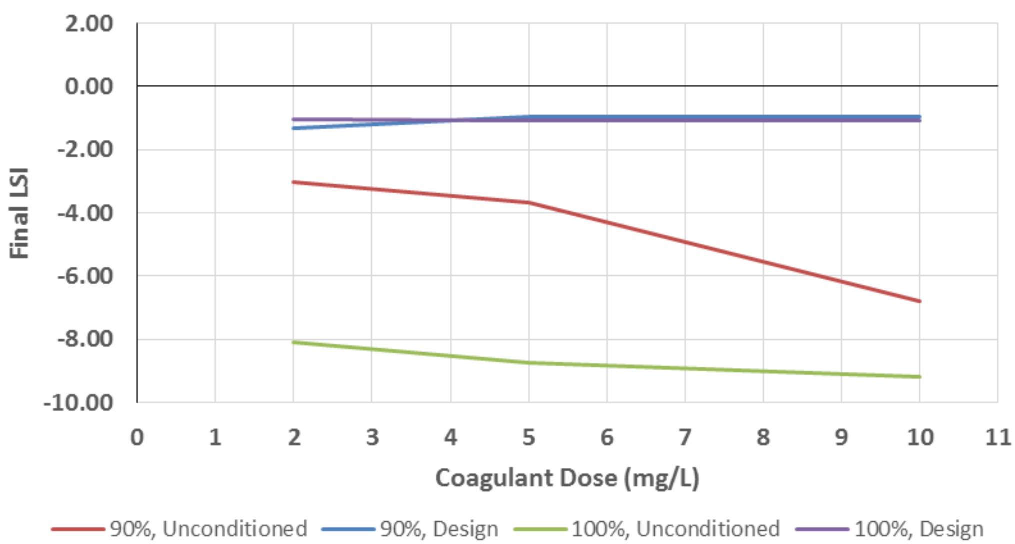

Figure 14. Final LSI Values in High Blend Tests.

It is informative to compare the LSI observed during the bench-scale testing to the LSI values associated with current plant operation. The LSI of the raw, coagulated, and finished water at the Alvarado WTP is plotted in **Figure 15**. These values were calculated using a chemical modeling package (WaterPro^{TM}) for dates when both plant operating data and major ion profiles were availabe, as shown in **Attachment 7**.

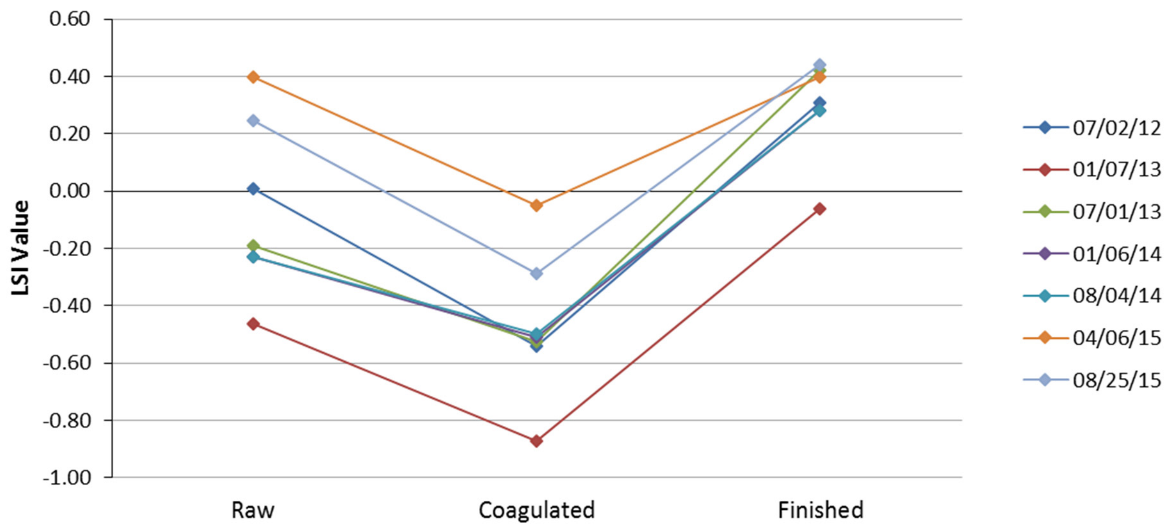

Figure 15. Raw, Coagulated, and Final LSI at Alvarado WTP.

Current plant operation already leads to slightly negative LSI values, which may be corrosive within the plant. The bench-scale results suggest that preventing treated water from becoming corrosive will be even more challenging during Pure Water operation. Proper conditioning of the Pure Water with both calcium and alkalinity is essential, and this finding supports the decision to add both at the NCAWPF as part of the NCAWPF design. Particularly for times of the year when the Pure Water makes up a very large fraction of the WTP influent, careful dosing of coagulant and control of final pH will be very important.

Conclusions and Recommendations

The results of this study show that Pure Water blended with existing water supplies can be successfully coagulated and filtered. The jar tests successfully produced filterable water from every Pure Water blend, and this finding was independent of coagulant dose. Treatability only broke down for blends consisting of 90-100% Unconditioned Pure Water, because of extreme changes in pH. However, blends of 90% and 100% Pure Water were still treatable when properly conditioned. Based on this result, it is expected that the treatment plants will be able to perform effectively with Pure Water augmentation. Under some conditions, solids loading may shift away from the sedimentation tanks and towards the filters.

Chemical stability proved to be the key challenge. Proper conditioning of the Pure Water with both calcium and alkalinity is essential, and the findings from this study support the decision to include both lime addition and carbon dioxide injection at the NCAWPF to achieve Pure Water with appropriate levels of hardness and alkalinity. This will be important to buffer against pH changes during coagulation. Nevertheless, particularly for times of the year when the Pure Water makes up a very large fraction of the WTP influent, careful dosing of coagulant and control of final pH will be very important.

Recommendations from this study include the following:

- *Post conditioning at NCAWPF.* The NCAWPF should add both carbon dioxide and lime to the Pure Water, to achieve a finished water with appropriate hardness and alkalinity.
- *Treatment plant adjustment.* The Alvarado and Miramar WTPs are expected to coagulate and flocculate Pure Water at blends up to 100% of their raw water, and make this water filterable.

Careful operation of the coagulation step is important to achieve this, and solids loading will likely shift towards the filters and away from the sedimentation tanks.

- *Careful coagulant dosing.* Ferric chloride can continue to be used as the coagulant. However, the coagulant should be dosed carefully to maintain control of the pH during the treatment process, even if the flocs formed will be smaller than they are under current operation.

- *pH control and chemistry monitoring.* Avoiding large swings in pH during coagulation and maintaining a consistent pH leaving the plant will be important to prevent chemical upsets to the distribution system or to the plant itself. Careful dosing of sodium hydroxide at the plant and monitoring of the water chemistry are important to maintain pH levels and LSI values consistent with current operation.

Future Work

Several future studies are suggested to follow up from this work.

- *Pipe Loop Studies.* Pipe loops with recirculating water are often used to study processes such as pipe corrosion, metal leaching and biofilm formation in distribution systems. Pipe loop studies with blends of Pure Water could be used to simulate water quality shocks and study their chemical and biological effects on the distribution system. Pipe loop tests could also be used to verify that the conditioned water produced by the WTPs will not cause metal leaching or adverse biofilm impacts.

- *Material Inventory.* The existing operational plans for lead and copper control could be used to identify possible problem areas in the distribution system. In addition, a complete inventory of materials in the WTPs could be undertaken, to study their potential vulnerability to coagaulated water with negative LSI.

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Attachments

1. Design Calculations for Jar Testing
2. Filterability Test Supporting Information
3. Analytical Data
4. Raw Water Profiles and Blending Calculations
5. Jar Test Datasheets and Data Summary
6. LSI Calculations for Each Jar Test
7. Full-scale Plant Data and Chemical Modeling

Attachment 1

Design Calculations for Jar Testing

Jar Test Design Calculations

Analysis of Full-Scale Flocculator

Density and Viscosity Functions

$$\mu_{H2O}(T) := 2.414 \cdot 10^{-5} Pa \cdot s \cdot 10^{\frac{247.8 \cdot K}{T - 140K}}$$

$$WaterDensityTable = \begin{pmatrix} 0 & 999.9 \\ 5 & 1000 \\ 10 & 999.7 \\ 20 & 998.2 \\ 30 & 995.7 \\ 40 & 992.2 \\ 50 & 988.1 \\ 60 & 983.2 \\ 70 & 977.8 \\ 80 & 971.8 \\ 90 & 965.3 \\ 100 & 958.4 \end{pmatrix}$$

$$cubicspline(xarray, yarray, x) := interp(cspline(xarray, yarray), xarray, yarray, x)$$

$$\rho_{H2O}(T) := cubicspline\left(WaterDensityTable^{\langle 0 \rangle}, WaterDensityTable^{\langle 1 \rangle} \cdot \frac{kg}{m^3}, \frac{T}{K} - 273.15\right)$$

$$\nu_{H2O}(T) := \frac{\mu_{H2O}(T)}{\rho_{H2O}(T)}$$

Average Shear and Energy Dissipation Rate

$$T_{design} := \begin{pmatrix} 0\,°C \\ 25\,°C \end{pmatrix}$$

$$G_{Floc} := \frac{50}{s}$$ range of 20-70/s $$\theta_{Floc} := 35min$$

$$G\theta_{Floc} := G_{Floc} \cdot \theta_{Floc}$$ $$G\theta_{Floc} = 105000$$

$$\varepsilon_{Floc.Avg} := G_{Floc}^{\,2} \cdot \nu_{H2O}(T_{design})$$ $$\varepsilon_{Floc.Avg} = \begin{pmatrix} 4.4 \\ 2.2 \end{pmatrix} \frac{mW}{kg}$$

Motor Power

$Q_{Basin56} := 110mgd$

$P_{FlocShaft}(T) := G_{Floc} \cdot Q_{Basin56} \cdot G\theta_{Floc} \cdot \overrightarrow{\left(\nu_{H2O}(T) \cdot \rho_{H2O}(T)\right)}$

$P_{FlocShaft}\left(T_{design}\right) = \begin{pmatrix} 44.4 \\ 22.5 \end{pmatrix} \cdot kW$

The actual power of the motors in basin 5,6 is

$hp_{Basin56} := (2 \cdot 7.5hp + 4 \cdot 5hp) \cdot 2 = 52 \cdot kW$

Each basin has the same line of 6 stages and 6 motors

The design apparently assumed that only the first stage would be at 70/s

Maximum Energy Dissipation Rate at Propeller Tip

$N_{Paddle} := 3.5 \cdot \frac{1}{min}$ $D_{Paddle} := 12ft$ $H_{Propeller} := 9in$

Paddle speed (measured); paddle wheel diameter and paddle board height (scaled from record dwgs)

Plate ratio (from CFD data for baffled flocculators):

$H_{Plate} := 100cm$ $V_{Plate} := 1\frac{m}{s}$ $\varepsilon_{PlateMax} := 0.043\frac{W}{kg}$

$$\Pi_{Plate} := \frac{H_{Plate}^{\frac{1}{3}} \cdot \varepsilon_{PlateMax}^{\frac{1}{3}}}{V_{Plate}} = 0.35$$

$$V_{Propeller} := \pi \cdot D_{Paddle} \cdot N_{Paddle} = 2.2 \cdot \frac{ft}{s}$$

$$\varepsilon_{PropellerTip} := \frac{\left(\Pi_{Plate} \cdot V_{Propeller}\right)^3}{H_{Propeller}} = 57 \cdot \frac{mW}{kg}$$

$\varepsilon_{PropellerTip} = 56.65\frac{mW}{kg}$

$$G_{PropellerTip} := \sqrt{\frac{\varepsilon_{PropellerTip}}{\nu_{H2O}\left(T_{design_1}\right)}} = 251.86\frac{1}{s}$$

$G_{PropellerTip} = 251.86\frac{1}{s}$

$$\alpha_{\varepsilon} := \frac{\varepsilon_{PropellerTip}}{\varepsilon_{Floc.Avg}} = \begin{pmatrix} 13 \\ 25 \end{pmatrix}$$

This high value of α_{ε} results in a slight inefficiency in the use of energy for flocculation. This inefficiency requires longer residence times.

Design recommendation for the jar test: don't worry about the maximum energy dissipation rate. It is low enough to not be a concern as long as floc strength for ferric hydroxide flocs is similar to PACl flocs (where I have more experience). Design the jar test to have the same average energy dissipation rate (or G) as is used in the Alvarado plant.

Analysis of Bench-Scale Flocculator

Jar Test Flocculator Configuration

$D_{Paddle.Jar} := 3in$ $\quad H_{Paddle.Jar} := 1in$ — Paddle dimensions

$$A_{Paddle.Jar} := D_{Paddle.Jar} \cdot H_{Paddle.Jar} = 3 \cdot in^2$$

$W_{Jar} := 5in$ $\quad L_{Jar} := 5in$ — Length and width of jars

$Vol_{Jar} := 2L$ — Water volume and depth

$$HW_{Jar} := \frac{Vol_{Jar}}{W_{Jar} \cdot L_{Jar}} = 4.88 \cdot in$$

$C_D := 1.8$ — Appoximate drag coefficient. (*Mixing in Coag. and Floc.* p. 412)

Calculated Speed to Match Maximum Energy Dissipation Rate

$$\varepsilon_{FlocJarTip} = \frac{\left(\Pi_{Plate} \cdot V_{Tip.Jar}\right)^3}{H_{Paddle.Jar}} = \frac{\left[\Pi_{Plate} \cdot \left(\pi \cdot D_{Paddle.Jar} \cdot N_{Floc.Jar}\right)\right]^3}{H_{Paddle.Jar}}$$

If we solve for an rpm that matches the energy dissipation rate of the full scale flocculator we get:

$$N_{Floc.Jar.Scaled} := \frac{H_{Paddle.Jar}^{\frac{1}{3}} \cdot \varepsilon_{PropellerTip}^{\frac{1}{3}}}{\pi \cdot D_{Paddle.Jar} \cdot \Pi_{Plate}}$$

$$N_{Floc.Jar.Scaled} = 80.77 \cdot \frac{1}{min}$$

$$\varepsilon_{Floc.Jar.Scaled} := \frac{C_D \cdot A_{Paddle.Jar}}{Vol_{Jar}} \cdot \frac{\left(\frac{\pi}{2} \cdot D_{Paddle.Jar} \cdot N_{Floc.Jar.Scaled}\right)^3}{2} = 3.64 \cdot \frac{mW}{kg}$$

Average Jar Test Energy Dissipation Rate

$$N_{Floc.Jar} := 80 \frac{1}{min}$$

Jar apparatus speed setting

$$V_{Tip.Jar} := \pi \cdot D_{Paddle.Jar} \cdot N_{Floc.Jar} = 1.05 \cdot \frac{ft}{s}$$

$$V_{Avg.Jar} := \left(\frac{\pi}{2} \cdot D_{Paddle.Jar} \cdot N_{Floc.Jar}\right) = 0.52 \cdot \frac{ft}{s}$$

For a single continuous paddle, the average velocity along the paddle is half the tip velocity.

$$\varepsilon_{Floc.Jar.Tip} := \frac{\left(\Pi_{Plate} \cdot V_{Tip.Jar}\right)^3}{H_{Paddle.Jar}}$$

$$\varepsilon_{Floc.Jar.Tip} = 55.05 \cdot \frac{mW}{kg}$$

Estimate power based on Reynolds and Richards (1996) eq. 8.16 or *Mixing in Coag. and Floc.* (1991) eq. 11-29.

$$P_{Floc.Jar} := C_D \cdot A_{Paddle.Jar} \cdot \rho_{H2O}\left(T_{design_1}\right) \cdot \frac{\left(\frac{\pi}{2} \cdot D_{Paddle.Jar} \cdot N_{Floc.Jar}\right)^3}{2} = 7.06 \cdot mW$$

$$\varepsilon_{Floc.Jar.Avg} := \frac{P_{Floc.Jar}}{Vol_{Jar} \cdot \rho_{H2O}\left(T_{design_1}\right)}$$

$$\varepsilon_{Floc.Jar.Avg} = 3.54 \cdot \frac{mW}{kg}$$

$$\alpha_{Floc.Jar} := \frac{\varepsilon_{Floc.Jar.Tip}}{\varepsilon_{Floc.Jar.Avg}}$$

$$\alpha_{Floc.Jar} = 15.55$$

Jar Test Shear and Gθ

$$\theta_{Jar} := 35min$$

Jar apparatus time setting for flocculation step

$$G_{Floc.Jar} := \sqrt{\frac{\varepsilon_{Floc.Jar.Avg}}{\nu_{H2O}\left(T_{design_1}\right)}}$$

$$G_{Floc.Jar} = 62.96 \frac{1}{s}$$

$$G\theta_{Floc.Jar} := G_{Floc.Jar} \cdot \theta_{Jar}$$

$$G\theta_{Floc.Jar} = 132222$$

MWH

By MJA Date 8/25/15 Client San Diego Pure Water Sheet 1 of 1

Chkd. By MSS Description TO-4 - Alvarado WTP Flocculator Settings Job No. 10507589

Speed Testing

Stage	Time (min)	Paddle Count	Speed (rpm)
1	1:00	7	3.5
2	1:00	6	3
3	1:00	4	2

Paddle Dimensions

Diameter ≈ 12 ft

Paddle Height ≈ 9 in

Attachment 2

Filterability Test Supporting Information

Filtration Model

Tufenkji, N. and M. Elimelech (2004). "Correlation equation for predicting single-collector efficiency in physicochemical filtration in saturated porous media." Environ Sci Technol, **38**(2), 529-536.

The model is based on Tufenkji and Elimelech but corrected to eliminate artificial dependencies on irrelevant parameters!

Physical Constants

$$\rho_w := 1000 \frac{kg}{m^3}$$

$$\mu := 0.00089 \cdot \frac{newton \cdot sec}{m^2} * \qquad \nu := \frac{\mu}{\rho_w}$$

$$k_b := 1.3806505 \cdot 10^{-23} \cdot \frac{joule}{K}$$

$$A := 0.75 \cdot 10^{-20} J$$

Model Inputs

Particle Properties

$$d_p := 0.1\mu m, 0.2 \cdot \mu m .. 100\mu m$$ Range of particle sizes

$$\rho_p := 2640 \frac{kg}{m^3}$$ Particle density (supended clay particles)

Filtration Conditions

$$V_a := 4 \frac{gpm}{ft^2}$$ Filtration rate

$$T := 293K$$ Assumed temperature

Filter Characteristics

$z_{Anth} := 18in$ $d_{Anth} := 1.25mm$ Anthracite layer

$z_{Sand} := 12in$ $d_{Sand} := 0.7mm$ Sand layer

$$\frac{z_{Anth}}{d_{Anth}} + \frac{z_{Sand}}{d_{Sand}} = 801$$

$\alpha := 1$ Attachment efficiency

$\varepsilon := 0.4$ Bed porosity

Dimensionless Groupings

Geometric Groups

$$\Pi_R(d_c, d_p) := \frac{d_p}{d_c}$$

$$\Pi_z(z, d_c) := \frac{3\cdot(1-\varepsilon)}{2\cdot \ln(10)}\cdot\left(\frac{z}{d_c}\right)$$

Force Ratios

$$\Pi_{Br}(V_a, d_c, d_p) := \frac{k_b\cdot T}{3\cdot\pi\cdot\mu\cdot d_p\cdot V_a\cdot d_c}$$ Brownian motion transport

$$\Pi_g(V_a, d_p, \rho_p) := \frac{d_p^{\;2}\cdot(\rho_p - \rho_w)\cdot g}{18\cdot\mu\cdot V_a}$$ Gravitational transport

$$Re := \frac{V_a\cdot d_{Anth}}{\nu} \qquad Re = 3.815$$

Porosity Effects

$$\gamma(\varepsilon) := (1-\varepsilon)^{\frac{1}{3}}$$

$$A_s(\varepsilon) := \frac{2\cdot\left(1-\gamma(\varepsilon)^5\right)}{2-3\cdot\gamma(\varepsilon)+3\cdot\gamma(\varepsilon)^5-2\cdot\gamma(\varepsilon)^6}$$

Transport due to Brownian Motion, Gravity, and Interception

Brownian Motion:

$$\eta_{Br}(V_a, d_c, d_p) := \frac{3}{4}\cdot A_s(\varepsilon)^{\frac{1}{3}}\cdot\Pi_R(d_c, d_p)^{-\frac{1}{6}}\cdot\Pi_{Br}(V_a, d_c, d_p)^{\frac{2}{3}}$$

Interception:

$$\eta_R(d_c, d_p) := \frac{1}{21.5}\cdot A_s(\varepsilon)\cdot\Pi_R(d_c, d_p)^{1.425}$$

Gravity:

$$\eta_g(V_a, d_p, \rho_p) := 0.31\cdot\Pi_g(V_a, d_p, \rho_p)$$

Total:

$$\eta(V_a, d_c, d_p, \rho_p) := \eta_{Br}(V_a, d_c, d_p) + \eta_R(d_c, d_p) + \eta_g(V_a, d_p, \rho_p)$$

Particle Removal

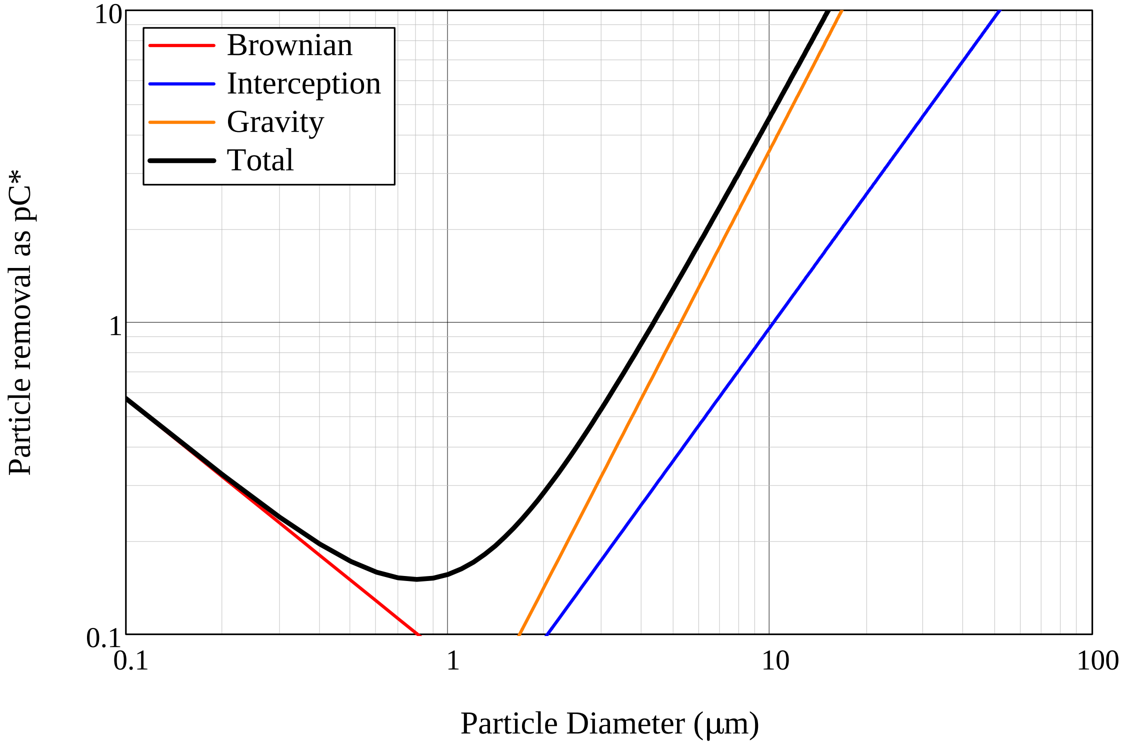
$$pC_{Br}(V_a, z, d_c, d_p, \alpha) := \Pi_z(z, d_c)\cdot\alpha\cdot\eta_{Br}(V_a, d_c, d_p)$$ Brownian motion

$$pC_R(z, d_c, d_p, \alpha) := \Pi_z(z, d_c)\cdot\alpha\cdot\eta_R(d_c, d_p)$$ Interception

$$pC_g(V_a, z, d_c, d_p, \rho_p, \alpha) := \Pi_z(z, d_c)\cdot\alpha\cdot\eta_g(V_a, d_p, \rho_p)$$ Gravity

$$pC\left(V_a, z, d_c, d_p, \rho_p, \alpha\right) := \Pi_z\left(z, d_c\right) \cdot \alpha \cdot \eta\left(V_a, d_c, d_p, \rho_p\right)$$ Total

Projected Performance



Filterability Test Datasheet

Test Date 8/25/15

Filter Paper Tests

Settled Water Turbidity 0.31

Paper Rating	Vial 1 (NTU)	Vial 2 (NTU)	Vial 3 (NTU)	Vial 4 (NTU)	Vial 5 (NTU)	Vial 6 (NTU)
2 μm	0.246	0.083	0.13			
8 μm	0.40	0.109	0.16			

Filter Cartridge Tests

Settled Water Turbidity 0.31

air trapped, redo

Cartridge Rating	Vial 1 (NTU)	Vial 2 (NTU)	Vial 3 (NTU)
5 μm	0.195	0.081	0.12
5 μm	0.096	0.079	
0.45 μm	0.082		
5 μm*		0.16	

Note:

Filter Eff. = ~~0.07~~ 0.08 NTU (plant filters)

DI ≈ 0.08 NTU

* Raw = 0.33

Not coag/floc/sed

Attachment 3

Analytical Data

San Diego Pure Water TO-4

Water Quality Constituents

Data Summary

PARAMETER	UNIT	DEMO PLANT WATER 08/17/15 Sampled at Demo Plant	08/25/15 Sampled at AWTP Lab	08/26/15 Sampled at AWTP Lab	09/24/15 Sampled at Demo Plant	09/29/15 Sampled at AWTP Lab	09/30/15 Sampled at AWTP Lab	12/02/15 Sampled at AWTP Lab	AVERAGE
Cations									
Calcium	mg/L		<5	<5				<5	<5
Magnesium	mg/L		<3	<3				<3	<3
Sodium	mg/L		16.8	16.2				17.0	16.7
Potassium	mg/L		1.38	5.83				1.86	3.0
Anions									
Bicarbonate	mg/L								
Carbonate	mg/L								
Chloride	mg/L		19.1	14				15.1	16.1
Sulfate	mg/L		1.45	0.57				0.72	0.9
General									
TDS	mg/L	40							40
Hardness	mg/L as $CaCO_3$	11							11
Alkalinity	mg/L as $CaCO_3$	12.3							12
TOC	mg/L								
Turbidity	NTU					0.132	0.079		0.11
pH	pH units	5.84			5.6	6.43	6.92	6.39	6.24
UV	ABS								

San Diego Pure Water TO-4

Water Quality Constituents

Data Summary

PARAMETER	UNIT	ALVARADO WTP INFLUENT 04/06/15 City Data	08/25/15 Sampled at AWTP Lab	08/26/15 Sampled at AWTP Lab	09/29/15 Sampled at AWTP Lab	09/30/15 Sampled at AWTP Lab	12/02/15 Sampled at AWTP Lab	AVERAGE
Cations								
Calcium	mg/L	74	70.9	59.7			52.7	64
Magnesium	mg/L	28.3	25.6	26.3			24.7	26
Sodium	mg/L	93.8	99.1	99			94.1	97
Potassium	mg/L	4.66	15.8	5.21			5.11	7.7
Anions								
Bicarbonate	mg/L	157					151	154
Carbonate	mg/L							
Chloride	mg/L	99.1	109	101			96.3	101
Sulfate	mg/L	229	261	260			236	247
General								
TDS	mg/L							
Hardness	mg/L as $CaCO_3$							
Alkalinity	mg/L as $CaCO_3$						124	124
TOC	mg/L	2.84						2.8
Turbidity	NTU	0.7	0.31	0.3	0.219	0.235	0.3	0.3
pH	pH units	8	7.9	8	7.87	7.95		7.9
UV	ABS		0.032	0.035				

City of San Diego Public Utilities Department
Environmental Monitoring and Technical Services
Water Quality Chemistry Services
Client/Source: Advanced Water Purification Demonstration Project

Monthly Analysis
Sample Collection August 17, 2015
Report Date: October 06, 2015

SOURCE	TDS	pH *	Total Alkalinity	Partial Alkalinity	Conductivity	Total Hardness	Calcium Hardness
UNITS	mg/L	pH	mg/L	mg/L	uMHO/cm	mg/L	mg/L
MDL	28		10	0		10	10
AWPD_A1_CONC	2260	**7.42**	261	0	3160	788	457
AWPD_A1_FEED	1140	**7.07**	124	0	1690	371	216
AWPD_A1_PERM	20	**5.55**	ND	0	37.2	ND	ND
AWPD_A2_CONC	4440	**7.56**	519	0	5190	1540	889
AWPD_A2_PERM	63	**5.81**	13.5	0	122	ND	ND
AWPD_ACOMB_PERM	28	**5.64**	ND	0	59.2	ND	ND
AWPD_B1_CONC	2050	**7.35**	243	0	2830	733	425
AWPD_B1_FEED	1130	**7.08**	123	0	1640	371	218
AWPD_B1_PERM	29	**5.64**	ND/11.9**	0	48.5	ND/12.8**	ND/12**
AWPD_B2_CONC	3280	**7.39**	373	0	4210	1190	689
AWPD_B2_PERM	69	**5.96**	18.3	0	143	14.7	14.7
AWPD_B3_CONC	4800	**7.52**	548	0	5460	1650	961
AWPD_B3_PERM	147	**6.01**	17.5	0	274	ND	ND
AWPD_BCOMB_PERM	45	**5.82**	10.2	0	89.4	ND	ND
AWPD_UV1	40	**5.84**	12.3	0	86.9	11	ND
AWP_ET_2	1070	**7.06**	128	0	1695	377	220
AWP_ET_4	1040	**6.89**	123	0	1680	373	216

*Analysis was completed past holding time.

**%RPD higher than normal due to values near the detection limit. Both results are included for informational purposes.

City of San Diego
Public Utilities Department
Enviromental Monitoring and Technical Services
Water Quality Chemistry Services
Report Date: September 23, 2015

Jar Testing
Metal Analysis Report

Sample ID	External ID	Sample Date	Analyte	**Result**	MDL	Units
W1065161	PLANT INFLUENT	08/25/15	CALCIUM	**70.9**	5	MG/L
W1065161	PLANT INFLUENT	08/25/15	CHLORIDE	**109**	0.5	MG/L
W1065161	PLANT INFLUENT	08/25/15	MAGNESIUM	**25.6**	3	MG/L
W1065161	PLANT INFLUENT	08/25/15	POTASSIUM	**15.8**	0.5	MG/L
W1065161	PLANT INFLUENT	08/25/15	SODIUM	**99.1**	20	MG/L
W1065161	PLANT INFLUENT	08/25/15	SULFATE	**261**	1	MG/L
W1065248	AWP RO PERMEATE	08/25/15	CALCIUM	**ND**	5	MG/L
W1065248	AWP RO PERMEATE	08/25/15	CHLORIDE	**19.1**	0.5	MG/L
W1065248	AWP RO PERMEATE	08/25/15	MAGNESIUM	**ND**	3	MG/L
W1065248	AWP RO PERMEATE	08/25/15	POTASSIUM	**1.38**	0.5	MG/L
W1065248	AWP RO PERMEATE	08/25/15	SODIUM	**16.8**	5	MG/L
W1065248	AWP RO PERMEATE	08/25/15	SULFATE	**1.45**	0.5	MG/L
W1065842	ALV PLANT INFLUENT	08/26/15	CALCIUM	**59.7**	5	MG/L
W1065842	ALV PLANT INFLUENT	08/26/15	CHLORIDE	**101**	0.5	MG/L
W1065842	ALV PLANT INFLUENT	08/26/15	MAGNESIUM	**26.3**	3	MG/L
W1065842	ALV PLANT INFLUENT	08/26/15	POTASSIUM	**5.21**	0.5	MG/L
W1065842	ALV PLANT INFLUENT	08/26/15	SODIUM	**99**	20	MG/L
W1065842	ALV PLANT INFLUENT	08/26/15	SULFATE	**260**	1	MG/L
W1065843	AWP RO PERMEATE	08/26/15	CALCIUM	**ND**	5	MG/L
W1065843	AWP RO PERMEATE	08/26/15	CHLORIDE	**14**	0.5	MG/L
W1065843	AWP RO PERMEATE	08/26/15	MAGNESIUM	**ND**	3	MG/L
W1065843	AWP RO PERMEATE	08/26/15	POTASSIUM	**5.83**	0.5	MG/L
W1065843	AWP RO PERMEATE	08/26/15	SODIUM	**16.2**	5	MG/L
W1065843	AWP RO PERMEATE	08/26/15	SULFATE	**.569**	0.5	MG/L

City of San Diego
Public Utilities Department
Enviromental Monitoring and Technical Services
Water Quality Chemistry Services
Report Date: September 23, 2015

Jar Testing
UV254 Report
MDL: 0.004
Units: ABS

Sample ID	External ID	Sample Date	Result
W1065123	PLANT INFLUENT	08/25/15	**.032**
W1065146	25% AWP RO PERMEATE	08/25/15	**.025**
W1065147	75% AWP RO PERMEATE	08/25/15	**.011**
W1065148	LOT 002 JAR 1F	08/25/15	**.035**
W1065149	LOT 002 JAR-2F	08/25/15	**.033**
W1065150	LOT 002 JAR-3F	08/25/15	**.033**
W1065151	LOT 002 JAR-4F	08/25/15	**.04**
W1065152	LOT 002 JAR-5F	08/25/15	**.044**
W1065153	LOT 002 JAR-6F	08/25/15	**.028**
W1065787	ALV. PLANT INFLUENT	08/26/15	**.035**
W1065819	LOT 005 JAR-4F	08/26/15	**.012**
W1065820	LOT 005 JAR-2F	08/26/15	**.03**
W1065821	LOT 005 JAR 1F	08/26/15	**.027**
W1065822	LOT 005 JAR-6F	08/26/15	**.012**
W1065823	25% AWP RO PERMEATE	08/26/15	**.026**
W1065824	LOT 005 JAR-5F	08/26/15	**.011**
W1065825	LOT 005 JAR-3F	08/26/15	**.026**
W1065826	75% AWP RO PERMEATE	08/26/15	**.011**
W1065827	LOT 004 JAR 1F	08/26/15	**.025**
W1065828	LOT 004 JAR-2F	08/26/15	**.025**
W1065829	LOT 004 JAR-3F	08/26/15	**.021**
W1065830	LOT 004 JAR-4F	08/26/15	**.013**
W1065831	LOT 004 JAR-5F	08/26/15	**.014**
W1065832	LOT 004 JAR-6F	08/26/15	**.009**

Michael Adelman

From: Tony Hancock
Sent: Wednesday, September 30, 2015 4:45 PM
To: Michael Adelman
Cc: Paige Russell; Mia Smith
Subject: RE: Message from "USSAN1MPC4502"

Follow Up Flag: Follow up
Flag Status: Completed

Also, here is the initial pH and turbidity of the WTP influent and Pure Water:

	pH	Turbidity (NTU)
9/29		
WTP Influent	7.87	0.219
Pure Water	6.43	0.132
9/30		
WTP Influent	7.95	0.235
Pure Water	6.92	0.079

Tony Hancock, P.E.
MWH
Phone: 1-619-957-6482

From: Michael Adelman
Sent: Wednesday, September 30, 2015 4:29 PM
To: Tony Hancock
Cc: Paige Russell
Subject: RE: Message from "USSAN1MPC4502"

Thanks Paige and Tony – I appreciate your effort helping out with these tests!

From: Tony Hancock
Sent: Wednesday, September 30, 2015 4:15 PM
To: Michael Adelman
Cc: Paige Russell
Subject: RE: Message from "USSAN1MPC4502"
Importance: High

Hi Michael,

Here are the data sheets for the two experiments today.

Best,

Tony Hancock, P.E.
MWH
Phone: 1-619-957-6482

From: Michael Adelman
Sent: Wednesday, September 30, 2015 9:26 AM
To: Tony Hancock
Cc: Paige Russell
Subject: RE: Message from "USSAN1MPC4502"

Hi Tony and Paige,

Thanks! I appreciate your help running these tests - hope you enjoyed your time at the plant.

I posted the datasheets on the server at the link below. If you have photos of your flocs you can put them in these folders as well.
\\uspas1s01\MUNI\Clients\San Diego Pure Water Program\TO-4 - Impact of Pure Water on WTPs\06 Studies and Reports\06-7 Bench-Scale Testing

Thanks,
Michael

-----Original Message-----
From: Tony Hancock
Sent: Tuesday, September 29, 2015 8:18 PM
To: Michael Adelman
Cc: Paige Russell
Subject: FW: Message from "USSAN1MPC4502"

Hi Michael,

Here are the data sheets for the first two experiments.

Best,

Tony Hancock, P.E.
MWH
Phone: 1-619-957-6482

-----Original Message-----
From: ussan1ricohmpc4502@mwhglobal.com [mailto:ussan1ricohmpc4502@mwhglobal.com]
Sent: Tuesday, September 29, 2015 8:12 PM
To: Tony Hancock
Subject: Message from "USSAN1MPC4502"

This E-mail was sent from "USSAN1MPC4502" (Aficio MP C4502).

Scan Date: 09.29.2015 20:12:03 (-0700)
Queries to: ussan1ricohmpc4502@mwhglobal.com

Pure Water Conditioning Datasheet

Test Date 12/2/15

Step 1: Add Sodium Bicarbonate

Dose 130 mg/L as $NaHCO_3$

		pH	Alkalinity (mg/L as $CaCO_3$)	Hardness (mg/L as $CaCO_3$)
PW-0	Starting	6.39		
PW-1	After Dosing	7.20		

Step 2: Add Saturated Lime Solution

Dose ______ mL of Saturated Lime Water

Stock Strength ______ mg/L Ca^{2+}

		pH	Alkalinity (mg/L as $CaCO_3$)	Hardness (mg/L as $CaCO_3$)
PW-2	After Dosing	10.81		

Step 3: Add Hydrochloric Acid

Dose ______ mL of HCl

Stock Strength ______ mol/L HCl

		pH	Alkalinity (mg/L as $CaCO_3$)	Hardness (mg/L as $CaCO_3$)
PW-3	After Dosing	7.86		

City of San Diego
Public Utilities Department
Environmental Monitoring and Technical Services
Water Quality Chemistry Services
Report Date: 12/17/15

San Diego Pure Water TO-4
High Blend Test Sampling Report

Analyte	Units	RW_DP 12/03/15	RW_AL 12/03/15	PW_3 12/02/15	PW_2 12/02/15	PW_1 12/02/15	PW_0 12/02/15	LS_1 12/03/15
ALKALINITY_PART	MG/L	0	0	0	61.1	0	0	
ALKALINITY_TOT	MG/L	ND	124	85.6	133	85.6	ND	
HARDNESS_CA	MG/L			115	54.3	ND	ND	1570
HARDNESS_TOTAL	MG/L			117	54.4	ND	ND	1730
CHLORIDE	MG/L	15.1	96.3					
SULFATE	MG/L	0.729	236					
CALCIUM	MG/L	ND	52.7					628**
MAGNESIUM	MG/L	ND	24.7					
POTASSIUM	MG/L	1.86	5.11					
SODIUM	MG/L	17.0	94.1					

**Calculated Value. From Hardness_CA

Attachment 4

Raw Water Profiles and Blending Calculations

San Diego Pure Water TO-4

Raw Water Profiles

Parameter	AWTP Raw Water - 04/06/15 mg/L	as $CaCO_3$	mmol/L	meq/L	AWTP Raw Water - 08/25/15 mg/L	as $CaCO_3$	mmol/L	meq/L	AWTP Raw Water - 08/26/15 mg/L	as $CaCO_3$	mmol/L	meq/L	AWTP Raw Water - 12/3/15 mg/L	as $CaCO_3$	mmol/L	meq/L
Cations																
Calcium	74	185	1.85	3.70	70.9	177	1.77	3.55	59.7	149	1.49	2.99	52.7	132	1.32	2.64
Magnesium	28.3	116	1.16	2.32	25.6	105	1.05	2.10	26.3	108	1.08	2.16	24.7	101	1.01	2.02
Sodium	93.8	204	4.08	4.08	99.1	215	4.31	4.31	99	215	4.30	4.30	94.1	205	4.09	4.09
Potassium	4.66	6.0	0.12	0.12	15.8	20.2	0.40	0.40	5.2	6.7	0.13	0.13	5.11	6.5	0.13	0.13
Total Cations				**10.2**				**10.4**				**9.6**				**8.9**
Anions																
Bicarbonate	157	129	2.57	2.57	113	92	1.85	1.85	122	100	2.01	2.01	150	123	2.46	2.46
Carbonate	0.7	1.2	0.01	0.02	0.4	0.7	0.01	0.01	0.6	0.9	0.01	0.02	0.7	1.2	0.01	0.02
Chloride	99.1	140	2.79	2.79	109	154	3.07	3.07	99.1	140	2.79	2.79	96.3	136	2.71	2.71
Sulfate	229	238	2.38	4.76	261	271	2.71	5.43	229	238	2.38	4.76	236	245	2.45	4.91
Total Anions				**10.2**				**10.4**				**9.6**				**10.1**
General																
TDS	687				694				641				660			
Alkalinity		130		2.6		93		1.9		101		2.0		124		2.5
pH	8.0				7.9				8.0				8.0			
Electroneutrality				0.07				0.00				0.00				1.22
Total Carbonate			2.65				1.91				2.06				2.53	
	α_1 =	0.97	α_2 =	0.00	α_1 =	0.97	α_2 =	0.00	α_1 =	0.97	α_2 =	0.00	α_1 =	0.97	α_2 =	0.00
Calculated Values	Solved for carbonate based on pH and known bicarbonate.				Solved for Total Carbonate based on electroneutrality condition.				Solved for Total Carbonate based on electroneutrality condition.				Solved for carbonate and bicarbonate based on measured pH and alkalinity.			

Equivalent Weights

	mg/meq	eq/mol	mg/mmol
Ca^{2+} =	20	2	40
Mg^{2+} =	12.2	2	24.4
Na^{+} =	23	1	23
K^{+} =	39.1	1	39.1
HCO_3^- =	61	1	61
CO_3^{2-} =	30	2	60
Cl^- =	35.5	1	35.5
SO_4^{2-} =	48.1	2	96.2
OH^- =	17	1	17
$CaCO_3$ =	50	2	100

Carbonate System

K_{A1} = 4.3E-07

K_{A2} = 4.7E-11

Chemical Dosing

Lime =	4	mg/L dose
Ca^{2+} =	2.2	mg/L added
Soda Ash =	35	mg/L dose
Na^{+} =	15.2	mg/L added
CO_3^{2-} =	19.8	mg/L added
C_t =	0.33	mmol/L added

San Diego Pure Water

Raw Water Profiles

Parameter	Demo Plant Water mg/L	as $CaCO_3$	mmol/L	meq/L	Pure Water - Design mg/L	as $CaCO_3$	mmol/L	meq/L	Pure Water - Lime mg/L	as $CaCO_3$	mmol/L	meq/L	Pure Water - Lime/Soda mg/L	as $CaCO_3$	mmol/L	meq/L
Cations																
Calcium	1	3	0.03	0.05	45.9	115	1.15	2.30	3.2	8	0.08	0.16	3.2	8	0.08	0.16
Magnesium	0.5	2	0.02	0.04	0.5	2	0.02	0.04	0.5	2	0.02	0.04	0.5	2	0.02	0.04
Sodium	17	37	0.74	0.74	52.6	114	2.29	2.29	17	37	0.74	0.74	32	70	1.39	1.39
Potassium	1.5	1.9	0.04	0.04	1.86	2.4	0.05	0.05	1.5	1.9	0.04	0.04	1.5	1.9	0.04	0.04
Total Cations				**0.9**				**4.7**				**1.0**				**1.6**
Anions																
Bicarbonate	15	12	0.25	0.25	104	85	1.71	1.71	20	16	0.32	0.32	28	23	0.46	0.46
Carbonate	0.0	0.0	0.00	0.00	0.4	0.6	0.01	0.01	0.9	1.5	0.02	0.03	12.9	21.4	0.21	0.43
Chloride	19	27	0.54	0.54	92.4	130	2.60	2.60	19	27	0.54	0.54	19	27	0.54	0.54
Sulfate	1.5	2	0.02	0.03	0.72	1	0.01	0.01	1.5	2	0.02	0.03	1.5	2	0.02	0.03
Total Anions				**0.8**				**4.3**				**0.9**				**1.5**
General																
TDS	56				299				63				98			
Alkalinity		12		0.2		86		1.7		18		0.4		44		0.9
pH	6.8				7.9				9.0				10.0			
Electroneutrality				0.06				0.33				0.06				0.18
Total Carbonate			0.34				1.77				0.34				0.67	
	α_1 =	0.73	α_2 =	0.00	α_1 =	0.97	α_2 =	0.00	α_1 =	0.95	α_2 =	0.04	α_1 =	0.68	α_2 =	0.32
Calculated Values	Solved for bicarbonate concentration based on measured alkalinity. Estimated calcium and magnesium (<MDL).				Based on stepwise conditioning - Refer to spreadsheet for Pure Water - Design				Demo Plant Water plus 4 mg/L Hydrated Lime. Dose estimated with WaterPro to get to measured pH of 9.0.				Pure Water Lime plus 35 mg/L Soda Ash. Resultant pH confirmed with WaterPro.			

San Diego Pure Water TO-4

Design Pure Water - Analysis based on Lab Data

Parameter	Demo Plant Water mg/L	as $CaCO_3$	mmol/L	meq/L	Step 1 - Add Sodium Bicarbonate mg/L	as $CaCO_3$	mmol/L	meq/L	Step 2 - Add Lime mg/L	as $CaCO_3$	mmol/L	meq/L	Step 3 - Add Hydrochloric Acid mg/L	as $CaCO_3$	mmol/L	meq/L
Cations																
Calcium	1	3	0.03	0.05	1	3	0.03	0.05	45.9	115	1.15	2.29	45.9	115	1.15	2.29
Magnesium	0.5	2	0.02	0.04	0.5	2	0.02	0.04	0.5	2	0.02	0.04	0.5	2	0.02	0.04
Sodium	17	37	0.74	0.74	52.6	114	2.29	2.29	52.6	114	2.29	2.29	52.6	114	2.29	2.29
Potassium	1.86	2.4	0.05	0.05	1.86	2.4	0.05	0.05	1.86	2.4	0.05	0.05	1.86	2.4	0.05	0.05
Total Cations				**0.9**				**2.4**				**4.7**				**4.7**
Anions																
Bicarbonate	7	6	0.11	0.11	94	77	1.54	1.54	27	22	0.44	0.44	104	86	1.71	1.71
Carbonate	0.0	0.0	0.00	0.00	0.1	0.1	0.00	0.00	79.9	133	1.33	2.66	0.3	0.6	0.01	0.01
Chloride	15.1	21	0.43	0.43	15.1	21	0.43	0.43	15.1	21	0.43	0.43	92.4	130	2.60	2.60
Sulfate	0.72	1	0.01	0.01	0.72	1	0.01	0.01	0.72	1	0.01	0.01	0.72	1	0.01	0.01
Hydroxide	0.0	0.0	0.00	0.00	0.0	0.0	0.00	0.00	11.0	11	0.65	0.65	0.0	0.0	0.00	0.00
Total Anions				**0.6**				**2.0**				**4.2**				**4.3**
General																
TDS	43				166				223				299			
Alkalinity		6		0.1		77		1.5		167		3.1		86		1.7
pH	6.39				7.20				10.81				7.86			
Electroneutrality				0.32				0.44				0.48				0.33
Total Carbonate			0.22				1.77				1.77				1.77	
	α_1 =	0.51	α_2 =	0.00	α_1 =	0.87	α_2 =	0.00	α_1 =	0.25	α_2 =	0.75	α_1 =	0.97	α_2 =	0.00
Assumptions	Estimated bicarbonate concentration based on final alkalninity. Estimated calcium and magnesium (<MDL).				Add $NaHCO_3$ at recorded dose.				Add lime to get recorded hardness.				Adjust pH to recorded value.			
LSI Calculation																
Ionic Strength	0.001				0.004				0.006				0.007			
Ca^{2+} Activity	0.86				0.76				0.73				0.69			
HCO_3^- Activity	0.96				0.93				0.92				0.91			
Saturation pH	10.65				9.59				8.50				7.93			
Langelier Index	**-4.26**				**-2.39**				**2.31**				**-0.07**			

Equivalent Weights

	mg/meq	eq/mol	mg/mmol
Ca^{2+} =	20	2	40
Mg^{2+} =	12.2	2	24.4
Na^+ =	23	1	23
K^+ =	39.1	1	39.1
HCO_3^- =	61	1	61
CO_3^{2-} =	30	2	60
Cl^- =	35.5	1	35.5
SO_4^{2-} =	48.1	2	96.2
OH^- =	17	1	17
$CaCO_3$ =	50	2	100

Equilibrium Constants

K_{A1} = 4.3E-07

K_{A2} = 4.7E-11

K_{sp} = 5.0E-09

pK_w = 14

Chemical Dosing

$NaHCO_3$ =	130	mg/L dose
Na^+ =	35.6	mg/L added
HCO_3^- =	94.4	mg/L added
C_t =	1.55	mmol/L added
$Ca(OH)_2$ =	83	mg/L dose
Ca^{2+} =	44.9	mg/L added
HCl =	79.5	mg/L dose
Cl^- =	77.3	mg/L added

San Diego Pure Water TO-4

Blend Concentrations

Parameter	Unit	Test 002 AWTP Raw Water - 08/25/15 **100%** Demo Plant Water **0%**	Test 003 AWTP Raw Water - 08/25/15 **75%** Pure Water - Lime **25%**	Test 004 AWTP Raw Water - 08/26/15 **75%** Pure Water - Lime/Soda **25%**
Total Dissolved Solids	mg/L	694	537	506
Calcium	mmol/L	1.77	1.35	1.14
Total Carbonate	mmol/L	1.91	1.52	1.71

Parameter	Unit	Test 002 AWTP Raw Water - 08/25/15 **100%** Demo Plant Water **0%**	Test 003 AWTP Raw Water - 08/25/15 **25%** Pure Water - Lime **75%**	Test 004 AWTP Raw Water - 08/26/15 **25%** Pure Water - Lime/Soda **75%**
Total Dissolved Solids	mg/L	694	221	234
Calcium	mmol/L	1.77	0.50	0.43
Total Carbonate	mmol/L	1.91	0.73	1.02

San Diego Pure Water TO-4

Blend Concentrations

Parameter	Unit	Test 005 AWTP Raw Water - 08/26/15 **75%** Demo Plant Water **25%**	Test 014 AWTP Raw Water - 12/3/15 **10%** Pure Water - Design **90%**	Test 024 AWTP Raw Water - 12/3/15 **0%** Pure Water - Design **100%**
Total Dissolved Solids	mg/L	495	335	299
Calcium	mmol/L	1.13	1.16	1.15
Total Carbonate	mmol/L	1.63	1.84	1.77

Parameter	Unit	Test 005 AWTP Raw Water - 08/26/15 **25%** Demo Plant Water **75%**	Test 014 AWTP Raw Water - 12/3/15 **10%** Demo Plant Water **90%**	Test 024 AWTP Raw Water - 12/3/15 **0%** Demo Plant Water **100%**
Total Dissolved Solids	mg/L	202	116	56
Calcium	mmol/L	0.39	0.15	0.03
Total Carbonate	mmol/L	0.77	0.56	0.34

Attachment 5

Jar Test Datasheets and Data Summary

San Diego Pure Water TO-4

Jar Test Data Summary

PARAMETER	UNIT	TEST 001 Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6	TEST 002 Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
Date	MM/DD/YY	08/25/15						08/25/15					
Jar Setup													
Reservoir Water Type	-	El Cap Reservoir water						Alvarado WTP influent water					
Reservoir Water Volume	L	1.5	1.5	1.5	0.5	0.5	0.5	2	2	2	2	2	2
Pure Water Type	-	Demo Plant effluent - unconditioned						Not Used					
Pure Water Volume	L	0.5	0.5	0.5	1.5	1.5	1.5						
Coagulant Type	-	Ferric chloride						Ferric chloride					
Coagulant Dose	mg/L	2	5	10	2	5	10	2	4	6	8	10	12
Test Configuration													
Rapid Mix Speed	rpm	300						300					
Rapid Mix Time	min	0.5						0.5					
Gentle Mix Speed	rpm	20						80					
Gentle Mix Time	min	36						35					
Quiescent Time	min	60						60					
Water Quality													
pH - Initial	pH units	6.42	6.51	6.53	6.55	6.53	6.54	8.06	8.06	8.06	8.06	8.06	8.06
pH - Post Rapid Mix	pH units	6.66	7.08	7.06	7.01	6.92	6.87	7.96	7.84	7.93	7.61	7.55	7.48
pH - Final	pH units	7.44	7.38	7.28	7.20	7.18	6.84	8.24	8.16	8.10	8.00	7.92	7.87
Turbidity - Initial	NTU	2.02	2.15	2.12	1.0	1.4	1.4	0.5	0.5	0.5	0.5	0.5	0.5
Turbidity - 30 min Settling	NTU	2.42	3.16	4.02	1.2	2.50	2.84	3.4	2.5	3.9	4.6	3.8	2.3
Turbidity - 60 min Settling	NTU	2.1	1.51	1.08	0.59	0.59	0.36	1.40	1.8	1.32	0.40	0.38	0.18
Turbidity - Filtered	NTU	-	-	-	-	-	-	0.161	0.165	0.167	0.136	0.127	0.108
UV254 - Initial	abs	-	-	-	-	-	-	0.032	0.032	0.032	0.032	0.032	0.032
UV254 - Filtered	abs	-	-	-	-	-	-	0.035	0.033	0.033	0.04	0.044	0.028
Visible Flocs?	-		small	large		small	large	small	large	large	large	large	small

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Jar Test Data Summary

PARAMETER	UNIT	TEST 003 Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6	TEST 004 Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
Date	MM/DD/YY	08/25/15						08/26/15					
Jar Setup													
Reservoir Water Type	-	Alvarado WTP influent water						Alvarado WTP influent water					
Reservoir Water Volume	L	1.5	1.5	1.5	0.5	0.5	0.5	1.5	1.5	1.5	0.5	0.5	0.5
Pure Water Type	-	Demo Plant effluent - pH raised to 9.0 with lime water						Demo Plant effluent - pH raised to 9.0 with lime water, added 35 mg/L soda ash					
Pure Water Volume	L	0.5	0.5	0.5	1.5	1.5	1.5	0.5	0.5	0.5	1.5	1.5	1.5
Coagulant Type	-	Ferric chloride						Ferric chloride					
Coagulant Dose	mg/L	2	5	10	2	5	10	2	5	10	2	5	10
Test Configuration													
Rapid Mix Speed	rpm	300						300					
Rapid Mix Time	min	0.5						0.5					
Gentle Mix Speed	rpm	80						80					
Gentle Mix Time	min	35						35					
Quiescent Time	min	60						60					
Water Quality													
pH - Initial	pH units	8.16	8.18	8.18	8.49	8.48	8.49	8.60	8.68	8.66	9.52	9.55	9.53
pH - Post Rapid Mix	pH units	8.00	7.72	7.46	7.93	7.58	7.25	8.27	8.26	7.74	9.38	9.27	8.89
pH - Final	pH units	8.08	7.85	7.65	7.97	7.74	7.46	8.26	8.22	7.81	9.33	9.22	8.76
Turbidity - Initial	NTU	0.505	0.67	0.50	0.22	0.30	0.20	1.18	0.96	0.7	0.28	0.29	0.29
Turbidity - 30 min Settling	NTU	1.6	3.6	5.6	0.61	0.94	0.93	2.6	3.1	2.6	0.76	1.2	1.2
Turbidity - 60 min Settling	NTU	0.80	1.0	0.50	0.37	0.25	0.22	1.31	1.62	0.43	0.30	0.19	0.16
Turbidity - Filtered	NTU	0.14	0.185	0.23	0.099	0.16	0.091	0.23	0.20	0.088	0.17	0.080	0.066
UV254 - Initial	abs	0.032	0.032	0.032	0.032	0.032	0.032	0.035	0.035	0.035	0.035	0.035	0.035
UV254 - Filtered	abs	-	-	-	-	-	-	0.025	0.025	0.021	0.013	0.14	0.009
Visible Flocs?	-	pinpoint	large	large	pinpoint	large	small	medium	large	large	medium	large	small
		Note: UV254 Initial readings are taken from UV 254 samples of unconditioned Demo Plant water that day						Note: UV254 Initial readings are taken from UV 254 samples of unconditioned Demo Plant water that day					

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Jar Test Data Summary

PARAMETER	UNIT	TEST 005 Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6	TEST 102 Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
Date	MM/DD/YY	08/26/15						09/29/15					
Jar Setup													
Reservoir Water Type	-	Alvarado WTP influent water						Alvarado WTP influent water					
Reservoir Water Volume	L	1.5	1.5	1.5	0.5	0.5	0.5	2	2	2	2	2	2
Pure Water Type	-	Demo Plant effluent - unconditioned						Not Used					
Pure Water Volume	L	0.5	0.5	0.5	1.5	1.5	1.5						
Coagulant Type	-	Ferric chloride						Kemira PAX-18					
Coagulant Dose	mg/L	2	5	10	2	5	10	2	4	6	8	10	12
Test Configuration													
Rapid Mix Speed	rpm	300						300					
Rapid Mix Time	min	0.5						0.5					
Gentle Mix Speed	rpm	80						80					
Gentle Mix Time	min	35						35					
Quiescent Time	min	60						60					
Water Quality													
pH - Initial	pH units	7.87	7.89	7.89	7.14	7.15	7.26	7.87	7.87	7.87	7.87	7.87	7.87
pH - Post Rapid Mix	pH units	7.65	7.77	7.48	7.36	7.08	6.91	7.73	7.54	7.7	7.69	7.68	7.59
pH - Final	pH units	7.88	7.70	7.62	7.40	7.23	6.98	7.88	7.77	7.70	7.69	7.68	7.57
Turbidity - Initial	NTU	0.34	0.30	0.3	0.35	0.25	0.20	0.218	0.218	0.218	0.218	0.219	0.218
Turbidity - 30 min Settling	NTU	0.65	2.8	4.5	2.1	1.1	0.65	0.30	1.3	1.25	1.42	1.62	1.45
Turbidity - 60 min Settling	NTU	0.46	1.3	1.6	0.2	0.19	0.34	0.281	0.39	0.397	0.474	0.519	0.438
Turbidity - Filtered	NTU	0.100	0.15	0.16	0.09	0.074	0.080	0.166	0.32	0.191	0.139	0.141	0.130
UV254 - Initial	abs	0.026	0.026	0.026	0.011	0.011	0.011						
UV254 - Filtered	abs	0.027	0.03	0.026	0.012	0.011	0.012						
Visible Flocs?	-	pinpoint	large	large	pinpoint	medium	medium	none	small	small	small	small	small

**Floc size observed at 35 min into gentle mix.

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Jar Test Data Summary

PARAMETER	UNIT	TEST 103 Jar 1	TEST 103 Jar 2	TEST 103 Jar 3	TEST 103 Jar 4	TEST 103 Jar 5	TEST 103 Jar 6	TEST 104 Jar 1	TEST 104 Jar 2	TEST 104 Jar 3	TEST 104 Jar 4	TEST 104 Jar 5	TEST 104 Jar 6
Date	MM/DD/YY	09/29/15						09/30/15					
Jar Setup													
Reservoir Water Type	-	Alvarado WTP influent water						Alvarado WTP influent water					
Reservoir Water Volume	L	1.5	1.5	1.5	0.5	0.5	0.5	1.5	1.5	1.5	0.5	0.5	0.5
Pure Water Type	-	Demo Plant effluent - pH raised to 9.0 with lime water						Demo Plant effluent - pH raised to 9.0 with lime water, added 35 mg/L soda ash					
Pure Water Volume	L	0.5	0.5	0.5	1.5	1.5	1.5	0.5	0.5	0.5	1.5	1.5	1.5
Coagulant Type	-	Kemira PAX-18						Kemira PAX-18					
Coagulant Dose	mg/L	2	5	10	2	5	10	2	5	10	2	5	10
Test Configuration													
Rapid Mix Speed	rpm	300						300					
Rapid Mix Time	min	0.5						0.5					
Gentle Mix Speed	rpm	80						80					
Gentle Mix Time	min	35						35					
Quiescent Time	min	60						60					
Water Quality													
pH - Initial	pH units	8.23	8.18	8.20	8.41	8.40	8.47	8.57	8.59	8.57	9.42	9.41	9.41
pH - Post Rapid Mix	pH units	8.17	7.73	7.63	8.28	7.73	7.55	8.42	8.04	7.84*	9.37	8.74	8.45
pH - Final	pH units	8.17	7.79	7.72	8.26	7.69	7.57	8.35	8.00	7.83	9.29	8.56	8.33
Turbidity - Initial	NTU	0.236	0.220	0.246	0.168	0.185	0.144	0.230	0.249	0.255	0.155	0.184	0.157
Turbidity - 30 min Settling	NTU	0.311	1.11	1.21	0.192	0.373	0.486	0.239	0.761	1.12	0.161	0.247	0.291
Turbidity - 60 min Settling	NTU	0.304	0.338	0.31	0.196	0.217	0.234	0.269	0.297	0.189	0.170	0.120	0.600
Turbidity - Filtered	NTU	0.246	0.121	0.100	0.094	0.076	0.108	0.162	0.128	0.105	0.169	0.090	0.093
UV254 - Initial	abs												
UV254 - Filtered	abs												
Visible Flocs?	-												

*Slower Rapid Mix error

San Diego Pure Water TO-4

Jar Test Data Summary

PARAMETER	UNIT	TEST 105 Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6	TEST 014 Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
Date	MM/DD/YY	09/30/15						12/03/15					
Jar Setup													
Reservoir Water Type	-	Alvarado WTP influent water						Alvarado WTP influent water					
Reservoir Water Volume	L	1.5	1.5	1.5	0.5	0.5	0.5	0.2	0.2	0.2	0.2	0.2	0.2
Pure Water Type	-	Demo Plant effluent - unconditioned						Demo Plant effluent - conditioned per design			Demo Plant effluent - unconditioned		
Pure Water Volume	L	0.5	0.5	0.5	1.5	1.5	1.5	1.8	1.8	1.8	1.8	1.8	1.8
Coagulant Type	-	Kemira PAX-18						Ferric chloride					
Coagulant Dose	mg/L	2	5	10	2	5	10	2	5	10	2	5	10
Test Configuration													
Rapid Mix Speed	rpm	300						300					
Rapid Mix Time	min	0.5						0.5					
Gentle Mix Speed	rpm	80						80					
Gentle Mix Time	min	35						35					
Quiescent Time	min	60						60					
Water Quality													
pH - Initial	pH units	7.79	7.83	7.86	7.54	7.44	7.39	7.46	7.57	7.59	7.56	7.21	7.05
pH - Post Rapid Mix	pH units	7.82	7.58	7.51	7.48	7.25	7.14	6.83	6.99	6.98	6.54	6.09	4.99
pH - Final	pH units	7.90	7.67	7.71	7.66	7.37	7.45	6.75	7.03	7.03	6.46	6.04	4.4
Turbidity - Initial	NTU	0.249	0.222	0.255	0.125	0.160	0.158	0.307	0.327	0.306	0.345	0.305	0.150
Turbidity - 30 min Settling	NTU	0.352	1.16	1.42	0.194	0.518	0.428	1.33	1.32	1.41	1.2	1.09	1.4
Turbidity - 60 min Settling	NTU	0.270	0.300	0.232	0.175	0.200	0.260	0.182	0.204	0.201	0.357	0.236	0.579
Turbidity - Filtered	NTU	0.159	0.112	0.109	0.101	0.07	0.085	0.079	0.081	0.082	0.098	0.087	0.13
UV254 - Initial	abs												
UV254 - Filtered	abs												
Visible Flocs?	-	none	small	small	none	none	none	small	small	small	small	small	small

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Jar Test Data Summary

PARAMETER	UNIT	TEST 024					
		Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
Date	MM/DD/YY	12/03/15					
Jar Setup							
Reservoir Water Type	-	Not used					
Reservoir Water Volume	L	0	0	0	0	0	0
Pure Water Type	-	Demo Plant effluent - conditioned per design			Demo Plant effluent - unconditioned		
Pure Water Volume	L	2.0	2.0	2.0	2.0	2.0	2.0
Coagulant Type	-	Ferric chloride					
Coagulant Dose	mg/L	2	5	10	2	5	10
Test Configuration							
Rapid Mix Speed	rpm	300					
Rapid Mix Time	min	0.5					
Gentle Mix Speed	rpm	80					
Gentle Mix Time	min	35					
Quiescent Time	min	60					
Water Quality							
pH - Initial	pH units	7.22	7.31	7.29	7.72	6.79	6.64
pH - Post Rapid Mix	pH units	6.92	6.93	6.9	4.32	3.97	3.71
pH - Final	pH units	6.97	6.95	6.94	4.20	3.87	3.64
Turbidity - Initial	NTU	0.251	0.265	0.314	0.177	0.290	0.217
Turbidity - 30 min Settling	NTU	0.522	0.85	1.06	0.165	0.086	0.092
Turbidity - 60 min Settling	NTU	0.248	0.226	0.329	0.077	0.074	0.078
Turbidity - Filtered	NTU	0.079	0.072	0.092	0.08	0.092	0.105
UV254 - Initial	abs						
UV254 - Filtered	abs						
Visible Flocs?	-	small	small	small	small	small	small

Jar Test Datasheet

Experiment ID 001 Test Date 8/13/15

Jar Setup Data

	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
Reservoir Water	1.5 L	1.5 L	1.5 L	500 mL	500 mL	500 mL
Pure Water	500 mL	500 mL	500 mL	1.5 L	1.5 L	1.5 L
Initial pH	6.42	6.51	6.53	6.55	6.53	6.54
Turbidity (NTU)	2.02	2.15	2.12	1.0 ~~0.82~~	1.4	1.4
UV254 (abs)						
Coagulant	$FeCl_3$	$FeCl_3$	$FeCl_3$	$FeCl_3$	$FeCl_3$	$FeCl_3$
Coagulant Dose	2 mg/L	5 mg/L	10 mg/L	2 mg/L	5 mg/L	10 mg/L

Experimental Parameters

Rapid Mix Speed 300rpm Rapid Mix Time 30 sec

Gentle Mix Speed 20 rpm Gentle Mix Time 36 min

Quiescent Time 60 min

Water Quality Data

Parameter	Time	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
pH	Rapid Mix	6.66	7.08	7.06	7.01	6.92	6.87
	Final	7.44	7.38	7.28	7.20	7.18	6.84
Turbidity (NTU)	30 min	2.42	3.16	4.02	1.2	2.50	2.84
	60 min	2.1	1.51	1.08	0.59	0.59	0.36
	Filtered						
UV254 (abs)							
	Filtered						
Visible Flocs?			Small	large		Small	large

Jar Test Datasheet

Experiment ID 002 Test Date 08/25/15

Jar Setup Data

	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
*Reservoir Water	2 L	2 L	2 L	2 L	2 L	2 L
Pure Water	—	—	—	—	—	~~87.48~~
Initial pH	←					8.06
Turbidity (NTU)	0.50	→				
UV254 (abs)						
Coagulant	$FeCl_3$	→				
Coagulant Dose	2 mg/L	4 mg/L	6 mg/L	8 mg/L	10 mg/L	12 mg/L

Experimental Parameters

Rapid Mix Speed 300 rpm

Rapid Mix Time 0:30 sec

Gentle Mix Speed 80 rpm

Gentle Mix Time 0:35 min

Quiescent Time 60 min

Water Quality Data

Parameter	Time	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
pH	Rapid Mix	7.96	7.84	7.93	7.61	7.55	7.48
	Final	8.24	8.16	8.10	8.00	7.92	7.87
Turbidity (NTU)	30min	3.4	2.5	3.9	4.6	3.8	2.3
	60min	1.40	1.8	1.32	0.40	0.38	0.18
	Filtered	0.161	0.165	0.167	0.136	0.127	0.108
UV254 (abs)							
	Filtered						
Visible Flocs?		small	large	large	large	large	small

* Plant Influent Water

Jar Test Datasheet

Experiment ID 003 Test Date 8/25/15

Jar Setup Data

	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
*Reservoir Water	1.5 L	1.5 L	1.5 L	0.5 L	0.5 L	0.5 L
Pure Water	0.5 L	0.5 L	0.5 L	1.5 L	1.5 L	1.5 L
Initial pH	8.16	8.18	8.18	8.49	8.48	8.49
Turbidity (NTU)	0.505	0.67	0.50	0.22	0.30	0.20
UV254 (abs)						
Coagulant	$FeCl_3$ →	→	→	→	→	→
Coagulant Dose	2 mg/L	5 mg/L	10 mg/L	2 mg/L	5 mg/L	10 mg/L

Experimental Parameters

Rapid Mix Speed 300 rpm Rapid Mix Time 30 sec

Gentle Mix Speed 80 rpm Gentle Mix Time 35 min

Quiescent Time 60 min

Water Quality Data

Parameter	Time	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
pH	Rapid Mix	8.00	7.72	7.46	7.93	7.58	7.25
	Final	8.08	7.85	7.65	7.97	7.74	7.46
Turbidity (NTU)	30 min	1.6	3.6	5.6	0.61	0.94	0.93
	60 min	0.80	1.0	0.50	0.37	0.25	0.22
	Filtered	0.14	0.185	0.23	0.099	0.16	0.091
UV254 (abs)							
	Filtered						
Visible Flocs?		pinpoint	large	large	pinpoint	large	small

* Plant Influent Water

Jar Test Datasheet

Experiment ID 004　　　　Test Date 8/26/15

Jar Setup Data

	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
Reservoir Water	1.5 L	1.5 L	1.5 L	0.5 L	0.5 L	0.5 L
Pure Water	0.5 L	0.5 L	0.5 L	1.5 L	1.5 L	1.5 L
Initial pH	8.60	8.68	8.66	9.52	9.55	9.53
Turbidity (NTU)	1.18	~~1.07~~ 0.96	0.7	0.28	0.29	0.29
UV254 (abs)						
Coagulant	$FeCl_3$ →	→	→	→	→	→
Coagulant Dose	2 mg/L	5 mg/L	10 mg/L	2 mg/L	5 mg/L	10 mg/L

Experimental Parameters

Rapid Mix Speed 300 rpm　　　　Rapid Mix Time 30 sec

Gentle Mix Speed 80 rpm　　　　Gentle Mix Time 35 min

Quiescent Time 60 min

Water Quality Data

Parameter	Time	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
pH	Rapid Mix	8.27	8.26	7.74	9.38	9.27	8.89
	Final	8.26	8.22	7.81	9.33	9.22	8.76
Turbidity (NTU)	30 min	2.6	3.1	2.6	0.76	1.2	1.2
	60 min	1.31	1.62	0.43	0.30	0.19	0.16
	Filtered	0.23	0.20	0.088	0.17	0.080	0.066
UV254 (abs)							
	Filtered						
Visible Flocs?		Med	large	large	Med	large	Small

Jar Test Datasheet

Experiment ID 005 Test Date 08/26/15

Jar Setup Data

	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
Reservoir Water	1.5 L	1.5 L	1.5 L	0.5 L	0.5 L	0.5 L
Pure Water	0.5 L	0.5 L	0.5 L	1.5 L	1.5 L	1.5 L
Initial pH	7.87	7.89	7.89	7.14	7.15	7.26
Turbidity (NTU)	0.34	0.30	0.3	0.35	0.25	0.20
UV254 (abs)						
Coagulant	$FeCl_3$	—	—	—	—	
Coagulant Dose	2 mg/L	5 mg/L	10 mg/L	2 mg/L	5 mg/L	10 mg/L

Experimental Parameters

Rapid Mix Speed 300 rpm Rapid Mix Time 30 s

Gentle Mix Speed 80 rpm Gentle Mix Time 35 min

Quiescent Time ________

Water Quality Data

Parameter	Time	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
pH	Rapid Mix	7.65	7.77	7.48	7.36	7.08	6.91
	Final	7.88	7.70	7.62	7.40	7.23	6.98
Turbidity (NTU)	30 min	0.65	2.8	4.5	2.1	1.1	0.65
	60 min	0.46	1.3	1.6	0.2	0.19	0.34
	Filtered	0.100	0.15	0.16	0.09	0.074	.080
UV254 (abs)							
	Filtered						
Visible Flocs?		pinpoint	large	large	pinpoint	med	med

Jar Test Datasheet

Experiment ID 102　　　　Test Date 9-29

Jar Setup Data

	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
Alvarado WTP Influent	2L	2L	2L	2L	2L	2L
Pure Water	0	0	0	0	0	0
Initial pH	7.87	7.87	7.87	7.87	7.87	7.87
Initial Turbidity (NTU)	0.219	0.219	0.219	0.219	0.219	0.219
UV254 (abs)						
Coagulant	Kemira PAX-18					
Coagulant Dose	2 mg/L	4 mg/L	6 mg/L	8 mg/L	10 mg/L	12 mg/L

c diluted

Experimental Parameters

Rapid Mix Speed 300 rpm　　　　Rapid Mix Time 30 sec

Gentle Mix Speed 80 rpm　　　　Gentle Mix Time 35 min

Quiescent Time 60 min

Water Quality Data

Parameter	Time	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
pH	Rapid Mix	7.73	7.54	7.55	7.51	7.49	7.48
	Final	7.88	7.77	7.70	7.69	7.68	7.57
Turbidity (NTU)	30 min	.30	1.3	1.25	1.42	1.62	~~1.50~~ 1.45
	60 min	0.281	0.39	.397	0.474	0.519	0.438
	Filtered	0.166	0.32	0.191	0.139	0.141	0.130
UV254 (abs)	[illegible]						
	Filtered						
Visible Flocs?		None	small	small	small	small	small

35 min ~~[illegible]~~ mix → Visible Flocs?

Jar Test Datasheet

Experiment ID 103　　　　Test Date 9/29/15

Jar Setup Data

	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
Alvarado WTP Influent	1.5L	1.5L	1.5L	0.5L	0.5L	0.5L
Pure Water	0.5L	0.5L	0.5L	1.5L	1.5L	1.5L
Initial pH	8.23	8.19	8.20	8.41	8.40	8.47
Initial Turbidity (NTU)	.236	0.220	0.246	0.169	0.185	0.144
UV254 (abs)						
Coagulant	Kemira PAX-18					
Coagulant Dose	2mg/L	5mg/L	10mg/L	2mg/L	5mg/L	10mg/L

Experimental Parameters

Rapid Mix Speed 300 rpm　　　　Rapid Mix Time 30 sec

Gentle Mix Speed 80 rpm　　　　Gentle Mix Time 35 min

Quiescent Time 60 min

Water Quality Data

Parameter	Time	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
pH	Rapid Mix	8.17	7.73	7.63	8.28	7.73	7.55
	Final	8.17	7.79	7.72	8.26	7.69	7.57
Turbidity (NTU)	30min	0.311	1.11	1.21	0.192	0.373	0.486
	60min	0.304	0.338	0.31	0.196	0.217	0.234
	Filtered	0.246	0.121	0.100	0.094	0.076	0.108
UV254 (abs)							
	Filtered						
Visible Flocs?							

Jar Test Datasheet

Experiment ID 104 Test Date 9/30/15

Jar Setup Data

	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
Alvarado WTP Influent	1.5L	1.5L	1.5L	0.5L	0.5L	0.5L
Pure Water	0.5L	0.5L	0.5L	1.5L	1.5L	1.5L
Initial pH	8.57	8.59	8.57	9.42	9.41	9.41
Initial Turbidity (NTU)	.230	.249	.255	.155	.184	.157
UV254 (abs)						
Coagulant	Kemira PAX-18					
Coagulant Dose	2mg/L	5mg/L	10mg/L	2mg/L	5mg/L	10mg/L

Experimental Parameters

Rapid Mix Speed 300 rpm Rapid Mix Time 30 sec

Gentle Mix Speed 80 rpm Gentle Mix Time 35 min

Quiescent Time 60 min

Water Quality Data

Slower Rapid Mix error → Jar 3

Parameter	Time	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
pH	Rapid Mix	8.42	8.04	7.84	9.37	8.74	8.45
	Final	8.35	8.00	7.83	9.29	8.56	8.33
Turbidity (NTU)	30 min	.239	.761	1.12	.161	.247	.291
	60 min	.269	.297	.189	0.170	0.120	0.600
	Filtered	0.162	0.128	0.105	0.169	0.090	0.093
UV254 (abs)							
	Filtered						
Visible Flocs?		none	small	small	none	none	none

Jar Test Datasheet

Experiment ID 105 Test Date 9/30/15

Jar Setup Data

	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
Alvarado WTP Influent	1.5 L	1.5 L	1.5 L	0.5 L	0.5 L	0.5 L
Pure Water	0.5 L	0.5 L	0.5 L	1.5 L	1.5 L	1.5 L
Initial pH	7.79	7.83	7.86	7.54	7.44	7.39
Initial Turbidity (NTU)	.249	.222	.255	0.125	0.160	0.158
UV254 (abs)						
Coagulant	Kemira PAX-18					
Coagulant Dose	2 mg/L	5 mg/L	10 mg/L	2 mg/L	5 mg/L	10 mg/L

Experimental Parameters

Rapid Mix Speed 300 rpm

Rapid Mix Time 30 sec

Gentle Mix Speed 80 rpm

Gentle Mix Time 35 min

Quiescent Time 60 min

Water Quality Data

Parameter	Time	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
pH	Rapid Mix	7.82	7.59	7.51	7.48	7.25	7.14
	Final	7.90	7.67	7.71	7.66	7.37	7.45
Turbidity (NTU)	30 min	0.352	1.16	1.42	0.194	0.518	0.429
	60 min	0.270	0.300	0.232	0.175	0.200	0.260
	Filtered	0.159	0.112	0.109	0.101	0.070	0.095
UV254 (abs)							
	Filtered						
Visible Flocs?		none	small	small	none	none	none

Jar Test Datasheet

Experiment ID 014

Test Date 12-3-15

Jar Setup Data

Alvarado WTP Influent 0.300 NTU

Uncond. Pure Water 0.096 NTU

Simulated Pure Water 0.185 NTU

	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
	simulated			unconditioned		
Vol Alvarado WTP Influent	0.2	0.2	0.2	0.2	0.2	0.2
Vol Simulated Pure Water	1.8	1.8	1.8	1.8	1.8	1.8
Initial pH	7.46	7.57	7.59	7.56	7.21	7.05
Initial Turbidity (NTU)	.307	0.327	0.306	.345	.305	0.150
Coagulant	Ferric Chloride					
Coagulant Dose mg/L	2	5	10	2	5	10
mL	6.9	17	33.9	6.8	17	33.9

Experimental Parameters

Rapid Mix Speed 300 rpm

Rapid Mix Time 30 sec

Gentle Mix Speed 80 rpm

Gentle Mix Time 35 min

Quiescent Time 60 min

Water Quality Data

Parameter	Time	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5	Jar 6
pH	Rapid Mix	6.83	6.99	6.98	6.54	6.09	4.99
	Final	6.75	7.03	7.03	6.46	6.04	4.40
Turbidity (NTU)	30 min	1.33	1.32	1.41	1.20	1.09	1.40
	60 min	0.182	0.204	0.201	0.357	0.236	0.579
	Filtered	0.079	0.081	0.082	0.098	0.087	0.130
Visible Flocs?		small	→	→	→	→	→

Expenment ID: 024-1 Test date: 12/3/15

	simulated			demo		
	1	2	3	4	5	6
WTP influent	0	0	0	0	0	0
simulated PW	2	2	2	2	2	2
Initial pH	7.22	7.31	7.29	7.72	6.79	6.64
Initial NTU	0.251	0.265	0.314	0.177	0.290	0.217
coag. dose mg/L	2	5	10	2	5	10
µL	6.8	17	33.9	6.8	17	33.9

		1	2	3	4	5	6
pH	Rapid mix	6.92	6.93	6.90	4.32	3.97	3.71
	Final	6.97	6.95	6.94	4.20	3.87	3.64
NTU	30 min	0.522	0.854	1.06	0.165	0.086	0.092
	60 min	0.248	0.226	0.329	0.077	0.074	0.078
	Filtered	0.079	0.072	0.092	0.080	0.092	0.105
visible flocs		Small →					→

Attachment 6

LSI Calculations for Each Jar Test

San Diego Pure Water TO-4

pH Trends and LSI Calculations from Jar Test Data

Parameter	Unit	Test 002 - Plant Influent																	
Test Conditions		Jar 1			Jar 2			Jar 3			Jar 4			Jar 5			Jar 6		
Coagulant Type	-	Ferric			Ferric			Ferric			Ferric			Ferric			Ferric		
Coagulant Dose	**mg/L**	**2**			**4**			**6**			**8**			**10**			**12**		
Blend Values																			
TDS	mg/L	694			694			694			694			694			694		
Calcium	mmol/L	1.77			1.77			1.77			1.77			1.77			1.77		
Total Carbonate	mmol/L	1.91			1.91			1.91			1.91			1.91			1.91		
Measured pH	**pH units**	**8.06**	**7.96**	**8.24**	**8.06**	**7.84**	**8.16**	**8.06**	**7.93**	**8.10**	**8.06**	**7.61**	**8.00**	**8.06**	**7.55**	**7.92**	**8.06**	**7.48**	**7.87**
Calculated Values																			
Ionic Strength	-	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
Calcium Activity	-	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Bicarbonate Activity	-	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Bicarbonate Fraction	-	0.97	0.97	0.98	0.97	0.96	0.98	0.97	0.97	0.98	0.97	0.94	0.97	0.97	0.94	0.97	0.97	0.93	0.97
Carbonate Fraction	-	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00
Bicarbonate	mmol/L	1.86	1.85	1.87	1.86	1.84	1.87	1.86	1.85	1.86	1.86	1.80	1.86	1.86	1.79	1.85	1.86	1.77	1.85
Saturation pH	pH units	7.80	7.80	7.80	7.80	7.80	7.80	7.80	7.80	7.80	7.80	7.81	7.80	7.80	7.82	7.80	7.80	7.82	7.80
Langelier Index	**-**	**0.26**	**0.16**	**0.44**	**0.26**	**0.04**	**0.36**	**0.26**	**0.13**	**0.30**	**0.26**	**-0.20**	**0.20**	**0.26**	**-0.27**	**0.12**	**0.26**	**-0.34**	**0.07**

Physical Constants

K_{A1} = 4.3E-07

K_{A2} = 4.7E-11

pK_{a2} = 10.33

K_{sp} = 5.0E-09

pK_{sp} = 8.30

San Diego Pure Water TO-4

pH Trends and LSI Calculations from Jar Test Data

Parameter	Unit	Test 003 - Pure Water Lime																	
Test Conditions		Jar 1			Jar 2			Jar 3			Jar 4			Jar 5			Jar 6		
Coagulant Type	-	Ferric			Ferric			Ferric			Ferric			Ferric			Ferric		
Coagulant Dose	**mg/L**	**2**			**5**			**10**			**2**			**5**			**10**		
Blend Values																			
TDS	mg/L	537			537			537			221			221			221		
Calcium	mmol/L	1.35			1.35			1.35			0.50			0.50			0.50		
Total Carbonate	mmol/L	1.52			1.52			1.52			0.73			0.73			0.73		
Measured pH	**pH units**	**8.16**	**8.00**	**8.08**	**8.18**	**7.72**	**7.85**	**8.18**	**7.46**	**7.65**	**8.49**	**7.93**	**7.97**	**8.48**	**7.58**	**7.74**	**8.49**	**7.25**	**7.46**
Calculated Values																			
Ionic Strength	-	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
Calcium Activity	-	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73
Bicarbonate Activity	-	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Bicarbonate Fraction	-	0.98	0.97	0.98	0.98	0.96	0.97	0.98	0.92	0.95	0.98	0.97	0.97	0.98	0.94	0.96	0.98	0.88	0.92
Carbonate Fraction	-	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00
Bicarbonate	mmol/L	1.49	1.48	1.48	1.49	1.45	1.47	1.49	1.40	1.44	0.71	0.71	0.71	0.71	0.69	0.70	0.71	0.65	0.67
Saturation pH	pH units	7.98	7.99	7.99	7.98	7.99	7.99	7.98	8.01	8.00	8.65	8.65	8.65	8.65	8.66	8.66	8.65	8.69	8.67
Langelier Index	**-**	**0.18**	**0.01**	**0.09**	**0.20**	**-0.27**	**-0.14**	**0.20**	**-0.55**	**-0.35**	**-0.16**	**-0.72**	**-0.68**	**-0.17**	**-1.08**	**-0.92**	**-0.16**	**-1.44**	**-1.21**

Physical Constants

K_{A1} = 4.3E-07

K_{A2} = 4.7E-11

pK_{a2} = 10.33

K_{sp} = 5.0E-09

pK_{sp} = 8.30

San Diego Pure Water TO-4

pH Trends and LSI Calculations from Jar Test Data

Parameter	Unit	Test 004 - Pure Water Lime/Soda																	
Test Conditions		Jar 1			Jar 2			Jar 3			Jar 4			Jar 5			Jar 6		
Coagulant Type	-	Ferric			Ferric			Ferric			Ferric			Ferric			Ferric		
Coagulant Dose	**mg/L**	**2**			**5**			**10**			**2**			**5**			**10**		
Blend Values																			
TDS	mg/L	506			506			506			234			234			234		
Calcium	mmol/L	1.14			1.14			1.14			0.43			0.43			0.43		
Total Carbonate	mmol/L	1.71			1.71			1.71			1.02			1.02			1.02		
Measured pH	**pH units**	**8.60**	**8.27**	**8.26**	**8.68**	**8.26**	**8.22**	**8.66**	**7.74**	**7.81**	**9.52**	**9.38**	**9.33**	**9.55**	**9.27**	**9.22**	**9.53**	**8.89**	**8.76**
Calculated Values																			
Ionic Strength	-	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
Calcium Activity	-	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Bicarbonate Activity	-	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Bicarbonate Fraction	-	0.98	0.98	0.98	0.97	0.98	0.98	0.97	0.96	0.96	0.86	0.90	0.91	0.86	0.92	0.93	0.86	0.96	0.97
Carbonate Fraction	-	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.00	0.00	0.13	0.10	0.09	0.14	0.08	0.07	0.14	0.04	0.03
Bicarbonate	mmol/L	1.67	1.67	1.67	1.66	1.67	1.67	1.67	1.64	1.65	0.88	0.92	0.93	0.87	0.94	0.94	0.88	0.98	0.99
Saturation pH	pH units	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.01	8.01	8.63	8.61	8.60	8.63	8.60	8.60	8.63	8.58	8.58
Langelier Index	**-**	**0.60**	**0.27**	**0.26**	**0.68**	**0.26**	**0.22**	**0.66**	**-0.27**	**-0.20**	**0.89**	**0.77**	**0.73**	**0.92**	**0.67**	**0.62**	**0.90**	**0.31**	**0.18**

Physical Constants

K_{A1} = 4.3E-07
K_{A2} = 4.7E-11
pK_{a2} = 10.33

K_{sp} = 5.0E-09
pK_{sp} = 8.30

San Diego Pure Water TO-4

pH Trends and LSI Calculations from Jar Test Data

Parameter	Unit	Test 005 - Unconditioned Pure Water																	
Test Conditions		Jar 1			Jar 2			Jar 3			Jar 4			Jar 5			Jar 6		
Coagulant Type	-	Ferric			Ferric			Ferric			Ferric			Ferric			Ferric		
Coagulant Dose	**mg/L**	**2**			**5**			**10**			**2**			**5**			**10**		
Blend Values																			
TDS	mg/L	495			495			495			202			202			202		
Calcium	mmol/L	1.13			1.13			1.13			0.39			0.39			0.39		
Total Carbonate	mmol/L	1.63			1.63			1.63			0.77			0.77			0.77		
Measured pH	**pH units**	**7.87**	**7.65**	**7.88**	**7.89**	**7.77**	**7.70**	**7.89**	**7.48**	**7.62**	**7.14**	**7.36**	**7.40**	**7.15**	**7.08**	**7.23**	**7.26**	**6.91**	**6.98**
Calculated Values																			
Ionic Strength	-	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Calcium Activity	-	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
Bicarbonate Activity	-	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Bicarbonate Fraction	-	0.97	0.95	0.97	0.97	0.96	0.95	0.97	0.93	0.95	0.86	0.91	0.91	0.86	0.84	0.88	0.89	0.78	0.80
Carbonate Fraction	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bicarbonate	mmol/L	1.58	1.55	1.58	1.58	1.56	1.55	1.58	1.51	1.54	0.66	0.70	0.70	0.66	0.64	0.68	0.68	0.60	0.62
Saturation pH	pH units	8.03	8.03	8.03	8.03	8.03	8.03	8.03	8.04	8.04	8.78	8.76	8.75	8.78	8.79	8.77	8.77	8.82	8.81
Langelier Index	**-**	**-0.16**	**-0.38**	**-0.15**	**-0.14**	**-0.26**	**-0.33**	**-0.14**	**-0.56**	**-0.42**	**-1.64**	**-1.40**	**-1.35**	**-1.63**	**-1.71**	**-1.54**	**-1.51**	**-1.91**	**-1.83**

Physical Constants

K_{A1} = 4.3E-07

K_{A2} = 4.7E-11

pK_{a2} = 10.33

K_{sp} = 5.0E-09

pK_{sp} = 8.30

San Diego Pure Water TO-4

pH Trends and LSI Calculations from Jar Test Data

Parameter	Unit	Test 102 - Plant Influent																	
Test Conditions		Jar 1			Jar 2			Jar 3			Jar 4			Jar 5			Jar 6		
Coagulant Type	-	Ferric			Ferric			Ferric			Ferric			Ferric			Ferric		
Coagulant Dose	**mg/L**	**2**			**4**			**6**			**8**			**10**			**12**		
Blend Values																			
TDS	mg/L	694			694			694			694			694			694		
Calcium	mmol/L	1.77			1.77			1.77			1.77			1.77			1.77		
Total Carbonate	mmol/L	1.91			1.91			1.91			1.91			1.91			1.91		
Measured pH	**pH units**	**7.87**	**7.73**	**7.88**	**7.87**	**7.54**	**7.77**	**7.87**	**7.70**	**7.70**	**7.87**	**7.69**	**7.69**	**7.87**	**7.68**	**7.68**	**7.87**	**7.59**	**7.57**
Calculated Values																			
Ionic Strength	-	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
Calcium Activity	-	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Bicarbonate Activity	-	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Bicarbonate Fraction	-	0.97	0.96	0.97	0.97	0.94	0.96	0.97	0.95	0.95	0.97	0.95	0.95	0.97	0.95	0.95	0.97	0.94	0.94
Carbonate Fraction	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bicarbonate	mmol/L	1.85	1.83	1.85	1.85	1.79	1.83	1.85	1.82	1.82	1.85	1.82	1.82	1.85	1.82	1.82	1.85	1.80	1.79
Saturation pH	pH units	7.80	7.81	7.80	7.80	7.82	7.81	7.80	7.81	7.81	7.80	7.81	7.81	7.80	7.81	7.81	7.80	7.81	7.82
Langelier Index	**-**	**0.07**	**-0.08**	**0.08**	**0.07**	**-0.28**	**-0.04**	**0.07**	**-0.11**	**-0.11**	**0.07**	**-0.12**	**-0.12**	**0.07**	**-0.13**	**-0.13**	**0.07**	**-0.22**	**-0.25**

Physical Constants

K_{A1} = 4.3E-07

K_{A2} = 4.7E-11

pK_{a2} = 10.33

K_{sp} = 5.0E-09

pK_{sp} = 8.30

San Diego Pure Water TO-4

pH Trends and LSI Calculations from Jar Test Data

Parameter	Unit	Test 103 - Pure Water Lime																	
Test Conditions		Jar 1			Jar 2			Jar 3			Jar 4			Jar 5			Jar 6		
Coagulant Type	-	Ferric			Ferric			Ferric			Ferric			Ferric			Ferric		
Coagulant Dose	**mg/L**	**2**			**5**			**10**			**2**			**5**			**10**		
Blend Values																			
TDS	mg/L	537			537			537			221			221			221		
Calcium	mmol/L	1.35			1.35			1.35			0.50			0.50			0.50		
Total Carbonate	mmol/L	1.52			1.52			1.52			0.73			0.73			0.73		
Measured pH	**pH units**	**8.23**	**8.17**	**8.17**	**8.18**	**7.73**	**7.79**	**8.20**	**7.63**	**7.72**	**8.41**	**8.28**	**8.26**	**8.40**	**7.73**	**7.69**	**8.47**	**7.55**	**7.57**
Calculated Values																			
Ionic Strength	-	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
Calcium Activity	-	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73
Bicarbonate Activity	-	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Bicarbonate Fraction	-	0.98	0.98	0.98	0.98	0.96	0.96	0.98	0.95	0.96	0.98	0.98	0.98	0.98	0.96	0.95	0.98	0.94	0.94
Carbonate Fraction	-	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.00
Bicarbonate	mmol/L	1.49	1.49	1.49	1.49	1.45	1.46	1.49	1.44	1.45	0.71	0.71	0.71	0.71	0.70	0.70	0.71	0.68	0.69
Saturation pH	pH units	7.98	7.98	7.98	7.98	7.99	7.99	7.98	8.00	7.99	8.65	8.65	8.65	8.65	8.66	8.66	8.65	8.67	8.66
Langelier Index	**-**	**0.25**	**0.19**	**0.19**	**0.20**	**-0.26**	**-0.20**	**0.22**	**-0.37**	**-0.27**	**-0.24**	**-0.37**	**-0.39**	**-0.25**	**-0.93**	**-0.97**	**-0.18**	**-1.12**	**-1.09**

Physical Constants

K_{A1} = 4.3E-07

K_{A2} = 4.7E-11

pK_{a2} = 10.33

K_{sp} = 5.0E-09

pK_{sp} = 8.30

San Diego Pure Water TO-4

pH Trends and LSI Calculations from Jar Test Data

Parameter	**Unit**	**Test 104 - Pure Water Lime/Soda**																	
Test Conditions		Jar 1			Jar 2			Jar 3			Jar 4			Jar 5			Jar 6		
Coagulant Type	-	Ferric			Ferric			Ferric			Ferric			Ferric			Ferric		
Coagulant Dose	**mg/L**	**2**			**5**			**10**			**2**			**5**			**10**		
Blend Values																			
TDS	mg/L	506			506			506			234			234			234		
Calcium	mmol/L	1.14			1.14			1.14			0.43			0.43			0.43		
Total Carbonate	mmol/L	1.71			1.71			1.71			1.02			1.02			1.02		
Measured pH	**pH units**	**8.57**	**8.42**	**8.35**	**8.59**	**8.04**	**8.00**	**8.57**	**7.84**	**7.83**	**9.42**	**9.37**	**9.29**	**9.41**	**8.74**	**8.56**	**9.41**	**8.45**	**8.33**
Calculated Values																			
Ionic Strength	-	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
Calcium Activity	-	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Bicarbonate Activity	-	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Bicarbonate Fraction	-	0.98	0.98	0.98	0.98	0.97	0.97	0.98	0.96	0.96	0.89	0.90	0.92	0.89	0.97	0.98	0.89	0.98	0.98
Carbonate Fraction	-	0.02	0.01	0.01	0.02	0.01	0.00	0.02	0.00	0.00	0.11	0.10	0.08	0.11	0.03	0.02	0.11	0.01	0.01
Bicarbonate	mmol/L	1.67	1.67	1.67	1.67	1.67	1.66	1.67	1.65	1.65	0.91	0.92	0.93	0.91	0.99	1.00	0.91	1.00	1.00
Saturation pH	pH units	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.01	8.01	8.61	8.61	8.60	8.61	8.58	8.57	8.61	8.57	8.57
Langelier Index	**-**	**0.57**	**0.42**	**0.35**	**0.59**	**0.04**	**0.00**	**0.57**	**-0.17**	**-0.18**	**0.81**	**0.76**	**0.69**	**0.80**	**0.16**	**-0.01**	**0.80**	**-0.12**	**-0.24**

Physical Constants

K_{A1} = 4.3E-07

K_{A2} = 4.7E-11

pK_{a2} = 10.33

K_{sp} = 5.0E-09

pK_{sp} = 8.30

San Diego Pure Water TO-4

pH Trends and LSI Calculations from Jar Test Data

Parameter	**Unit**	**Test 105 - Unconditioned Pure Water**																	
Test Conditions		Jar 1			Jar 2			Jar 3			Jar 4			Jar 5			Jar 6		
Coagulant Type	-	Ferric			Ferric			Ferric			Ferric			Ferric			Ferric		
Coagulant Dose	**mg/L**	**2**			**5**			**10**			**2**			**5**			**10**		
Blend Values																			
TDS	mg/L	495			495			495			202			202			202		
Calcium	mmol/L	1.13			1.13			1.13			0.39			0.39			0.39		
Total Carbonate	mmol/L	1.63			1.63			1.63			0.77			0.77			0.77		
Measured pH	**pH units**	**7.79**	**7.82**	**7.90**	**7.83**	**7.58**	**7.67**	**7.86**	**7.51**	**7.71**	**7.54**	**7.48**	**7.66**	**7.44**	**7.25**	**7.37**	**7.39**	**7.14**	**7.45**
Calculated Values																			
Ionic Strength	-	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Calcium Activity	-	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
Bicarbonate Activity	-	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Bicarbonate Fraction	-	0.96	0.96	0.97	0.96	0.94	0.95	0.97	0.93	0.95	0.94	0.93	0.95	0.92	0.88	0.91	0.91	0.86	0.92
Carbonate Fraction	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bicarbonate	mmol/L	1.57	1.57	1.58	1.57	1.53	1.55	1.57	1.52	1.56	0.72	0.71	0.73	0.71	0.68	0.70	0.70	0.66	0.71
Saturation pH	pH units	8.03	8.03	8.03	8.03	8.04	8.03	8.03	8.04	8.03	8.74	8.75	8.74	8.75	8.77	8.76	8.75	8.78	8.75
Langelier Index	**-**	**-0.24**	**-0.21**	**-0.13**	**-0.20**	**-0.46**	**-0.36**	**-0.17**	**-0.53**	**-0.32**	**-1.20**	**-1.27**	**-1.08**	**-1.31**	**-1.52**	**-1.39**	**-1.36**	**-1.64**	**-1.30**

Physical Constants

K_{A1} = 4.3E-07

K_{A2} = 4.7E-11

pK_{a2} = 10.33

K_{sp} = 5.0E-09

pK_{sp} = 8.30

San Diego Pure Water TO-4

pH Trends and LSI Calculations from Jar Test Data

Parameter	Unit	Test 014 - 90% Pure Water																	
Test Conditions		Jar 1			Jar 2			Jar 3			Jar 4			Jar 5			Jar 6		
Coagulant Type	-	Ferric			Ferric			Ferric			Ferric			Ferric			Ferric		
Coagulant Dose	**mg/L**	**2**			**5**			**10**			**2**			**5**			**10**		
Blend Values																			
TDS	mg/L	335			335			335			116			116			116		
Calcium	mmol/L	1.16			1.16			1.16			0.15			0.15			0.15		
Total Carbonate	mmol/L	1.84			1.84			1.84			0.56			0.56			0.56		
Measured pH	**pH units**	**7.46**	**6.83**	**6.75**	**7.57**	**6.99**	**7.03**	**7.59**	**6.98**	**7.03**	**7.56**	**6.54**	**6.46**	**7.21**	**6.09**	**6.04**	**7.05**	**4.99**	**4.40**
Calculated Values																			
Ionic Strength	-	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Calcium Activity	-	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79
Bicarbonate Activity	-	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Bicarbonate Fraction	-	0.92	0.74	0.71	0.94	0.81	0.82	0.94	0.80	0.82	0.94	0.60	0.55	0.87	0.35	0.32	0.83	0.04	0.01
Carbonate Fraction	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bicarbonate	mmol/L	1.70	1.37	1.30	1.73	1.49	1.51	1.73	1.48	1.51	0.53	0.34	0.31	0.49	0.19	0.18	0.46	0.02	0.01
Saturation pH	pH units	7.94	8.04	8.06	7.93	8.00	7.99	7.93	8.00	7.99	9.26	9.45	9.49	9.29	9.69	9.72	9.31	10.62	11.20
Langelier Index	**-**	**-0.48**	**-1.21**	**-1.31**	**-0.36**	**-1.01**	**-0.96**	**-0.34**	**-1.02**	**-0.96**	**-1.70**	**-2.91**	**-3.03**	**-2.08**	**-3.60**	**-3.68**	**-2.26**	**-5.63**	**-6.80**

Physical Constants

K_{A1} = 4.3E-07

K_{A2} = 4.7E-11

pK_{a2} = 10.33

K_{sp} = 5.0E-09

pK_{sp} = 8.30

San Diego Pure Water TO-4

pH Trends and LSI Calculations from Jar Test Data

Parameter	Unit	Test 024 - 100% Pure Water																	
Test Conditions		Jar 1			Jar 2			Jar 3			Jar 4			Jar 5			Jar 6		
Coagulant Type	-	Ferric			Ferric			Ferric			Ferric			Ferric			Ferric		
Coagulant Dose	**mg/L**	**2**			**5**			**10**			**2**			**5**			**10**		
Blend Values																			
TDS	mg/L	299			299			299			56			56			56		
Calcium	mmol/L	1.15			1.15			1.15			0.03			0.03			0.03		
Total Carbonate	mmol/L	1.77			1.77			1.77			0.34			0.34			0.34		
Measured pH	**pH units**	**7.22**	**6.92**	**6.97**	**7.31**	**6.93**	**6.95**	**7.29**	**6.90**	**6.94**	**7.72**	**4.32**	**4.20**	**6.79**	**3.97**	**3.87**	**6.64**	**3.71**	**3.64**
Calculated Values																			
Ionic Strength	-	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Calcium Activity	-	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Bicarbonate Activity	-	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Bicarbonate Fraction	-	0.88	0.78	0.80	0.90	0.79	0.79	0.89	0.77	0.79	0.96	0.01	0.01	0.73	0.00	0.00	0.65	0.00	0.00
Carbonate Fraction	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bicarbonate	mmol/L	1.55	1.38	1.42	1.59	1.39	1.40	1.58	1.37	1.40	0.32	0.00	0.00	0.25	0.00	0.00	0.22	0.00	0.00
Saturation pH	pH units	7.97	8.02	8.01	7.96	8.02	8.02	7.97	8.03	8.02	10.13	12.16	12.28	10.25	12.51	12.61	10.29	12.77	12.84
Langelier Index	**-**	**-0.75**	**-1.10**	**-1.04**	**-0.65**	**-1.09**	**-1.07**	**-0.68**	**-1.13**	**-1.08**	**-2.41**	**-7.84**	**-8.08**	**-3.46**	**-8.54**	**-8.74**	**-3.65**	**-9.06**	**-9.20**

Physical Constants

K_{A1} = 4.3E-07

K_{A2} = 4.7E-11

pK_{a2} = 10.33

K_{sp} = 5.0E-09

pK_{sp} = 8.30

Attachment 7

Full-Scale Plant Data and Chemical Modeling

Work Problem #:				
System Name:	AWTP - Raw Water	AWTP - Coagulated	AWTP - Treated	AWTP - Raw Water
Source Point:	City Data	City Data	City Data	City Data
Date of Sample:	04/06/15	04/06/15	04/06/15	07/02/12
TDS, mg/L =	687	687	687	534
Calcium (total), mg/L as Ca^{2+} =	74.0	74.0	74.0	54.8
Total Alkalinity, mg/L as $CaCO_3$ =	130.0	130.0	130.0	91.0
pH =	8.00	8.00	8.00	7.80
Water Temperature, °C =	19.6	19.6	19.6	23.3
Field Water Temperature, °C =	19.6	19.6	19.6	23.3
Cl^-, mg/L =	99.1	99.1	99.1	106.0
SO_4^{2-}, mg/L =	229.0	229.0	229.0	163.0
Mg^{2+}, mg/L =	28.3	28.3	28.3	19.6
Reagent Addition		5.56 mg/L Ferric Chloride	5.56 mg/L Ferric Chloride 3.36 mg/L Hypochlorite 3.3 mg/L Caustic Soda	

Initial Results

pH =	8.00	8.00	8.00	7.80
Aggressive Index (AI) =	12.3	12.3	12.3	11.8
Ryznar Index (RI) =	7.20	7.20	7.20	7.78
Langelier Index, Calcite =	0.40	0.40	0.40	0.01
CCPP =	7.56	7.56	7.56	0.24
$B_{H20} + B_{CO3}$ =	0.161	0.161	0.161	0.148
$Alk/(Cl^- + SO_4^{2-})$ =	0.3	0.3	0.3	0.3

Results after Chemical Addition

Measured Results

pH - Final			8.0	

Model Results

Interim pH =		7.56	8.00	
Equilibrium pH =		N/A	7.63	
Aggressive Index (AI) =		11.9	12.3	
Ryznar Index (RI) =		7.66	7.20	
Langelier Index, Calcite =		-0.05	0.40	
CCPP =		-1.15	7.58	
$B_{H20} + B_{CO3}$ =		0.332	0.160	
$Alk/(Cl^- + SO_4^{2-})$ =		0.3	0.3	

Work Problem #:				
System Name: Source Point: Date of Sample:	AWTP - Coagulated City Data 07/02/12	AWTP - Treated City Data 07/02/12	AWTP - Raw Water City Data 01/07/13	AWTP - Coagulated City Data 01/07/13
TDS, mg/L =	534	534	357	357
Calcium (total), mg/L as Ca^{2+} =	54.8	54.8	32.4	32.4
Total Alkalinity, mg/L as $CaCO_3$ =	91.0	91.0	76.3	76.3
pH =	7.80	7.80	7.70	7.70
Water Temperature, ^{o}C =	23.3	23.3	14.1	14.1
Field Water Temperature, ^{o}C =	23.3	23.3	14.1	14.1
Cl^{-}, mg/L =	106.0	106.0	77.5	77.5
SO_4^{2-}, mg/L =	163.0	163.0	76.5	76.5
Mg^{2+}, mg/L =	19.6	19.6	15.5	15.5
Reagent Addition	7.1 mg/L Ferric Chloride	7.1 mg/L Ferric Chloride 4 mg/L Hypochlorite 5.85 mg/L Caustic Soda		5.2 mg/L Ferric Chloride

Initial Results

pH =	7.80	7.80	7.70	7.70
Aggressive Index (AI) =	11.8	11.8	11.5	11.5
Ryznar Index (RI) =	7.78	7.78	8.63	8.63
Langelier Index, Calcite =	0.01	0.01	-0.46	-0.46
CCPP =	0.24	0.24	-4.97	-4.97
$B_{H20} + B_{CO3}$ =	0.148	0.148	0.170	0.170
Alk/(Cl^{-} + SO_4^{2-}) =	0.3	0.3	0.4	0.4

Results after Chemical Addition

Measured Results

pH - Final		8.1		

Model Results

Interim pH =	7.27	8.10		7.32
Equilibrium pH =	N/A	7.81		N/A
Aggressive Index (AI) =	11.3	12.1		11.0
Ryznar Index (RI) =	8.36	7.48		9.06
Langelier Index, Calcite =	-0.54	0.31		-0.87
CCPP =	-11.42	3.55		-13.79
$B_{H20} + B_{CO3}$ =	0.387	0.103		0.348
Alk/(Cl^{-} + SO_4^{2-}) =	0.3	0.3		0.4

Work Problem #:				
System Name: Source Point: Date of Sample:	AWTP - Treated City Data 01/07/13	AWTP - Raw Water City Data 07/01/13	AWTP - Coagulated City Data 07/01/13	AWTP - Treated City Data 07/01/13
TDS, mg/L =	357	521	521	521
Calcium (total), mg/L as Ca^{2+} =	32.4	58.1	58.1	58.1
Total Alkalinity, mg/L as $CaCO_3$ =	76.3	110.6	110.6	110.6
pH =	7.70	7.50	7.50	7.50
Water Temperature, ^{o}C =	14.1	22.0	22.0	22.0
Field Water Temperature, ^{o}C =	14.1	22.0	22.0	22.0
Cl^{-}, mg/L =	77.5	74.9	74.9	74.9
SO_4^{2-}, mg/L =	76.5	153.0	153.0	153.0
Mg^{2+}, mg/L =	15.5	23.7	23.7	23.7
Reagent Addition	5.2 mg/L Ferric Chloride 3.9 mg/L Hypochlorite 4.85 mg/L Caustic Soda		7.4 mg/L Ferric Chloride	7.4 mg/L Ferric Chloride 3.4 mg/L Hypochlorite 9.6 mg/L Caustic Soda

Initial Results

pH =	7.70	7.50	7.50	7.50
Aggressive Index (AI) =	11.5	11.7	11.7	11.7
Ryznar Index (RI) =	8.63	7.88	7.88	7.88
Langelier Index, Calcite =	-0.46	-0.19	-0.19	-0.19
CCPP =	-4.97	-4.20	-4.20	-4.20
$B_{H20} + B_{CO3}$ =	0.170	0.324	0.324	0.324
$Alk/(Cl^{-} + SO_4^{2-})$ =	0.4	0.4	0.4	0.4

Results after Chemical Addition

Measured Results

pH - Final	8.1			8.1

Model Results

Interim pH =	8.10		7.50	8.10
Equilibrium pH =	N/A		N/A	7.71
Aggressive Index (AI) =	11.9		11.3	12.3
Ryznar Index (RI) =	8.21		8.24	7.26
Langelier Index, Calcite =	-0.06		-0.52	0.42
CCPP =	-0.41		-15.86	6.27
$B_{H20} + B_{CO3}$ =	0.092		0.572	0.129
$Alk/(Cl^{-} + SO_4^{2-})$ =	0.4		0.4	0.4

Work Problem #:				
System Name: Source Point: Date of Sample:	AWTP - Raw Water City Data 01/06/14	AWTP - Coagulated City Data 01/06/14	AWTP - Treated City Data 01/06/14	AWTP - Raw Water City Data 08/04/14
TDS, mg/L =	526	526	526	454
Calcium (total), mg/L as Ca^{2+} =	50.0	50.0	50.0	41.8
Total Alkalinity, mg/L as $CaCO_3$ =	125.4	125.4	125.4	102.5
pH =	7.60	7.60	7.60	7.60
Water Temperature, ^oC =	12.8	12.8	12.8	23.1
Field Water Temperature, ^oC =	12.8	12.8	12.8	23.1
Cl^-, mg/L =	79.9	79.9	79.9	78.8
SO_4^{2-}, mg/L =	137.0	137.0	137.0	111.0
Mg^{2+}, mg/L =	26.8	26.8	26.8	18.4
Reagent Addition		6.2 mg/L Ferric Chloride	6.2 mg/L Ferric Chloride 3.23 mg/L Hypochlorite 8.4 mg/L Caustic Soda	

Initial Results

pH =	7.60	7.60	7.60	7.60
Aggressive Index (AI) =	11.7	11.7	11.7	11.6
Ryznar Index (RI) =	8.06	8.06	8.06	8.05
Langelier Index, Calcite =	-0.23	-0.23	-0.23	-0.23
CCPP =	-5.30	-5.30	-5.30	-3.85
$B_{H20} + B_{CO3}$ =	0.345	0.345	0.345	0.244
Alk/(Cl^- + SO_4^{2-}) =	0.5	0.5	0.5	0.5

Results after Chemical Addition

Measured Results

pH - Final			8.1	

Model Results

Interim pH =		7.34	8.10	
Equilibrium pH =		N/A	7.84	
Aggressive Index (AI) =		11.5	12.3	
Ryznar Index (RI) =		8.35	7.54	
Langelier Index, Calcite =		-0.51	0.28	
CCPP =		-15.10	4.56	
$B_{H20} + B_{CO3}$ =		0.556	0.152	
Alk/(Cl^- + SO_4^{2-}) =		0.5	0.5	

Work Problem #:				
System Name:	AWTP - Coagulated	AWTP - Treated	AWTP - Raw Water	AWTP - Coagulated
Source Point:	City Data	City Data	Sampled at AWTP Lab	Sampled at AWTP Lab
Date of Sample:	08/04/14	08/04/14	08/25/15	08/25/15
TDS, mg/L =	454	454	694	694
Calcium (total), mg/L as Ca^{2+} =	41.8	41.8	70.9	70.9
Total Alkalinity, mg/L as $CaCO_3$ =	102.5	102.5	93.0	93.0
pH =	7.60	7.60	7.90	7.90
Water Temperature, °C =	23.1	23.1	28.2	28.2
Field Water Temperature, °C =	23.1	23.1	28.2	28.2
Cl^-, mg/L =	78.8	78.8	109.0	109.0
SO_4^{2-}, mg/L =	111.0	111.0	261.0	261.0
Mg^{2+}, mg/L =	18.4	18.4	25.6	25.6
Reagent Addition	4.4 mg/L Ferric Chloride	4.4 mg/L Ferric Chloride 3.21 mg/L Hypochlorite 5.9 mg/L Caustic Soda		5.6 mg/L Ferric Chloride

Initial Results

pH =	7.60	7.60	7.90	7.90
Aggressive Index (AI) =	11.6	11.6	12.0	12.0
Ryznar Index (RI) =	8.05	8.05	7.41	7.41
Langelier Index, Calcite =	-0.23	-0.23	0.25	0.25
CCPP =	-3.85	-3.85	3.41	3.41
$B_{H20} + B_{CO3}$ =	0.244	0.244	0.125	0.125
Alk/(Cl^- + SO_4^{2-}) =	0.5	0.5	0.2	0.2

Results after Chemical Addition

Measured Results

pH - Final		8.1		

Model Results

Interim pH =	7.34	8.10		7.38
Equilibrium pH =	N/A	7.84		N/A
Aggressive Index (AI) =	11.3	12.1		11.5
Ryznar Index (RI) =	8.34	7.54		7.96
Langelier Index, Calcite =	-0.50	0.28		-0.29
CCPP =	-10.95	3.47		-5.70
$B_{H20} + B_{CO3}$ =	0.395	0.118		0.304
Alk/(Cl^- + SO_4^{2-}) =	0.4	0.5		0.2

Work Problem #:	
System Name:	AWTP - Treated
Source Point:	Sampled at AWTP Lab
Date of Sample:	08/25/15
TDS, mg/L =	694
Calcium (total), mg/L as Ca^{2+} =	70.9
Total Alkalinity, mg/L as $CaCO_3$ =	93.0
pH =	7.90
Water Temperature, ^oC =	28.2
Field Water Temperature, ^oC =	28.2
Cl^-, mg/L =	109.0
SO_4^{2-}, mg/L =	261.0
Mg^{2+}, mg/L =	25.6
Reagent Addition	5.6 mg/L Ferric Chloride 3.4 mg/L Hypochlorite 4.4 mg/L Caustic Soda

Initial Results

pH =	7.90
Aggressive Index (AI) =	12.0
Ryznar Index (RI) =	7.41
Langelier Index, Calcite =	0.25
CCPP =	3.41
$B_{H20} + B_{CO3}$ =	0.125
$Alk/(Cl^- + SO_4^{2-})$ =	0.2

Results after Chemical Addition

Measured Results

pH - Final	8.1

Model Results

Interim pH =	8.10
Equilibrium pH =	7.68
Aggressive Index (AI) =	12.2
Ryznar Index (RI) =	7.21
Langelier Index, Calcite =	0.44
CCPP =	5.43
$B_{H20} + B_{CO3}$ =	0.104
$Alk/(Cl^- + SO_4^{2-})$ =	0.2

Alvarado Water Treatment Plant

Winter/Spring

	1/7/2013	1/6/2014	4/6/2015
pH Raw	7.7	7.6	8
pH Finished	8.1	8.1	8
Raw Temp	14.1	12.8	19.6
Turb Raw	0.3	0.2	0.7
Turb Settled	0.2	0.3	0.2
Turb Filtered	0.05	0.06	0.08
Ferric Dose	5.2	6.2	5.6
Poly Dose	1.73	1.95	1.6
Cl2 Dose	3.9	3.23	3.36
Cl2 Residual	3	3	3

Summer/Fall

	8/4/2014	7/2/2012	7/1/2013
pH Raw	7.6	7.8	7.5
pH Finished	8.1	8.1	8.1
Raw Temp	23.1	23.3	22
Turb Raw	0.3	1.4	0.4
Turb Settled	0.4	0.4	0.4
Turb Filtered	0.08	0.08	0.06
Ferric Dose	4.4	7.1	7.4
Poly Dose	1	1.9	1.7
Cl2 Dose	3.21	4	3.4
Cl2 Residual	2.8	2.9	3

Alvarado Water Treatment Plant

	8/25/2015	8/26/2015	9/29/2015	9/30/2015
pH Raw	7.9	8	7.9	7.9
pH Finished	8.1	8.1	8	7.9
Raw Temp	28.2	28.5	27	27.1
Turb Raw	0.31	0.3	0.22	0.23
Turb Settled	0.25	0.2	0.2	0.21
Turb Filtered	0.07	0.08	0.07	0.08
Ferric Dose	5.6	5.78	5.25	5.34
Poly Dose	1.44	1.51	1.52	1.53
Cl2 Dose	3.4	3.28	3.28	3.19
Cl2 Residual	2.9	2.8	2.7	2.7

APPENDIX F: DWTP Operational Evaluation Technical Memo (TM)

Pure Water San Diego

Technical Memorandum

WTP Operational Evaluation

Memo Information

To: John Helminski, Amy Dorman, Joseph Quicho, Mike Williams

CC: Julie L. Labonte, Peggy Umphres, Jaime Brown

From: James Borchardt, Michael Adelman, Mia Smith, Maysoon Sharif

Date: 04/18/2016

Task Order/Number: TO4 T5

City Task Lead Name: Joseph Quicho

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Table of Contents

Introduction and Overview

This Technical Memorandum (TM) discusses the impacts of the upcoming Pure Water Program on the operation of the City of San Diego's existing potable water treatment plants (WTPs). Under the Pure Water Program, the new North City Advanced Water Purification Facility (NCAWPF) will produce about 30 million gallons per day (MGD) of high-purity reuse water, hereinafter referred to as Pure Water. The San Vicente Reservoir (SVR) Option includes the blending and dilution of Pure Water into the existing San Vicente Reservoir. The Miramar Reservoir (MR) Option includes the discharge of Pure Water into Miramar Reservoir for treatment at the existing Miramar WTP, and potential future Pure Water discharge into Lake Murray for treatment at the existing Alvarado WTP. The addition of Pure Water into the raw water supply at these WTPs would change the existing water quality and water chemistry, and potentially affect the existing treatment processes. In order to better understand the potential impacts on plant operations, bench-scale studies were conducted to determine the specific water quality implications of augmenting the WTP influent with Pure Water. The results of these studies suggest that plant operations staff will have to make the adjustments to the following treatment processes:

- Coagulation: Dose coagulant with close attention to filtered water turbidity and coagulated water pH. Run jar tests including a filterability step after major changes in the Pure Water blend ratio, and use a coagulant dose that is just enough to produce filterable water.

- Flocculation: Use similar mixing settings to current operation. Gradually increase paddle speed only if filtered water turbidity is unstable and not responding to increased coagulant dose.

- Sedimentation: Rely less on sedimentation for overall turbidity removal. Only clean sludge out of the sedimentation tanks as needed – the cleaning frequency will likely decrease.

- Filtration: Rely mainly on the media filters to achieve low turbidity in the finished water. Backwash frequency may increase due to less removal by sedimentation tanks; or decrease due to lower overall suspended solids loading.

- Post-Conditioning: Dose sodium hydroxide to maintain finished water stability and avoid chemical upsets to the distribution system. Target pH >8.0 and LSI>0.

The operational implications presented in this TM are part of a broader technical analysis of the impacts of the MR Option on the existing drinking water system including the Miramar Reservoir itself; its recreational fishery; and the Miramar WTP and its associated distribution system. These analyses and their cost implications are presented in the following TMs:

- Water Quality and Treatability Study TM, which describes bench-scale testing with blends of Pure Water and existing raw water to determine the effects of the MR Option on treatability and chemical stability.

- WTP Operational Evaluation TM (This Report), which discusses the implications of the bench scale results for treatment plant operations.

- Operations Model TM and Water Quality Model TM, which describe models of Miramar Reservoir that were built to assess Pure Water effects on reservoir management and water quality.

- Pure Water Simulations TM, which presents the results of the Miramar Reservoir modeling and their implications for reservoir operation.

- Fisheries Management TM, which describes the effects of the MR Option on the existing recreational fishery in Miramar Reservoir and options for fishery management.

- Water Operations Cost Evaluation TM, which discusses the cost impacts to the Miramar Reservoir WTP associated with the MR option and encompassing all of the above impacts.

Background

Both the Miramar Water Treatment Plant (MWTP) and the Alvarado Water Treatment Plant (AWTP) are located in San Diego, California. They are managed by the City of San Diego's Public Utilities Department. The MWTP is currently rated for 144 MGD and serves around 500,000 customers. The slightly smaller AWTP is rated for 120 MGD. Both plants operate conventional water treatment processes which include coagulation, flocculation, sedimentation, filtration, pH adjustment, and disinfection. Both WTPs also include ozonation to improve disinfection and control of dissolved organics.

The operations of these processes have been optimized for the current raw water quality. However, the augmentation of the raw water with Pure Water at these WTPs may require changes to achieve effective treatment. Pure Water will be "lean" with low suspended solids, dissolved solids, hardness, and alkalinity. Leaner waters are harder to flocculate: with fewer suspended particles, there is a larger average distance between them and it is more difficult to achieve effective collisions between particles in the flocculator (Weber-Shirk and Lion, 2010). Additionally, it is harder to control the pH of leaner waters due to lower alkalinity and buffering capacity. The flocculation step, which is critical for effective settling and filtration to produce low-turbidity finished water, will therefore become more difficult.

Beyond these treatability impacts, the Pure Water could potentially upset the water chemistry in the WTPs and the distribution system without proper conditioning. Changes in the composition of the raw water may destabilize the chemical equilibrium in the distribution system, which can cause corrosion of pipes, degradation of mortar linings, and mobilization of metals in home plumbing. Unwanted corrosion and leaching of metals are familiar operational problems that have recently afflicted several U.S. cities such as Flint, MI following a change in water supply, and they can cause issues of colored water, turbidity, taste and odor or more serious toxicity problems associated with the release of lead or copper. Water chemistry may have biological implications as well: changes in water supply have been shown to cause shifts in the biofilm community in a drinking water system (Li et al., 2016).

The stability of water is influenced by several factors, including pH, dissolved ions, alkalinity, and organic carbon. There is no perfect single measure of stability, but the Langelier Saturation Index (LSI) is probably the most common proxy for chemical stability. The LSI characterizes saturation with respect to calcium carbonate solubility, and it is widely used in environmental engineering practice because of the prevalence of both calcium and the carbonate system. Water with negative LSI is below saturation with respect to $CaCO_3$, and a water with highly negative LSI will tend to be aggressive – it may attack materials such as concrete or mobilize metals in the distribution system. On the other hand, water with a slightly positive LSI will tend to deposit a protective layer of scale on piping, which generally reduces both clogging by scale and pipe corrosion. Maintaining a slightly positive LSI is a common operational target for municipal water systems (Kawamura, 2000).

LSI is calculated using Equation (1) below, after the method presented by Tchobanoglous et al. (2003):

$$LSI = pH - pH_S \qquad (1)$$

Where pH = solution pH
pH_S = saturation pH for calcium carbonate

The saturation pH is calculated in turn from Equation (2):

$$pH_S = -\log\left(\frac{K_{a2} \times \gamma_{Ca}[Ca] \times \gamma_{HCO_3}[HCO_3]}{K_{sp}}\right) \quad (2)$$

Where K_{a2} = second ionization constant for the carbonate system = 4.7×10^{-11}
γ_{Ca} = activity coefficient for calcium
[Ca] = calcium concentration, mol/L
γ_{HCO3} = activity coefficient for bicarbonate
[HCO_3] = bicarbonate concentration, mol/L
K_{sp} = solubility product constant for $CaCO_3$ = 5.0×10^{-9}

Treatment Effects and Mitigation

This section discusses the effects of Pure Water augmentation on the treatment processes at the existing WTPs. These include impacts on coagulant addition, flocculator operation, sedimentation tank operation, filter operation, and permit compliance. Impacts on the chemical stability and corrosivity of treated water are discussed in the next section.

Coagulant Addition

One major effect of Pure Water augmentation will be greater sensitivity of the coagulation step. The current EPA standard for filtered effluent turbidity is 0.3 NTU, and the WTPs currently target (and achieve) <0.1 NTU in the filtered water. Theoretically, blends of Pure Water should require a lower coagulant dose to meet these goals, because of their lower initial turbidities.

This hypothesis was validated with the results of bench scale testing. As shown in **Table 1**, the WTPs currently apply coagulant doses of 4 – 6 mg/L of ferric chloride to produce a filtered effluent that meets the turbidity standard.

Table 1. Average WTP Operations Data

Facility	Coagulant		Turbidity (NTU)		
	Type	Dose (mg/L)	Raw	Settled	Filtered*
Miramar WTP	$FeCl_3$	4	0.50	0.22	0.070
Alvarado WTP	$FeCl_3$	6	0.55	0.32	0.068

*US EPA Standard: 0.3 NTU, Treatment Goal: <0.1 NTU

As shown in **Table 2**, high blends of Pure Water were able to meet the standard with less coagulant, with doses as low as 2 mg/L of ferric chloride. These high blends represent an extreme but plausible case for Pure Water operation: Pure Water is produced at a constant flow rate of 30 mgd and plant demand varies, so the 90% and 100% blends are representative of times of the year when plant demand is at or below the Pure Water flow. Based on the projections in the Pure Water Simulations TM, this is likely to occur under some conditions. For the data in **Table 2**, it is important to note that the filtered water turbidities in the table are qualitative indicators of filterability, rather than precise projections of full-scale performance under Pure Water operation.

Table 2. Bench-scale Data from High Blend Tests

Test Blend (% Pure Water)	Conditioning	Coagulant		Turbidity (NTU)		
		Type	Dose (mg/L)	Raw	Settled	Filtered*
90%	Design	$FeCl_3$	2	0.307	0.182	0.079
100%	Design	$FeCl_3$	2	0.265	0.226	0.072
90%	Unconditioned	$FeCl_3$	5	0.305	0.236	0.087
100%	Unconditioned	$FeCl_3$	2	0.177	0.077	0.080

*US EPA Standard: 0.3 NTU, Treatment Goal: <0.1 NTU

In addition to the reduced consumption of coagulant to flocculate the water, the lower coagulant dose is also advantageous to avoid large changes in pH as were observed in some of the jar tests. Coagulant addition reduces both pH and LSI (**Figure 1**), so minimizing the coagulant dose is beneficial to help prevent chemical instability.

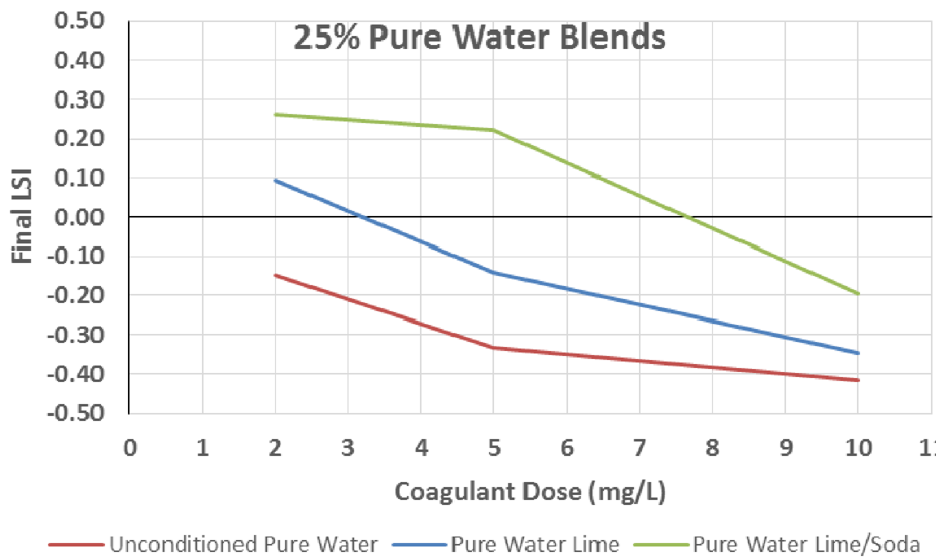

Figure 1. Final LSI Values in 25% Blends for $FeCl_3$ Test Data.

The recommended operational strategy for the coagulation step is to dose coagulant cautiously and avoid overfeeding. Currently, the WTP operations staff has a finely tuned understanding of the range of incoming water quality and the respective coagulant requirements. Because of this, they do not need to conduct regular jar testing to adjust the coagulant dose. However, under the changing water quality with Pure Water operation, it is recommended that the plant staff begin to conduct regular jar testing, including a filtration step with 5 µm filter cartridges, to select an optimized coagulant dose that produces filterable water with the lowest possible coagulant dose. The pH and water chemistry should also be routinely monitored, as described in the next section.

This coagulant dosing strategy represents a change from current operation, but as Pure Water comes online the water quality in Lake Miramar and Lake Murray will change gradually over the time scale of months. During the initial adaptation period, jar testing is recommended after every 5% change in the Pure Water blending ratio. More frequent jar testing than this will likely not be needed.

Flocculator Operation

Flocculation processes should continue similar to current operation. The bench-scale studies used average and peak energy dissipation rates and $G\theta$ values similar to the full-scale AWTP and MWTP flocculators, and the flocculation step (as measured by the ability to produce filterable water) was successful across the range of blending, conditioning, and coagulation conditions tested in the study. Flocculation does not perfectly scale up from bench- to full-scale, but the bench-scale tests used similar energy dissipation rate to the full-scale flocculators, and this has been shown to govern floc size (Tse et al., 2013). It does not seem likely that flocculator settings will have to change based on the observations in the study.

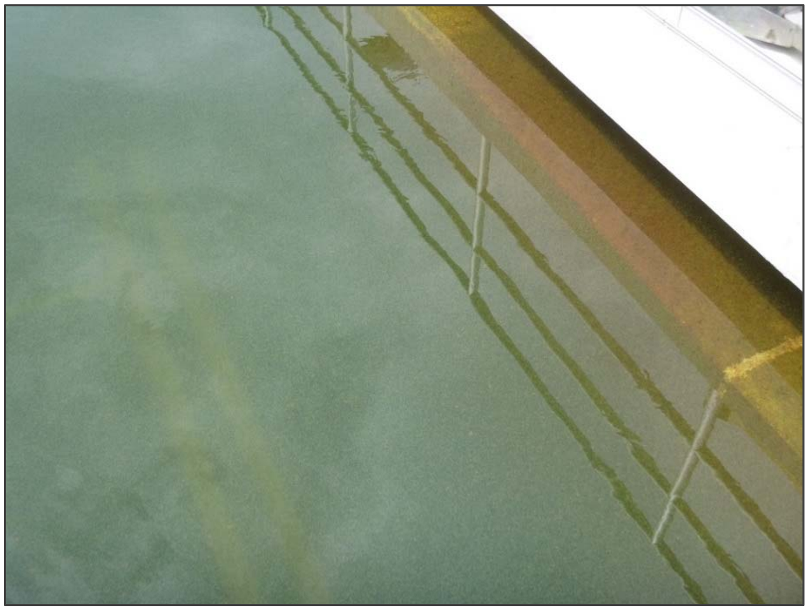

Figure 2. Visible Flocs in the Flocculator at Miramar WTP.

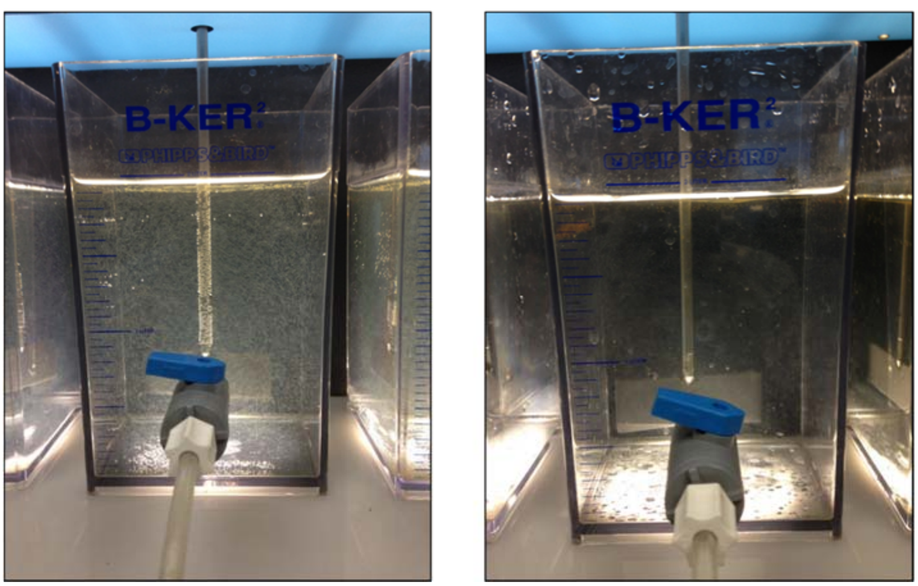

Figure 3. Flocs at Bench Scale with Plant Raw Water (Left) and 75% Pure Water (Right).

A likelier implication of Pure Water operation is that the visual feedback from the flocculation process will change. The current plant operation produces large, visible flocs in the flocculator as shown in **Figure 2**. Under some Pure Water conditions, the flocs were visibly smaller, as shown in **Figure 3**. It is important to note that floc size did not correlate to overall treatability – during jar testing, the jar on the right in **Figure 3** with the 75% Pure Water blend and smaller flocs produced filtered water with lower turbidity than the jar on the left with current Plant raw water.

The lower concentration of suspended solids as well as the lower coagulant doses will likely lead to both smaller flocs and a smaller total floc volume under Pure Water operation. The plant operators will have to adjust to different visual feedback on the effectiveness of flocculation – as long as the filters are still working, the flocs formed in the flocculator need not be as visible as they are under current operation. A reduction in the number and size of visible flocs does not necessarily mean that more coagulant is needed or that flocculation is not working.

Sedimentation Tank Operation

The sedimentation process mainly captures visible flocs. The overflow rates and surface areas of the existing sedimentation tanks at MWTP and AWTP give capture velocities from 0.3 to 0.6 mm/s, respectively. Assuming typical floc characteristics, flocs that will settle at 0.3 to 0.6 mm/s will be around 0.2 mm in size, as shown in **Figure 4**. Flocs of this size and larger are expected to be captured by the sedimentation tanks.

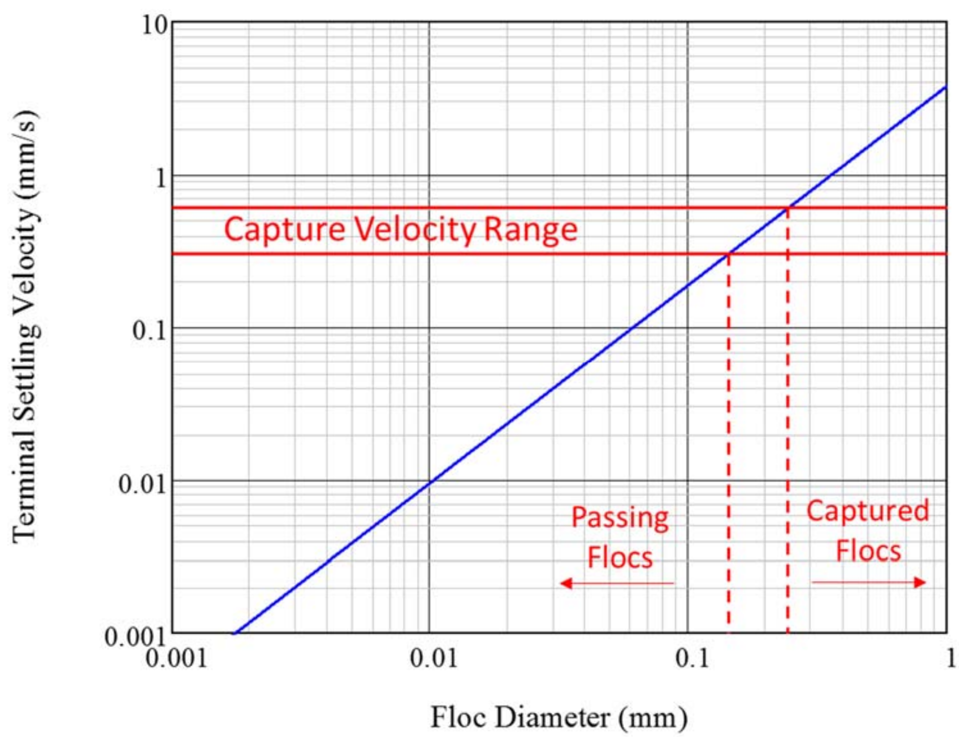

Figure 4. Settling Velocity as a Function of Floc Size.

The graph in **Figure 4** is based on Equation (3), as presented by Adachi and Tanaka (1997). Calculations are shown in **Attachment 1**.

$$V_t = \left(\frac{g{d_0}^2}{18\Phi\nu_w}\right)\left(\frac{\rho_{Floc0} - \rho_w}{\rho_w}\right)\left(\frac{d}{d_0}\right)^{D_{Fractal}-1} \quad (3)$$

Where V_t = floc terminal settling velocity, mm/s
d = floc diameter, mm
d_0 = primary colloidal particle size, 1 µm for suspended clay particles
ρ_{Floc0} = density of primary colloidal particles, 2640 kg/m^3 for clay
Φ = floc shape factor, 45/24 for clay flocs (Adelman et al., 2013)
$D_{Fractal}$ = floc fractal dimension, typically around 2.3 for clay flocs
ν_w = kinematic viscosity of water
ρ_w = density of water
g = gravitational acceleration

The performance of the sedimentation tanks is expected to vary widely under Pure Water operation. While the bench-scale tests produced filterable water across the range of conditions, the settlability of this water was much more variable, as shown in **Figure 5**. This likely had to do with the flocs of widely varying size and density (and, therefore, settling velocity) produced under different Pure Water conditions.

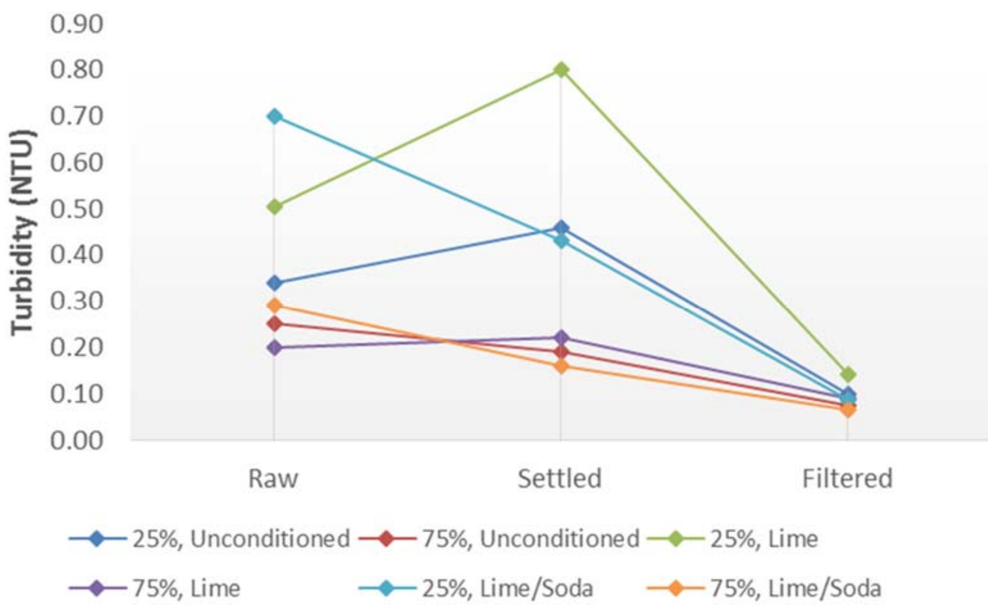

Figure 5. Raw, Settled, and Filtered Turbidity from Most Successful $FeCl_3$ Jars.

This has several operational implications. Under some conditions, the settled water turbidity will be elevated, which is not a problem as long as the water is still filterable and the filtered water turbidities remain low. Therefore, settled water turbidity will not be as reliable an indicator of the effectiveness of flocculation as it has been under previous plant operation. In addition, the required cleaning frequency of the sedimentation tanks and production of sludge will decrease, perhaps significantly so.

Filter Operation

The media filters will remain the critical step in turbidity removal. The filtration process can efficiently capture particles in 5 µm and larger – and while this requires the particles to have flocculated sufficiently to grow, it is much smaller than the range of visible flocs captured by sedimentation. This is illustrated in

Figure 6, which plots the predicted performance of the filters at Alvarado WTP as a function of particle size. Supporting models for the existing filters at both WTPs are shown in **Attachment 1**.

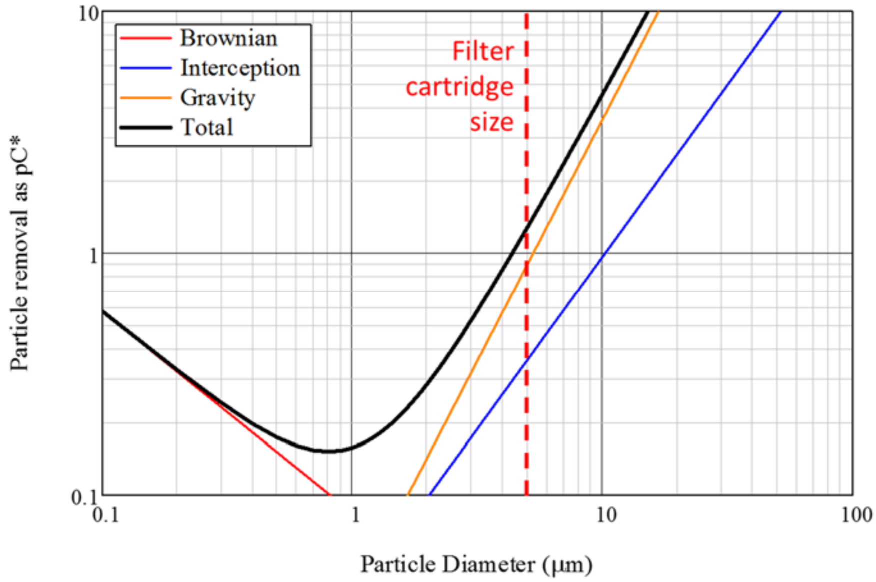

Figure 6. Projected Filter Performance vs. Particle Size at Alvarado WTP.

Filter effluent turbidity is the most important measure of the effectiveness of coagulation and flocculation, in both jar testing and full-scale operations. For jar testing to determine the proper coagulant dose, it is recommended that a 5 μm cartridge filtration step be included to gauge whether the coagulation and flocculation process made the water qualitatively filterable. **Figure 6** shows the rationale for the selection of the 5 μm size exclusion test – the filters achieve >1 log (or >90%) removal of particles at this size.

With their existing media configuration, the filters will allow both WTPs to handle the expected variation in flocculated particle size and settled water turbidity under Pure Water operation. Note that the filterability test was qualitative, and filtered water turbidity under Pure Water operation cannot be precisely predicted from the bench-scale data – but with sufficient flocculation, the filters are expected to perform well. Given the shift in solids loading from the sedimentation tanks to the filters, it is possible that filter backwash frequency will increase slightly under Pure Water operation – although it is also possible that this effect will be offset by the lower total suspended solids load in the Pure Water.

Permit Compliance

Data from the bench-scale studies suggest that the WTPs will have no difficulty meeting the US EPA turbidity standard of 0.3 NTU in the filtered water. However, the current operating permit also requires at least 80% reduction in turbidity through the plants. Under Pure Water operations, there will be lower influent turbidity, and meeting the 80% reduction requirement is uncertain. For example, 80% turbidity removal from 0.25 NTU raw water requires filtered water turbidities of 0.05 NTU. This is typical of levels seen in current operation, but slight variations in filtered water turbidity – as are possible under current or Pure Water operation – could lead to less than 80% overall removal.

It is recommended that this portion of the plant permit be revisited with regulators. With highly effective source control, disinfection systems (ozone and chlorine), and filtered water turbidities well below the EPA MCL, there is a strong argument for relief from this permit provision, perhaps (for example) when the plant raw water turbidity is lower than a certain threshold value.

Chemical Stability Effects and Mitigation

This section discusses the effects of Pure Water augmentation on chemical stability and corrosivity within the WTPs and throughout the distribution system.

Stability under Current and Pure Water Operation

Major ion data and plant operating data were used to calculate the LSI of the raw, coagulated, and finished water under current plant operation, as shown in **Figure 7** and **Figure 8**. These stability indices were calculated with the WaterPro™ chemical modeling package based on the measured alkalinity and calcium concentrations; reported chemical doses; and measured pH values at the two plants during different times of the year. Data and calculations are found in **Attachment 2.**

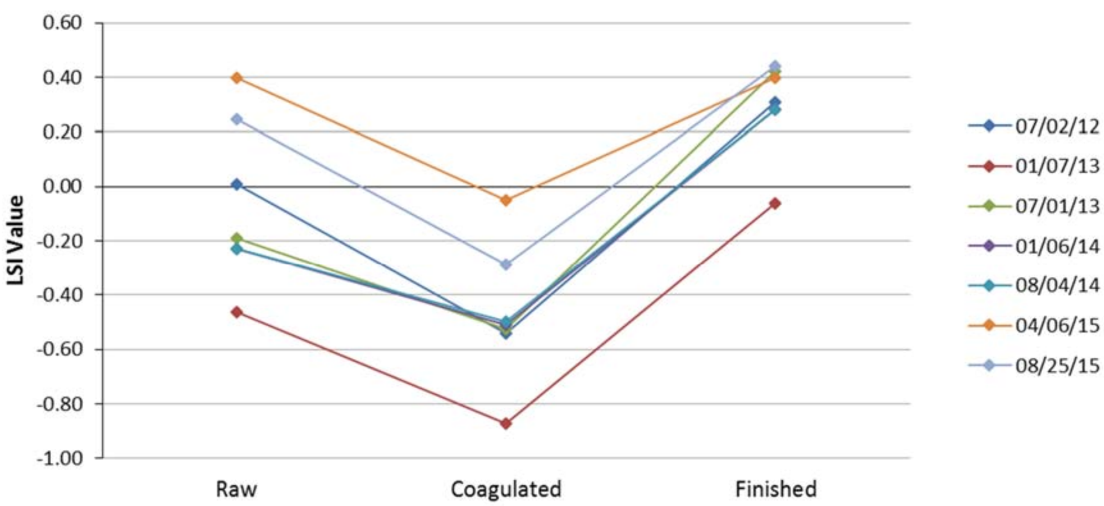

Figure 7. Raw, Coagulated, and Finished LSI at Alvarado WTP.

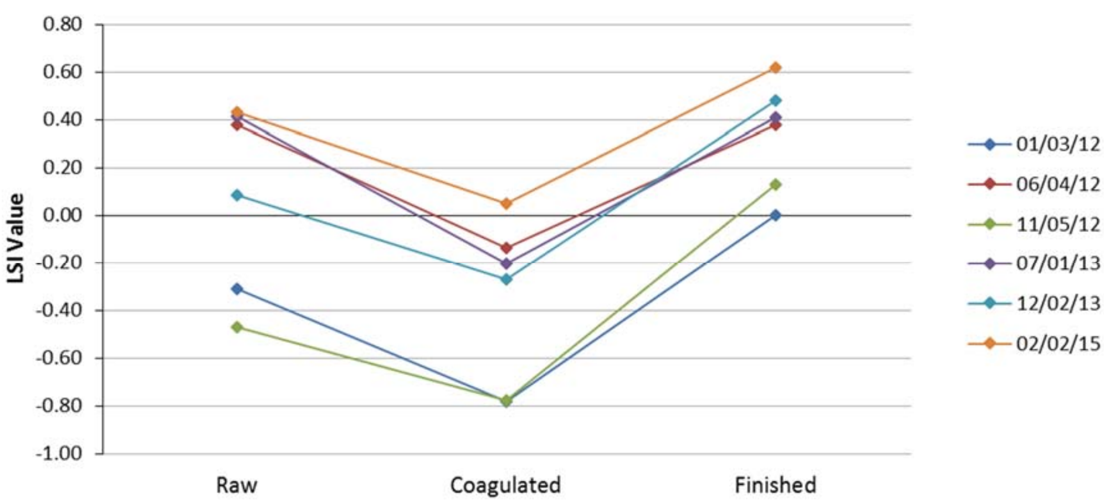

Figure 8. Raw, Coagulated, and Finished LSI at Miramar WTP.

As shown in **Figure 7** and **Figure 8**, the raw water LSI had a wide range from -0.5 to +0.4. After coagulant addition, the LSI typically dipped well into negative territory, dropping as low as -0.9. Following pH adjustment with sodium hydroxide (NaOH), the finished water LSI returned generally to positive territory. The calculated finished water LSI values ranged from -0.1 to +0.4.

Under Pure Water operation, the LSI will potentially be lower, as shown in **Figure 1**. Possible impacts and mitigation strategies for lower LSI values are discussed below.

In-Plant and Distribution System Impacts

Water with lower LSI could be more aggressive within the treatment plant itself. Negative LSI values may be indicative of the potential to corrode plant facilities, including the concrete lining of tanks as well as equipment or piping made of metal. While negative LSI values in the plant could be an impact of Pure Water operation, corrosion has already been observed at the WTPs under current operation. The negative LSI following coagulant addition, as shown in **Figure 7** and **Figure 8**, appears to explain this observation.

Current plant operation effectively achieves positive LSI in the water that is sent to the distribution system. This establishes a chemical equilibrium that helps prevent pipe corrosion and metal leaching. Under Pure Water operation, it is possible to have negative LSI values in water whose pH is within an acceptable range, which would cause a potential chemical upset.

Mitigation of Chemical Upsets

The single most important mitigation strategy against chemical upsets is proper conditioning of the Pure Water at the NCAWPF. The results of the bench-scale study support the decision to include lime and carbon dioxide feed at the NCAWPF to produce Pure Water with appropriate hardness and alkalinity.

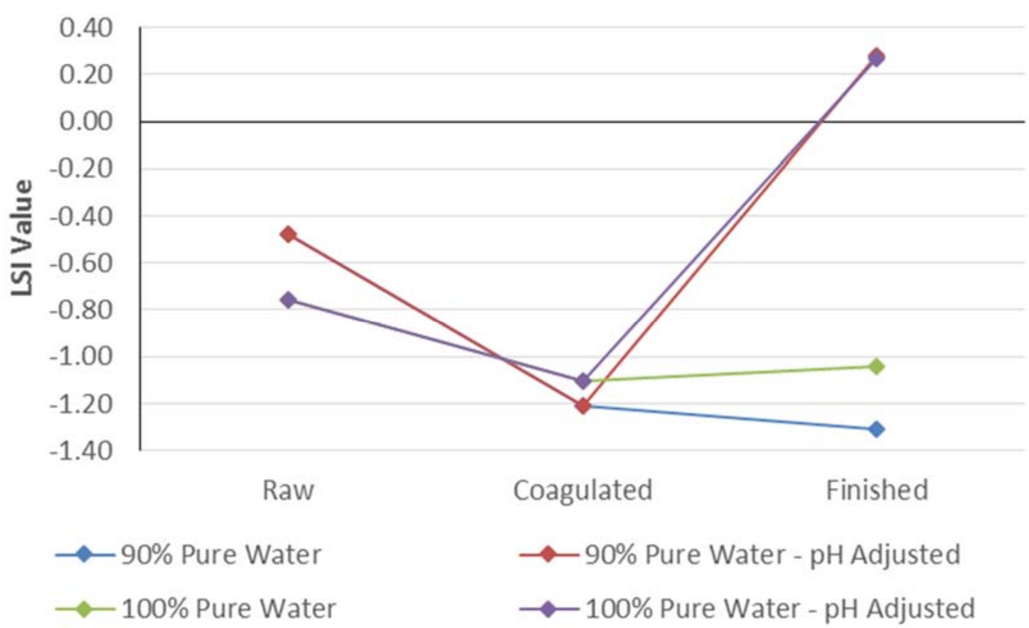

Figure 9. Raw, Coagulated, and Finished LSI with Pure Water from Lab Data.

The operational goal for the WTPs will be to adjust the pH by NaOH addition to the finished water to achieve pH above 8.0, along with sampling for hardness, alkalinity, and total dissolved solids to verify that the LSI remains positive. Because of its importance to protection of the distribution system, it is recommended that this water quality monitoring and LSI calculation be added to the daily sampling routine at the WTPs. If this monitoring finds insufficient hardness or alkalinity in the water at the WTPs, this may indicate a problem with post-conditioning at the NCAWPF.

Chemical modeling with the lab data from the highest percentage Pure Water blends shows that this proposed operating strategy should be possible: with no pH adjustment, these waters had highly negative LSI. However, raising the pH to 8.2 would give LSI values around +0.2 to +0.3 (**Figure 9**). Finished water with pH of 8.2 and LSI of +0.2 should be sufficiently similar to the existing water chemistry to avoid an upset to the distribution system, although pipe loop testing is recommended to confirm this before Pure Water operation begins. In a pipe loop test, sample water is recirculated through pipes representative of the distribution system, in order to study processes such as pipe corrosion, metal leaching and biofilm formation. As such, pipe loop studies with blends of Pure Water would help verify that the conditioned water produced by the WTPs will not cause upsets to the distribution system.

Adding an injection point for NaOH at the influent of both WTPs is an additional step that could help prevent in-plant corrosion by shifting some of this dosing to the head of the plant. This would raise the pH and LSI of the coagulated water. The bench scale testing confirmed that treatability with ferric chloride was maintained at higher pH levels with Pure Water blends, so this recommendation should not adversely affect flocculation. This new injection point may even be helpful to prevent corrosion of plant facilities caused by the low pH and LSI values of the coagulated water under current operation.

WTP Guidelines for Pure Water Operation

Based on the jar-testing and analysis above, there are several recommendations to maintain treatment performance and mitigate stability and corrosion issues within the plant and distribution system. These operational recommendations are summarized below, with items noted that add to the current operational routine. An operators' guide, including troubleshooting suggestions, can be found in **Attachment 3.**

Coagulation

Strategy	Dose coagulant with close attention to filtered water turbidity and coagulated water pH. Run jar tests including a filterability step after major changes in the Pure Water blend ratio, and use a coagulant dose that is just enough to produce filterable water.
Monitoring and Feedback	• Jar testing including flocculation, sedimentation, and 5 μm cartridge filtration to select a coagulant dose to produce filterable water. [NEW] • Repeat jar testing with each 5% change in blend ratio. [NEW] • Sampling for hardness and alkalinity in coagulated water and calculation of LSI value. [NEW] • Real-time monitoring of raw and coagulated water pH. [NEW] • Real-time monitoring of filtered water turbidity.
Alarms	• High or unstable filtered water turbidity – non-optimized coagulation. • Low coagulated water pH or LSI – indicates coagulant overdose.

Flocculation

Strategy	Use similar mixing settings to current operation. Gradually increase paddle speed only if filtered water turbidity is unstable and not responding to increased coagulant dose.
Monitoring and Feedback	• Logging of mixing speed and calculated *G, Gθ*, and energy dissipation rate values in the SCADA system. [NEW] • Real-time monitoring of filtered water turbidity. • Visual observation of flocculator – reduced size or number of flocs compared to current operation is not necessarily a problem. [NEW] • Jar tests of different mixing conditions scaled by energy dissipation rate, if necessary. [NEW]
Alarms	• High or unstable filtered water turbidity – may indicate more energy is required.

Sedimentation

Strategy	Rely less on sedimentation for overall turbidity removal. Only clean sludge out of the sedimentation tanks as needed – the cleaning frequency will likely decrease.
Monitoring and Feedback	• Real-time monitoring of settled water turbidity. • Monitoring of sludge levels in the sedimentation tanks.
Alarms	• High sludge level.

Filtration

Strategy	Rely mainly on the media filters to achieve low turbidity in the finished water. Backwash frequency may increase due to less removal by sedimentation tanks; or decrease due to lower raw water turbidity.
Monitoring and Feedback	• Real-time monitoring of filtered water turbidity. • Real-time monitoring of headloss to indicate end of filter cycle. • Logging of new baseline filter cycle lengths. [NEW]
Alarms	• High filtered water turbidity – indicates ineffective coagulation. • Low coagulated water pH or LSI – indicates coagulant overdose.

Post-Conditioning

Strategy	Dose sodium hydroxide to maintain finished water stability and avoid chemical upsets to the distribution system. Target pH >8.0 and LSI>0.
Monitoring and Feedback	• Sampling for hardness and alkalinity in finished water and calculation of LSI value with each 5% change in blend. [NEW] • Real-time monitoring of finished water pH.
Alarms	• Low finished water pH – indicates under-dosing of NaOH. • Low finished water LSI – possible conditioning issue at NCAWPF.

Conclusions and Future Work

The existing Miramar and Alvarado WTPs are expected to be able to treat supplies augmented with Pure Water. Coagulant dosing will have to be done more cautiously, and the required dose will most likely decrease. The coagulant dose should be optimized to maintain filterability, with the understanding that settlability will vary. The flocculators can continue to operate with similar settings, but flocs will be less numerous and less visible. Turbidity removal by the sedimentation tanks will become more variable, and the filters will remove a higher share of the turbidity. The cleaning frequency of the sedimentation tanks will decrease, sludge production will decrease, and the backwash frequency of the filters may or may not increase. Overall, production of low-turbidity filtered effluent will be the most important indicator of the effectiveness of coagulation and flocculation.

Possible chemical instability of the Pure Water-augmented raw water is mitigated most importantly by proper conditioning at the NCAWPF to increase the hardness and alkalinity. During treatment at the WTPs, the pH will be adjusted to >8.0 to maintain positive LSI values in the finished water and avoid chemical or biological upsets in the treatment system. Current operation produces water with negative LSI within the plants themselves – and while this situation could intensify under Pure Water operation, it has already led to corrosion of basins and equipment. Mitigation of this corrosion and addition of a NaOH injection point at the WTP influent are steps that should be considered regardless of future Pure Water operation.

Several items of future work are recommended as a follow-up to this study. Pipe loop studies with Pure Water should be conducted before full scale operations, in order to assess the stabilization strategy recommended above, and verify that Pure Water operation will not cause chemical or biological upsets to the distribution system. In addition, a complete materials inventory at the WTPs is recommended to identify and address areas that may be sensitive to corrosion under negative LSI conditions.

Pilot-scale treatment plant studies may not be as useful as the other recommended studies. The general operational strategies for adapting to Pure Water as outlined in this TM would not change with a pilot plant, and the more detailed adjustments – such as the new coagulant dosing strategy and filter run lengths – could be determined at full scale during the transition period to Pure Water operation because of the gradual changes in water quality in Lake Miramar and Lake Murray.

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Adachi, Y., and Tanaka, Y. (1997). "Settling velocity of an aluminum kaolinite floc." *Water Res.,* **31**(4), 449-454.

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Weber-Shirk, M.L. and Lion, L.W. (2010). "Flocculation model and collision potential for reactors with flows characterized by high Peclet numbers." *Water Res.*, **44**(18), 5180-5187.

Attachments

1. Sedimentation and Filtration Process Modeling
2. Plant Data and Water Chemistry Calculations
3. WTP Guidelines for Pure Water Operation

Attachment 1

Sedimentation and Filtration Process Modeling

Floc Sedimentation Model

Adachi, Y., and Tanaka, Y. (1997). “Settling velocity of an aluminum kaolinite floc.” *Water Res.,* **31**(4), 449-454..

Physical Constants

$\rho_w := 998.2 \frac{kg}{m^3}$ Density of water (at 20 deg C)

$\mu_w := 0.0010016 \cdot \frac{N \cdot s}{m^2}$* Dynamic viscosity of water (at 20 deg C)

$\nu_w := \frac{\mu_w}{\rho_w} = 1.003 \frac{mm^2}{s}$ Kinematic viscosity of water (at 20 deg C)

$g = 9.807 \frac{m}{s^2}$ Gravitational acceleration

Model Inputs

Range of Floc Sizes

$d_{Floc.Range} := 0.001mm, 0.002mm .. 1mm$ Range of particle sizes

Primary Particle Properties

$\rho_{Floc0} := 2640 \frac{kg}{m^3}$ Particle density (supended clay particles)

$d_0 := 1\mu m$ Primary particle size

Floc Properties

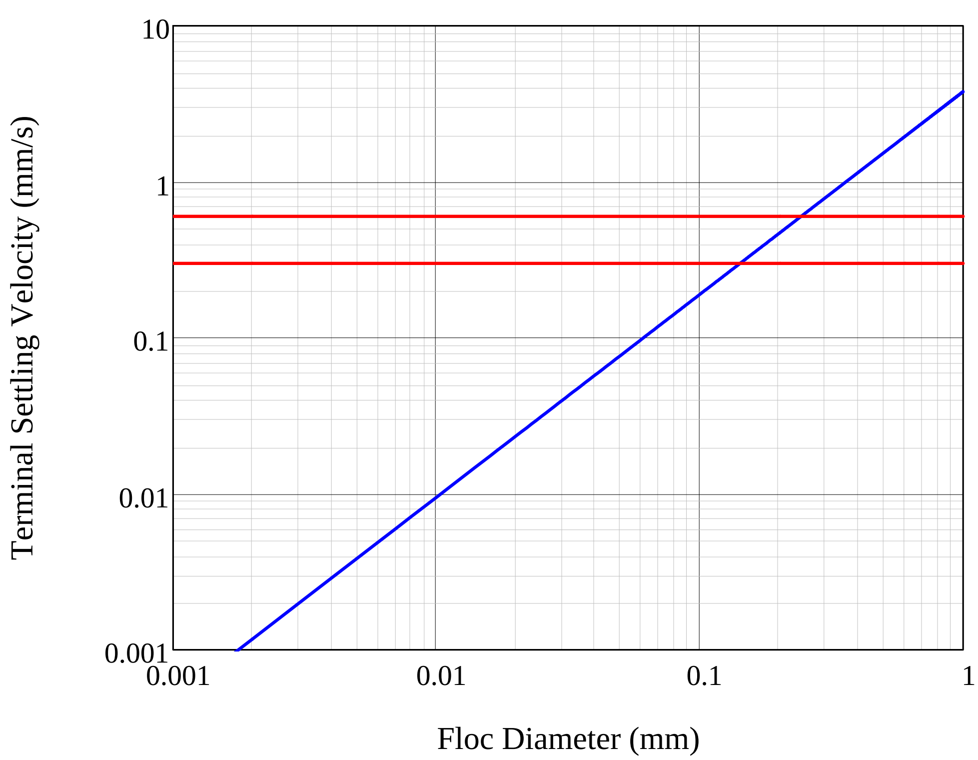
$D_{Fractal} := 2.3$ Floc fractal dimension

$\phi := \frac{45}{24}$ Floc shape factor

Floc Settling Velocity

$$V_t(d) := \left(\frac{g \cdot d_0^{\,2}}{18\phi \cdot \nu_w}\right) \cdot \left(\frac{\rho_{Floc0} - \rho_w}{\rho_w}\right) \cdot \left(\frac{d}{d_0}\right)^{D_{Fractal}-1}$$

$V_{Capture.Low} := 0.3 \frac{mm}{s}$ $V_{Capture.High} := 0.6 \frac{mm}{s}$ Range of capture velocities at the existing sed tanks



Capture Velocity Estimates

Miramar WTP

$LR_{Sed.MWTP} := 0.4 \ \frac{gpm}{ft^2}$

$V_{Capture.MWTP} := LR_{Sed.MWTP} = 0.27 \ \frac{mm}{s}$

Alvarado WTP

$Q_{Plant.AWTP} := 120 \ mgd$

$L_{Basins12.AWTP} := 137.6 \ ft$

$L_{Basins34.AWTP} := 236.92 \ ft$

$W_{Basins12.AWTP} := 170 \ ft$

$W_{Basins34.AWTP} := 93.5 \ ft$

$A_{Basins12.AWTP} := L_{Basins12.AWTP} \cdot W_{Basins12.AWTP} = 23392 \ ft^2$

$A_{Basins34.AWTP} := L_{Basins34.AWTP} \cdot W_{Basins34.AWTP} = 22152.02 \ ft^2$

$V_{Capture.AWTP} := \frac{Q_{Plant.AWTP}}{2 \cdot A_{Basins12.AWTP} + 2 \cdot A_{Basins34.AWTP}}$

$V_{Capture.AWTP} = 0.62 \ \frac{mm}{s}$

Filtration Model - Alvarado WTP

Tufenkji, N. and M. Elimelech (2004). "Correlation equation for predicting single-collector efficiency in physicochemical filtration in saturated porous media." Environ Sci Technol, **38**(2), 529-536.

The model is based on Tufenkji and Elimelech but corrected to eliminate artificial dependencies on irrelevant parameters!

Physical Constants

$$\rho_w := 998.2 \frac{kg}{m^3}$$

$$\mu := 0.0010016 \cdot \frac{N \cdot s}{m^2} * \qquad \nu := \frac{\mu}{\rho_w} = 1.003 \cdot \frac{mm^2}{s}$$

$$k_b := 1.3806505 \cdot 10^{-23} \cdot \frac{joule}{K}$$

$$A := 0.75 \cdot 10^{-20} J$$

Model Inputs

Particle Properties

$$d_p := 0.1\mu m, 0.2 \cdot \mu m .. 100\mu m$$ Range of particle sizes

$$\rho_p := 2640 \frac{kg}{m^3}$$ Particle density (supended clay particles)

Filtration Conditions

$$V_a := 4 \frac{gpm}{ft^2}$$ Filtration rate

$$T := 293K$$ Assumed temperature

Filter Characteristics

$z_{Anth} := 18in$ $d_{Anth} := 1.25mm$ Anthracite layer

$z_{Sand} := 12in$ $d_{Sand} := 0.7mm$ Sand layer

$$\frac{z_{Anth}}{d_{Anth}} + \frac{z_{Sand}}{d_{Sand}} = 801$$

$\alpha := 1$ Attachment efficiency

$\varepsilon := 0.4$ Bed porosity

Dimensionless Groupings

Geometric Groups

$$\Pi_R(d_c, d_p) := \frac{d_p}{d_c}$$

$$\Pi_z(z, d_c) := \frac{3 \cdot (1 - \varepsilon)}{2 \cdot \ln(10)} \cdot \left(\frac{z}{d_c}\right)$$

Force Ratios

$$\Pi_{Br}(V_a, d_c, d_p) := \frac{k_b \cdot T}{3 \cdot \pi \cdot \mu \cdot d_p \cdot V_a \cdot d_c}$$

Brownian motion transport

$$\Pi_g(V_a, d_p, \rho_p) := \frac{{d_p}^2 \cdot (\rho_p - \rho_w) \cdot g}{18 \cdot \mu \cdot V_a}$$

Gravitational transport

$$Re := \frac{V_a \cdot d_{Anth}}{\nu} \qquad Re = 3.384$$

Porosity Effects

$$\gamma(\varepsilon) := (1-\varepsilon)^{\frac{1}{3}}$$

$$A_s(\varepsilon) := \frac{2\cdot\left(1-\gamma(\varepsilon)^5\right)}{2-3\cdot\gamma(\varepsilon)+3\cdot\gamma(\varepsilon)^5-2\cdot\gamma(\varepsilon)^6}$$

Transport due to Brownian Motion, Gravity, and Interception

Brownian Motion:

$$\eta_{Br}\left(V_a, d_c, d_p\right) := \frac{3}{4}\cdot A_s(\varepsilon)^{\frac{1}{3}}\cdot\Pi_R\left(d_c, d_p\right)^{-\frac{1}{6}}\cdot\Pi_{Br}\left(V_a, d_c, d_p\right)^{\frac{2}{3}}$$

Interception:

$$\eta_R\left(d_c, d_p\right) := \frac{1}{21.5}\cdot A_s(\varepsilon)\cdot\Pi_R\left(d_c, d_p\right)^{1.425}$$

Gravity:

$$\eta_g\left(V_a, d_p, \rho_p\right) := 0.31\cdot\Pi_g\left(V_a, d_p, \rho_p\right)$$

Total:

$$\eta\left(V_a, d_c, d_p, \rho_p\right) := \eta_{Br}\left(V_a, d_c, d_p\right)+\eta_R\left(d_c, d_p\right)+\eta_g\left(V_a, d_p, \rho_p\right)$$

Particle Removal

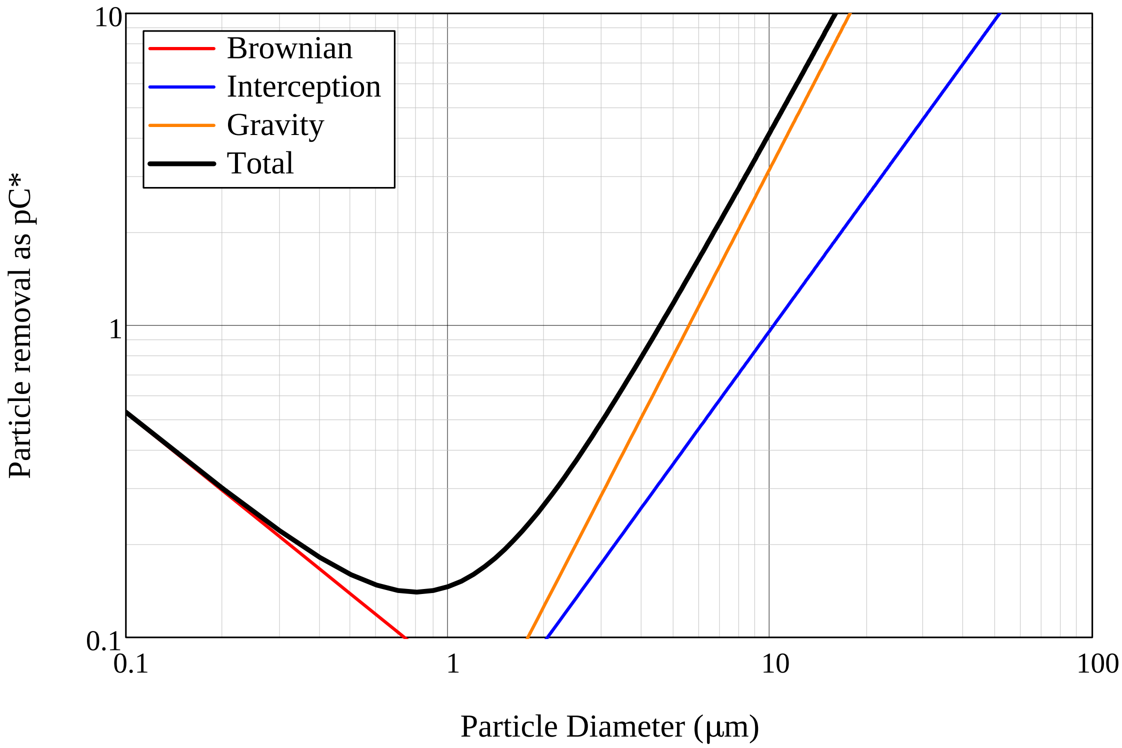
$$pC_{Br}\left(V_a, z, d_c, d_p, \alpha\right) := \Pi_z\left(z, d_c\right)\cdot\alpha\cdot\eta_{Br}\left(V_a, d_c, d_p\right)$$ Brownian motion

$$pC_R\left(z, d_c, d_p, \alpha\right) := \Pi_z\left(z, d_c\right)\cdot\alpha\cdot\eta_R\left(d_c, d_p\right)$$ Interception

$$pC_g\left(V_a, z, d_c, d_p, \rho_p, \alpha\right) := \Pi_z\left(z, d_c\right)\cdot\alpha\cdot\eta_g\left(V_a, d_p, \rho_p\right)$$ Gravity

$$pC\left(V_a, z, d_c, d_p, \rho_p, \alpha\right) := \Pi_z\left(z, d_c\right)\cdot\alpha\cdot\eta\left(V_a, d_c, d_p, \rho_p\right)$$ Total

Projected Performance



Filtration Model - Miramar WTP

Tufenkji, N. and M. Elimelech (2004). "Correlation equation for predicting single-collector efficiency in physicochemical filtration in saturated porous media." Environ Sci Technol, **38**(2), 529-536.

The model is based on Tufenkji and Elimelech but corrected to eliminate artificial dependencies on irrelevant parameters!

Physical Constants

$$\rho_w := 998.2\,\frac{kg}{m^3}$$

$$\mu := 0.0010016\cdot\frac{N\cdot s}{m^2}*$$

$$\nu := \frac{\mu}{\rho_w} = 1.003\cdot\frac{mm^2}{s}$$

$$k_b := 1.3806505\cdot 10^{-23}\cdot\frac{joule}{K}$$

$$A := 0.75\cdot 10^{-20} J$$

Model Inputs

Particle Properties

$$d_p := 0.1\mu m, 0.2\cdot\mu m .. 100\mu m$$

Range of particle sizes

$$\rho_p := 2640\,\frac{kg}{m^3}$$

Particle density
(supended clay particles)

Filtration Conditions

$$V_a := 9\,\frac{gpm}{ft^2}$$

Filtration rate

$$T := 293K$$

Assumed temperature

Filter Characteristics

$z_{Anth} := 48in$ $d_{Anth} := 1.25mm$ Anthracite layer

$z_{Sand} := 9in$ $d_{Sand} := 0.7mm$ Sand layer

$$\frac{z_{Anth}}{d_{Anth}} + \frac{z_{Sand}}{d_{Sand}} = 1302$$

$\alpha := 1$ Attachment efficiency

$\varepsilon := 0.4$ Bed porosity

Dimensionless Groupings

Geometric Groups

$$\Pi_R(d_c, d_p) := \frac{d_p}{d_c}$$

$$\Pi_z(z, d_c) := \frac{3\cdot(1-\varepsilon)}{2\cdot \ln(10)} \cdot \left(\frac{z}{d_c}\right)$$

Force Ratios

$$\Pi_{Br}(V_a, d_c, d_p) := \frac{k_b \cdot T}{3\cdot\pi\cdot\mu\cdot d_p\cdot V_a\cdot d_c}$$ Brownian motion transport

$$\Pi_g(V_a, d_p, \rho_p) := \frac{{d_p}^2\cdot(\rho_p - \rho_w)\cdot g}{18\cdot\mu\cdot V_a}$$ Gravitational transport

$$Re := \frac{V_a\cdot d_{Anth}}{\nu}$$ $Re = 7.614$

Porosity Effects

$$\gamma(\varepsilon) := (1-\varepsilon)^{\frac{1}{3}}$$

$$A_s(\varepsilon) := \frac{2\cdot\left(1-\gamma(\varepsilon)^5\right)}{2-3\cdot\gamma(\varepsilon)+3\cdot\gamma(\varepsilon)^5-2\cdot\gamma(\varepsilon)^6}$$

Transport due to Brownian Motion, Gravity, and Interception

Brownian Motion:

$$\eta_{Br}\left(V_a, d_c, d_p\right) := \frac{3}{4}\cdot A_s(\varepsilon)^{\frac{1}{3}}\cdot\Pi_R\left(d_c, d_p\right)^{-\frac{1}{6}}\cdot\Pi_{Br}\left(V_a, d_c, d_p\right)^{\frac{2}{3}}$$

Interception:

$$\eta_R\left(d_c, d_p\right) := \frac{1}{21.5}\cdot A_s(\varepsilon)\cdot\Pi_R\left(d_c, d_p\right)^{1.425}$$

Gravity:

$$\eta_g\left(V_a, d_p, \rho_p\right) := 0.31\cdot\Pi_g\left(V_a, d_p, \rho_p\right)$$

Total:

$$\eta\left(V_a, d_c, d_p, \rho_p\right) := \eta_{Br}\left(V_a, d_c, d_p\right) + \eta_R\left(d_c, d_p\right) + \eta_g\left(V_a, d_p, \rho_p\right)$$

Particle Removal

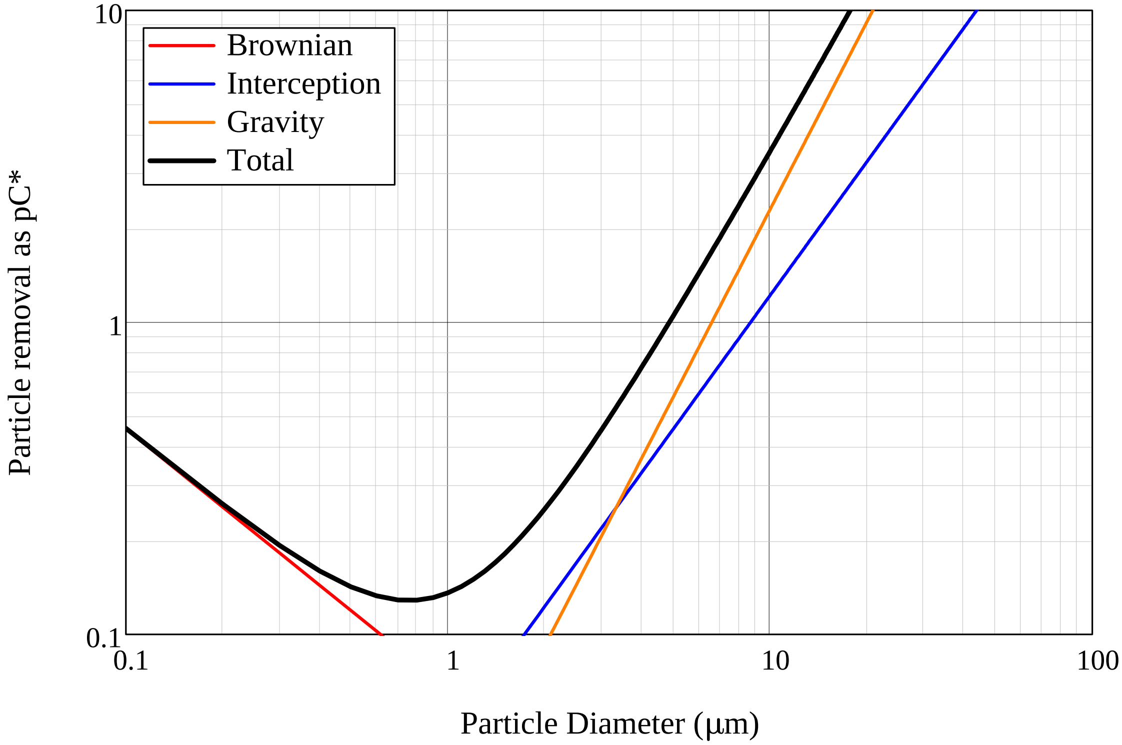
$$pC_{Br}\left(V_a, z, d_c, d_p, \alpha\right) := \Pi_z\left(z, d_c\right)\cdot\alpha\cdot\eta_{Br}\left(V_a, d_c, d_p\right)$$ Brownian motion

$$pC_R\left(z, d_c, d_p, \alpha\right) := \Pi_z\left(z, d_c\right)\cdot\alpha\cdot\eta_R\left(d_c, d_p\right)$$ Interception

$$pC_g\left(V_a, z, d_c, d_p, \rho_p, \alpha\right) := \Pi_z\left(z, d_c\right)\cdot\alpha\cdot\eta_g\left(V_a, d_p, \rho_p\right)$$ Gravity

$$pC\left(V_a, z, d_c, d_p, \rho_p, \alpha\right) := \Pi_z\left(z, d_c\right)\cdot\alpha\cdot\eta\left(V_a, d_c, d_p, \rho_p\right)$$ Total

Projected Performance



Attachment 2

Plant Data and Water Chemistry Calculations

Work Problem #:				
System Name: Source Point: Date of Sample:	AWTP - Raw Water City Data 04/06/15	AWTP - Coagulated City Data 04/06/15	AWTP - Treated City Data 04/06/15	AWTP - Raw Water City Data 07/02/12
TDS, mg/L =	687	687	687	534
Calcium (total), mg/L as Ca^{2+} =	74.0	74.0	74.0	54.8
Total Alkalinity, mg/L as $CaCO_3$ =	130.0	130.0	130.0	91.0
pH =	8.00	8.00	8.00	7.80
Water Temperature, ^oC =	19.6	19.6	19.6	23.3
Field Water Temperature, ^oC =	19.6	19.6	19.6	23.3
Cl^-, mg/L =	99.1	99.1	99.1	106.0
SO_4^{2-}, mg/L =	229.0	229.0	229.0	163.0
Mg^{2+}, mg/L =	28.3	28.3	28.3	19.6
Reagent Addition		5.56 mg/L Ferric Chloride	5.56 mg/L Ferric Chloride 3.36 mg/L Hypochlorite 3.3 mg/L Caustic Soda	

Initial Results

pH =	8.00	8.00	8.00	7.80
Aggressive Index (AI) =	12.3	12.3	12.3	11.8
Ryznar Index (RI) =	7.20	7.20	7.20	7.78
Langelier Index, Calcite =	0.40	0.40	0.40	0.01
CCPP =	7.56	7.56	7.56	0.24
$B_{H20} + B_{CO3}$ =	0.161	0.161	0.161	0.148
$Alk/(Cl^- + SO_4^{2-})$ =	0.3	0.3	0.3	0.3

Results after Chemical Addition

Measured Results

pH - Final			8.0	

Model Results

Interim pH =		7.56	8.00	
Equilibrium pH =		N/A	7.63	
Aggressive Index (AI) =		11.9	12.3	
Ryznar Index (RI) =		7.66	7.20	
Langelier Index, Calcite =		-0.05	0.40	
CCPP =		-1.15	7.58	
$B_{H20} + B_{CO3}$ =		0.332	0.160	
$Alk/(Cl^- + SO_4^{2-})$ =		0.3	0.3	

Work Problem #:				
System Name: Source Point: Date of Sample:	AWTP - Coagulated City Data 07/02/12	AWTP - Treated City Data 07/02/12	AWTP - Raw Water City Data 01/07/13	AWTP - Coagulated City Data 01/07/13
TDS, mg/L =	534	534	357	357
Calcium (total), mg/L as Ca^{2+} =	54.8	54.8	32.4	32.4
Total Alkalinity, mg/L as $CaCO_3$ =	91.0	91.0	76.3	76.3
pH =	7.80	7.80	7.70	7.70
Water Temperature, ^oC =	23.3	23.3	14.1	14.1
Field Water Temperature, ^oC =	23.3	23.3	14.1	14.1
Cl^-, mg/L =	106.0	106.0	77.5	77.5
SO_4^{2-}, mg/L =	163.0	163.0	76.5	76.5
Mg^{2+}, mg/L =	19.6	19.6	15.5	15.5
Reagent Addition	7.1 mg/L Ferric Chloride	7.1 mg/L Ferric Chloride 4 mg/L Hypochlorite 5.85 mg/L Caustic Soda		5.2 mg/L Ferric Chloride

Initial Results

pH =	7.80	7.80	7.70	7.70
Aggressive Index (AI) =	11.8	11.8	11.5	11.5
Ryznar Index (RI) =	7.78	7.78	8.63	8.63
Langelier Index, Calcite =	0.01	0.01	-0.46	-0.46
CCPP =	0.24	0.24	-4.97	-4.97
$B_{H20} + B_{CO3}$ =	0.148	0.148	0.170	0.170
$Alk/(Cl^- + SO_4^{2-})$ =	0.3	0.3	0.4	0.4

Results after Chemical Addition

Measured Results

pH - Final		8.1		

Model Results

Interim pH =	7.27	8.10		7.32
Equilibrium pH =	N/A	7.81		N/A
Aggressive Index (AI) =	11.3	12.1		11.0
Ryznar Index (RI) =	8.36	7.48		9.06
Langelier Index, Calcite =	-0.54	0.31		-0.87
CCPP =	-11.42	3.55		-13.79
$B_{H20} + B_{CO3}$ =	0.387	0.103		0.348
$Alk/(Cl^- + SO_4^{2-})$ =	0.3	0.3		0.4

Work Problem #:				
System Name: Source Point: Date of Sample:	AWTP - Treated City Data 01/07/13	AWTP - Raw Water City Data 07/01/13	AWTP - Coagulated City Data 07/01/13	AWTP - Treated City Data 07/01/13
TDS, mg/L =	357	521	521	521
Calcium (total), mg/L as Ca^{2+} =	32.4	58.1	58.1	58.1
Total Alkalinity, mg/L as $CaCO_3$ =	76.3	110.6	110.6	110.6
pH =	7.70	7.50	7.50	7.50
Water Temperature, ^oC =	14.1	22.0	22.0	22.0
Field Water Temperature, ^oC =	14.1	22.0	22.0	22.0
Cl^-, mg/L =	77.5	74.9	74.9	74.9
SO_4^{2-}, mg/L =	76.5	153.0	153.0	153.0
Mg^{2+}, mg/L =	15.5	23.7	23.7	23.7
Reagent Addition	5.2 mg/L Ferric Chloride 3.9 mg/L Hypochlorite 4.85 mg/L Caustic Soda		7.4 mg/L Ferric Chloride	7.4 mg/L Ferric Chloride 3.4 mg/L Hypochlorite 9.6 mg/L Caustic Soda

Initial Results

pH =	7.70	7.50	7.50	7.50
Aggressive Index (AI) =	11.5	11.7	11.7	11.7
Ryznar Index (RI) =	8.63	7.88	7.88	7.88
Langelier Index, Calcite =	-0.46	-0.19	-0.19	-0.19
CCPP =	-4.97	-4.20	-4.20	-4.20
$B_{H20} + B_{CO3}$ =	0.170	0.324	0.324	0.324
$Alk/(Cl^- + SO_4^{2-})$ =	0.4	0.4	0.4	0.4

Results after Chemical Addition

Measured Results

pH - Final	8.1			8.1

Model Results

Interim pH =	8.10		7.50	8.10
Equilibrium pH =	N/A		N/A	7.71
Aggressive Index (AI) =	11.9		11.3	12.3
Ryznar Index (RI) =	8.21		8.24	7.26
Langelier Index, Calcite =	-0.06		-0.52	0.42
CCPP =	-0.41		-15.86	6.27
$B_{H20} + B_{CO3}$ =	0.092		0.572	0.129
$Alk/(Cl^- + SO_4^{2-})$ =	0.4		0.4	0.4

Work Problem #:				
System Name:	AWTP - Raw Water	AWTP - Coagulated	AWTP - Treated	AWTP - Raw Water
Source Point:	City Data	City Data	City Data	City Data
Date of Sample:	01/06/14	01/06/14	01/06/14	08/04/14
TDS, mg/L =	526	526	526	454
Calcium (total), mg/L as Ca^{2+} =	50.0	50.0	50.0	41.8
Total Alkalinity, mg/L as $CaCO_3$ =	125.4	125.4	125.4	102.5
pH =	7.60	7.60	7.60	7.60
Water Temperature, ^oC =	12.8	12.8	12.8	23.1
Field Water Temperature, ^oC =	12.8	12.8	12.8	23.1
Cl^-, mg/L =	79.9	79.9	79.9	78.8
SO_4^{2-}, mg/L =	137.0	137.0	137.0	111.0
Mg^{2+}, mg/L =	26.8	26.8	26.8	18.4
Reagent Addition		6.2 mg/L Ferric Chloride	6.2 mg/L Ferric Chloride 3.23 mg/L Hypochlorite 8.4 mg/L Caustic Soda	

Initial Results

pH =	7.60	7.60	7.60	7.60
Aggressive Index (AI) =	11.7	11.7	11.7	11.6
Ryznar Index (RI) =	8.06	8.06	8.06	8.05
Langelier Index, Calcite =	-0.23	-0.23	-0.23	-0.23
CCPP =	-5.30	-5.30	-5.30	-3.85
$B_{H20} + B_{CO3}$ =	0.345	0.345	0.345	0.244
Alk/(Cl^- + SO_4^{2-}) =	0.5	0.5	0.5	0.5

Results after Chemical Addition

Measured Results

pH - Final			8.1	

Model Results

Interim pH =		7.34	8.10	
Equilibrium pH =		N/A	7.84	
Aggressive Index (AI) =		11.5	12.3	
Ryznar Index (RI) =		8.35	7.54	
Langelier Index, Calcite =		-0.51	0.28	
CCPP =		-15.10	4.56	
$B_{H20} + B_{CO3}$ =		0.556	0.152	
Alk/(Cl^- + SO_4^{2-}) =		0.5	0.5	

Work Problem #:				
System Name:	AWTP - Coagulated	AWTP - Treated	AWTP - Raw Water	AWTP - Coagulated
Source Point:	City Data	City Data	Sampled at AWTP Lab	Sampled at AWTP Lab
Date of Sample:	08/04/14	08/04/14	08/25/15	08/25/15
TDS, mg/L =	454	454	694	694
Calcium (total), mg/L as Ca^{2+} =	41.8	41.8	70.9	70.9
Total Alkalinity, mg/L as $CaCO_3$ =	102.5	102.5	93.0	93.0
pH =	7.60	7.60	7.90	7.90
Water Temperature, ^oC =	23.1	23.1	28.2	28.2
Field Water Temperature, ^oC =	23.1	23.1	28.2	28.2
Cl^-, mg/L =	78.8	78.8	109.0	109.0
SO_4^{2-}, mg/L =	111.0	111.0	261.0	261.0
Mg^{2+}, mg/L =	18.4	18.4	25.6	25.6
Reagent Addition	4.4 mg/L Ferric Chloride	4.4 mg/L Ferric Chloride 3.21 mg/L Hypochlorite 5.9 mg/L Caustic Soda		5.6 mg/L Ferric Chloride

Initial Results

pH =	7.60	7.60	7.90	7.90
Aggressive Index (AI) =	11.6	11.6	12.0	12.0
Ryznar Index (RI) =	8.05	8.05	7.41	7.41
Langelier Index, Calcite =	-0.23	-0.23	0.25	0.25
CCPP =	-3.85	-3.85	3.41	3.41
$B_{H20} + B_{CO3}$ =	0.244	0.244	0.125	0.125
$Alk/(Cl^- + SO_4^{2-})$ =	0.5	0.5	0.2	0.2

Results after Chemical Addition

Measured Results

pH - Final		8.1		

Model Results

Interim pH =	7.34	8.10		7.38
Equilibrium pH =	N/A	7.84		N/A
Aggressive Index (AI) =	11.3	12.1		11.5
Ryznar Index (RI) =	8.34	7.54		7.96
Langelier Index, Calcite =	-0.50	0.28		-0.29
CCPP =	-10.95	3.47		-5.70
$B_{H20} + B_{CO3}$ =	0.395	0.118		0.304
$Alk/(Cl^- + SO_4^{2-})$ =	0.4	0.5		0.2

Work Problem #:	
System Name:	AWTP - Treated
Source Point:	Sampled at AWTP Lab
Date of Sample:	08/25/15
TDS, mg/L =	694
Calcium (total), mg/L as Ca^{2+} =	70.9
Total Alkalinity, mg/L as $CaCO_3$ =	93.0
pH =	7.90
Water Temperature, ^oC =	28.2
Field Water Temperature, ^oC =	28.2
Cl^-, mg/L =	109.0
SO_4^{2-}, mg/L =	261.0
Mg^{2+}, mg/L =	25.6
Reagent Addition	5.6 mg/L Ferric Chloride 3.4 mg/L Hypochlorite 4.4 mg/L Caustic Soda

Initial Results

pH =	7.90
Aggressive Index (AI) =	12.0
Ryznar Index (RI) =	7.41
Langelier Index, Calcite =	0.25
CCPP =	3.41
$B_{H20} + B_{CO3}$ =	0.125
$Alk/(Cl^- + SO_4^{2-})$ =	0.2

Results after Chemical Addition

Measured Results

pH - Final	8.1

Model Results

Interim pH =	8.10
Equilibrium pH =	7.68
Aggressive Index (AI) =	12.2
Ryznar Index (RI) =	7.21
Langelier Index, Calcite =	0.44
CCPP =	5.43
$B_{H20} + B_{CO3}$ =	0.104
$Alk/(Cl^- + SO_4^{2-})$ =	0.2

Alvarado Water Treatment Plant

Winter/Spring

	1/7/2013	1/6/2014	4/6/2015
pH Raw	7.7	7.6	8
pH Finished	8.1	8.1	8
Raw Temp	14.1	12.8	19.6
Turb Raw	0.3	0.2	0.7
Turb Settled	0.2	0.3	0.2
Turb Filtered	0.05	0.06	0.08
Ferric Dose	5.2	6.2	5.6
Poly Dose	1.73	1.95	1.6
Cl2 Dose	3.9	3.23	3.36
Cl2 Residual	3	3	3

Summer/Fall

	8/4/2014	7/2/2012	7/1/2013
pH Raw	7.6	7.8	7.5
pH Finished	8.1	8.1	8.1
Raw Temp	23.1	23.3	22
Turb Raw	0.3	1.4	0.4
Turb Settled	0.4	0.4	0.4
Turb Filtered	0.08	0.08	0.06
Ferric Dose	4.4	7.1	7.4
Poly Dose	1	1.9	1.7
Cl2 Dose	3.21	4	3.4
Cl2 Residual	2.8	2.9	3

Alvarado Water Treatment Plant

	8/25/2015	8/26/2015	9/29/2015	9/30/2015
pH Raw	7.9	8	7.9	7.9
pH Finished	8.1	8.1	8	7.9
Raw Temp	28.2	28.5	27	27.1
Turb Raw	0.31	0.3	0.22	0.23
Turb Settled	0.25	0.2	0.2	0.21
Turb Filtered	0.07	0.08	0.07	0.08
Ferric Dose	5.6	5.78	5.25	5.34
Poly Dose	1.44	1.51	1.52	1.53
Cl2 Dose	3.4	3.28	3.28	3.19
Cl2 Residual	2.9	2.8	2.7	2.7

Work Problem #:				
System Name:	MWTP - Raw Water	MWTP - Coagulated	MWTP - Treated	MWTP - Raw Water
Source Point:	City Data	City Data	City Data	City Data
Date of Sample:	01/03/12	01/03/12	01/03/12	06/04/12
TDS, mg/L =	291	291	291	510
Calcium (total), mg/L as Ca^{2+} =	31.6	31.6	31.6	48.8
Total Alkalinity, mg/L as $CaCO_3$ =	67.3	67.3	67.3	101.8
pH =	7.90	7.90	7.90	8.20
Water Temperature, ^oC =	14.0	14.0	14.0	21.8
Field Water Temperature, ^oC =	14.0	14.0	14.0	21.8
Cl^-, mg/L =	60.5	60.5	60.5	79.1
SO_4^{2-}, mg/L =	59.6	59.6	59.6	160.0
Mg^{2+}, mg/L =	8.1	8.1	8.1	19.9
Reagent Addition		3.96 mg/L Ferric Chloride	3.96 mg/L Ferric Chloride 3.94 mg/L Hypochlorite 3.05 mg/L Caustic Soda	

Initial Results

pH =	7.90	7.90	7.90	8.20
Aggressive Index (AI) =	11.6	11.6	11.6	12.2
Ryznar Index (RI) =	8.52	8.52	8.52	7.44
Langelier Index, Calcite =	-0.31	-0.31	-0.31	0.38
CCPP =	-2.41	-2.41	-2.41	4.39
$B_{H20} + B_{CO3}$ =	0.105	0.105	0.105	0.107
$Alk/(Cl^- + SO_4^{2-})$ =	0.5	0.5	0.5	0.4

Results after Chemical Addition

Measured Results

pH - Final			8.2	

Model Results

Interim pH =		7.45	8.20	
Equilibrium pH =		N/A	8.20	
Aggressive Index (AI) =		11.1	11.9	
Ryznar Index (RI) =		9.01	8.21	
Langelier Index, Calcite =		-0.78	0.00	
CCPP =		-9.21	0.01	
$B_{H20} + B_{CO3}$ =		0.239	0.073	
$Alk/(Cl^- + SO_4^{2-})$ =		0.4	0.5	

Work Problem #:				
System Name: Source Point: Date of Sample:	MWTP - Coagulated City Data 06/04/12	MWTP - Treated City Data 06/04/12	MWTP - Raw Water City Data 11/05/12	MWTP - Coagulated City Data 11/05/12
TDS, mg/L =	510	510	342	342
Calcium (total), mg/L as Ca^{2+} =	48.8	48.8	32.3	32.3
Total Alkalinity, mg/L as $CaCO_3$ =	101.8	101.8	78.7	78.7
pH =	8.20	8.20	7.60	7.60
Water Temperature, ^oC =	21.8	21.8	19.2	19.2
Field Water Temperature, ^oC =	21.8	21.8	19.2	19.2
Cl^-, mg/L =	79.1	79.1	70.8	70.8
SO_4^{2-}, mg/L =	160.0	160.0	71.8	71.8
Mg^{2+}, mg/L =	19.9	19.9	13.6	13.6
Reagent Addition	3.96 mg/L Ferric Chloride	3.96 mg/L Ferric Chloride 4.60 mg/L Hypochlorite 2 mg/L Caustic Soda		4.09 mg/L Ferric Chloride

Initial Results

pH =	8.20	8.20	7.60	7.60
Aggressive Index (AI) =	12.2	12.2	11.4	11.4
Ryznar Index (RI) =	7.44	7.44	8.54	8.54
Langelier Index, Calcite =	0.38	0.38	-0.47	-0.47
CCPP =	4.39	4.39	-5.73	-5.73
$B_{H20} + B_{CO3}$ =	0.107	0.107	0.199	0.199
Alk/(Cl^- + SO_4^{2-}) =	0.4	0.4	0.5	0.5

Results after Chemical Addition

Measured Results

pH - Final		8.2		

Model Results

Interim pH =	7.68	8.20		7.60
Equilibrium pH =	N/A	7.84		7.31
Aggressive Index (AI) =	11.7	12.2		11.1
Ryznar Index (RI) =	7.96	7.44		8.87
Langelier Index, Calcite =	-0.14	0.38		-0.78
CCPP =	-2.08	4.42		-12.60
$B_{H20} + B_{CO3}$ =	0.201	0.107		0.339
Alk/(Cl^- + SO_4^{2-}) =	0.3	0.4		0.4

Work Problem #:				
System Name:	MWTP - Treated	MWTP - Raw Water	MWTP - Coagulated	MWTP - Treated
Source Point:	City Data	City Data	City Data	City Data
Date of Sample:	11/05/12	07/01/13	07/01/13	07/01/13
TDS, mg/L =	342	529	529	529
Calcium (total), mg/L as Ca^{2+} =	32.3	63.9	63.9	63.9
Total Alkalinity, mg/L as $CaCO_3$ =	78.7	77.2	77.2	77.2
pH =	7.60	8.20	8.20	8.20
Water Temperature, ^oC =	19.2	25.3	25.3	25.3
Field Water Temperature, ^oC =	19.2	25.3	25.3	25.3
Cl^-, mg/L =	70.8	79.2	79.2	79.2
SO_4^{2-}, mg/L =	71.8	183.0	183.0	183.0
Mg^{2+}, mg/L =	13.6	23.7	23.7	23.7
Reagent Addition	4.09 mg/L Ferric Chloride 4.43 mg/L Hypochlorite 5.1 mg/L Caustic Soda		3.85 mg/L Ferric Chloride	3.85 mg/L Ferric Chloride 4.62 mg/L Hypochlorite 1.9 mg/L Caustic Soda

Initial Results

pH =	7.60	8.20	8.20	8.20
Aggressive Index (AI) =	11.4	12.2	12.2	12.2
Ryznar Index (RI) =	8.54	7.37	7.37	7.37
Langelier Index, Calcite =	-0.47	0.41	0.41	0.41
CCPP =	-5.73	3.81	3.81	3.81
$B_{H20} + B_{CO3}$ =	0.199	0.083	0.083	0.083
$Alk/(Cl^- + SO_4^{2-})$ =	0.5	0.3	0.3	0.3

Results after Chemical Addition

Measured Results

pH - Final	8.2			8.2

Model Results

Interim pH =	8.20		7.58	8.20
Equilibrium pH =	8.07		N/A	7.80
Aggressive Index (AI) =	12.0		11.6	12.2
Ryznar Index (RI) =	7.93		7.99	7.37
Langelier Index, Calcite =	0.13		-0.21	0.41
CCPP =	1.18		-2.62	3.82
$B_{H20} + B_{CO3}$ =	0.087		0.176	0.083
$Alk/(Cl^- + SO_4^{2-})$ =	0.5		0.2	0.3

Work Problem #:				
System Name:	MWTP - Raw Water	MWTP - Coagulated	MWTP - Treated	MWTP - Raw Water
Source Point:	City Data	City Data	City Data	City Data
Date of Sample:	12/02/13	12/02/13	12/02/13	02/02/15
TDS, mg/L =	567	567	567	698
Calcium (total), mg/L as Ca^{2+} =	55.6	55.6	55.6	73.6
Total Alkalinity, mg/L as $CaCO_3$ =	105.8	105.8	105.8	132.9
pH =	7.90	7.90	7.90	8.10
Water Temperature, ^oC =	17.4	17.4	17.4	14.6
Field Water Temperature, ^oC =	17.4	17.4	17.4	14.6
Cl^-, mg/L =	84.1	84.1	84.1	94.7
SO_4^{2-}, mg/L =	189.0	189.0	189.0	239.0
Mg^{2+}, mg/L =	26.6	26.6	26.6	27.6
Reagent Addition		4.03 mg/L Ferric Chloride	4.03 mg/L Ferric Chloride 3.76 mg/L Hypochlorite 5 mg/L Caustic Soda	

Initial Results

pH =	7.90	7.90	7.90	8.10
Aggressive Index (AI) =	12.0	12.0	12.0	12.4
Ryznar Index (RI) =	7.73	7.73	7.73	7.24
Langelier Index, Calcite =	0.09	0.09	0.09	0.43
CCPP =	1.35	1.35	1.35	7.75
$B_{H20} + B_{CO3}$ =	0.155	0.155	0.155	0.152
Alk/(Cl^- + SO_4^{2-}) =	0.3	0.3	0.3	0.3

Results after Chemical Addition

Measured Results

pH - Final			8.3	

Model Results

Interim pH =		7.55	8.30	
Equilibrium pH =		N/A	7.84	
Aggressive Index (AI) =		11.6	12.4	
Ryznar Index (RI) =		8.10	7.34	
Langelier Index, Calcite =		-0.27	0.48	
CCPP =		-5.22	5.75	
$B_{H20} + B_{CO3}$ =		0.287	0.112	
Alk/(Cl^- + SO_4^{2-}) =		0.3	0.3	

Work Problem #:		
System Name:	MWTP - Coagulated	MWTP - Treated
Source Point:	City Data	City Data
Date of Sample:	02/02/15	02/02/15
TDS, mg/L =	698	698
Calcium (total), mg/L as Ca^{2+} =	73.6	73.6
Total Alkalinity, mg/L as $CaCO_3$ =	132.9	132.9
pH =	8.10	8.10
Water Temperature, ^oC =	14.6	14.6
Field Water Temperature, ^oC =	14.6	14.6
Cl^-, mg/L =	94.7	94.7
SO_4^{2-}, mg/L =	239.0	239.0
Mg^{2+}, mg/L =	27.6	27.6
Reagent Addition	4.06 mg/L Ferric Chloride	4.06 mg/L Ferric Chloride 3.5 mg/L Hypochlorite 3.45 mg/L Caustic Soda

Initial Results

pH =	8.10	8.10
Aggressive Index (AI) =	12.4	12.4
Ryznar Index (RI) =	7.24	7.24
Langelier Index, Calcite =	0.43	0.43
CCPP =	7.75	7.75
$B_{H20} + B_{CO3}$ =	0.152	0.152
Alk/(Cl^- + SO_4^{2-}) =	0.3	0.3

Results after Chemical Addition

Measured Results

pH - Final		8.3

Model Results

Interim pH =	7.72	8.30
Equilibrium pH =	7.67	7.72
Aggressive Index (AI) =	12.0	12.6
Ryznar Index (RI) =	7.62	7.05
Langelier Index, Calcite =	0.05	0.62
CCPP =	1.34	10.12
$B_{H20} + B_{CO3}$ =	0.266	0.138
Alk/(Cl^- + SO_4^{2-}) =	0.3	0.3

Miramar Water Treatment Plant

Winter/Spring

	LOW 1/3/2012	INTERMEDIATE 12/2/2013	HIGH 2/2/2015
pH Raw	7.9	7.9	8.1
pH Finished	8.2	8.3	8.3
Raw Temp	14	17.4	14.6
Turb Raw	0.86	0.47	0.4
Turb Settled	0.21	0.2	0.2
Turb Filtered	0.07	0.07	0.06
Ferric Dose	3.96 mg/L	4.03 mg/L	4.06 mg/L
Poly Dose	1.59 mg/L	1.04 mg/L	0.95 mg/L
Cl2 Dose	3.94 mg/L	3.76 mg/L	3.50 mg/L
Cl2 Residual	2.8	2.7	2.9

Summer/Fall

	11/5/2012	6/4/2012	7/1/2013
pH Raw	7.6	8.2	8.2
pH Finished	8.2	8.2	8.2
Raw Temp	19.2	21.8	25.3
Turb Raw	0.38	0.72	0.7
Turb Settled	0.2	0.43	0.3
Turb Filtered	0.07	0.07	0.08
Ferric Dose	4.09 mg/L	3.96 mg/L	3.85mg/L
Poly Dose	1.01 mg/L	1.06 mg/L	0.91 mg/L
Cl2 Dose	4.43 mg/L	4.60 mg/L	4.62 mg/L
Cl2 Residual	2.9	3	2.7

Attachment 3

WTP Guidelines for Pure Water Operation

WTP GUIDELINES FOR PURE WATER OPERATION

Coagulation

Strategy

Dose coagulant with close attention to filtered water turbidity and coagulated water pH. Run jar tests including a filterability step after major changes in the Pure Water blend ratio, and use a coagulant dose that is just enough to produce filterable water.

Monitoring and Feedback

- Jar testing including flocculation, sedimentation, and 5 µm cartridge filtration to select a coagulant dose that produces filterable water. **[NEW]**
- Repeat jar testing with each 5% change in blend ratio. **[NEW]**
- Sampling for hardness and alkalinity in coagulated water and calculation of LSI value. **[NEW]**
- Real-time monitoring of raw and coagulated water pH. **[NEW]**
- Real-time monitoring of filtered water turbidity.

Alarms

- High or unstable filtered water turbidity –non-optimized coagulation.
- Low coagulated water pH or LSI – indicates coagulant overdose.

Flocculation

Strategy

Use similar mixing settings to current operation. Gradually increase paddle speed only if filtered water turbidity is unstable and not responding to increased coagulant dose.

Monitoring and Feedback

- Logging of mixing speed and calculated *G*, *Gθ*, and energy dissipation rate values in the SCADA system. **[NEW]**
- Real-time monitoring of filtered water turbidity.
- Visual observation of flocculator – reduced size or number of flocs compared to current operation is not necessarily a problem. **[NEW]**
- Jar tests of different mixing conditions scaled by energy dissipation rate, if necessary. **[NEW]**

Alarms

- High or unstable filtered water turbidity – may indicate more energy is required.

Sedimentation

Strategy

Rely less on sedimentation for overall turbidity removal. Only clean sludge out of the sedimentation tanks as needed – the cleaning frequency will likely decrease.

Monitoring and Feedback

- Real-time monitoring of settled water turbidity.
- Monitoring of sludge levels in the sedimentation tanks.

Alarms

- High sludge level.

Filtration

Strategy

Rely mainly on the media filters to achieve low turbidity in the finished water. Backwash frequency may increase due to less removal by sedimentation tanks; or decrease due to lower raw water turbidity.

Monitoring and Feedback

- Real-time monitoring of filtered water turbidity.
- Real-time monitoring of headloss to indicate end of filter cycle.
- Logging of new baseline filter cycle lengths. **[NEW]**

Alarms

- High filtered water turbidity – indicates ineffective coagulation.
- Low coagulated water pH or LSI – indicates coagulant overdose.

Post-Conditioning

Strategy

Dose sodium hydroxide to maintain finished water stability and avoid chemical upsets to the distribution system. Target pH >8.0 and LSI>0.

Monitoring and Feedback

- Sampling for hardness and alkalinity in finished water and calculation of LSI value with each 5% change in blend. **[NEW]**
- Real-time monitoring of finished water pH.

Alarms

- Low finished water pH – indicates under-dosing of NaOH.
- Low finished water LSI – possible conditioning issue at NCAWPF.

Troubleshooting Guide

Observation	Action
High filtered water turbidity	1) Incrementally increase coagulant dose and look for signs of improvement in flocculation as indicated by filter performance. Check pH of coagulated water to ensure it hasn't significantly dropped. 2) If coagulated water pH has started to drop to an unacceptable range, gradually increase paddle speed of flocculators until better filtration performance is observed.
Low measured pH or calculated LSI of coagulated water	Decrease coagulant dose until parameters are within acceptable range.
High sludge level	Increase frequency of sedimentation tank purging.
Low finished water pH	1) Gradually increase dose of NaOH until pH is acceptable. 2) Check calibration of pH meter and functioning of NaOH feed system.
Low finished water LSI at target finished water pH	Coordination is required with NCAWPF to verify that it is adding sufficient carbonate and alkalinity.

APPENDIX G: MIRAMAR RESERVOIR MONITORING

NORTH CITY PURE WATER PROJECT, TITLE 22 ENGINEERING REPORT

APPENDIX G

TABLE 1

SAMPLING AND ANALYSIS PROGRAM

Sampling by Water Quality Laboratory		
Source	**Sampling Frequency**	**Parameter**
Influent[1]	**Daily**	**Bacteriological (total and fecal coliform)**
Influent, Effluent[2], Clearwells[3]	**5 days/week**	**Temperature Chlorine residual (free & total) pH**
Influent, Clearwells	**5 days/week**	**Color Turbidity Specific conductance**
Effluent, Clearwells	**5 days/week**	**Bacteriological (total coliform and E. coli)**
Influent, Effluent	**Weekly**	**Total Organic Carbon Total THM's**
Influent, Effluent	**Weekly**	**Bacteriological (heterotrophic plate count) Ammonia Nitrite Nitrate Chlorine residual (free & total) pH temperature**
Influent	**Bi-Monthly**	**Bromide Sulfate (Feb, Mar, May, June, Aug, Sep, Nov, Dec)**
Effluent	**Bi-Monthly**	**Bromate**
Influent	**Monthly**	**Protozoan (Giardia and Cryptosporidium)**
Effluent	**Monthly**	**Conductivity**

[1] "Influent" is raw water inflow to the treatment plant; sample site designation 1 SYS; this a blend of water withdrawn from Miramar Reservoir and water delivered directly from the Second San Diego Aqueduct.
[2] "Effluent" is outflow from the treatment plant just before the clearwells; sample site designation 3 SYS.
[3] "Clearwells" is outflow from the two clearwells, sample site designations 5 SYS and 6 SYS.

Sampling by Water Quality Laboratory		
Source	**Sampling Frequency**	**Parameter**
		Turbidity Color
Source	**Sampling Frequency**	**Parameter**
Influent, Effluent	Monthly	Calcium Magnesium Sodium Potassium Iron Manganese Copper Zinc Sulfate (Jan, Apr, Jul, Oct) Silica Aluminum pH Non-carbonate hardness Total hardness Total alkalinity Lead & Copper Phosphate (Total, Ortho, Poly) Carbonate hardness Chloride Total dissolved solids Bicarbonate Temperature Langlier Index Ryzner Index Fluoride Phenophthalein Alkalinity Haloacetic Acids
Influent, Effluent	Quarterly	Regulated Organic Compounds Unregulated Organic Compounds
Influent, Effluent	Annually	MBAS
Influent, Effluent	Every 4 years	Radiological (performed quarterly every four years)

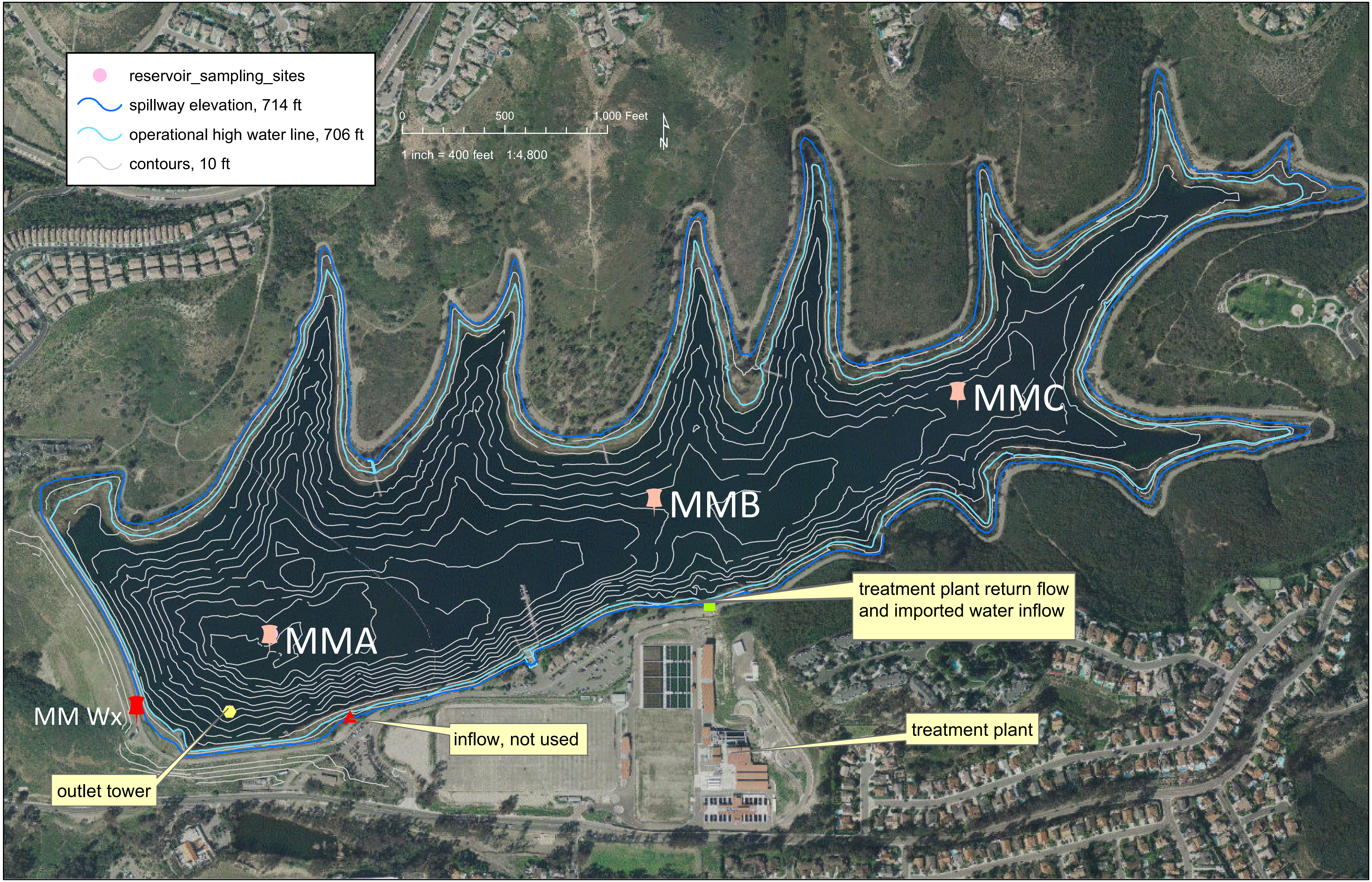
Sampling By Miramar Water Treatment Plant Operators		
Source	**Sampling Frequency**	**Parameter**
Influent	**Daily**	**Turbidity** **pH** **Taste & Odor** **Temperature** **Fluoride** **Chlorine residual free** **Chlorine residual total**
Settled Water[4]	**Daily**	**Turbidity** **pH** **Temperature**
Filtered Water[5]	**Daily**	**Chlorine residual free**
Effluent	**Daily**	**Chlorine residual free** **Chlorine residual total** **Turbidity** **Taste & Odor** **Temperature** **Fluoride** **pH**
Clearwells	**Monday, Wednesday, Friday**	**Chlorine residual free** **Chlorine residual total** **pH** **Turbidity** **Free Ammonia** **Mono CL2**
SOZ Ozone[6]	**Daily**	**Ozone residual**

[4] Sampled at the combined settled water channel
[5] Sampled at combined outflow from the filters
[6] Sampled at the ozone contactors

City of San Diego Reservoir Monitoring Plan

		Field Measurements		Laboratory Analyses [samples collected for laboratory analyses]										
		Secchi Transparency	WQ Profile[1]	Bacteriology[2]	Plankton	TON	Turbidity & Color	TOC	GMA[3]	Nutrients[4]	Organics One[5]	Organics Two[6]	Metals[7]	MIB & Geosmin
	Regulated: (Y/N)	N	N	N	N	N	N	N	Y	Y(NO2,NO3)	Y	Y	Y	N
	Regulated frequency:								Annual	Annual	Annual	Annual	Annual	
Sample Site or Source														
Miramar (outlets: 81,66,52)	MMA-0	weekly	weekly	weekly	episodic			monthly	quarterly	monthly	quarterly	quarterly	quarterly	weekly
	MMA-outlets					weekly	weekly	monthly						weekly
	MMA-BTM							monthly		monthly				
	MM-SSR-186			weekly										

[1]WQ Profile- Depth (m), Temperature (°C), Dissolved Oxygen (%, mg/L), pH, Specific Conductivity (µS/cm), Oxygen Reduction Potential (mV),Chlorophyll (µg/L), Blue Green Algae (RFU).
[2]Bacteriology- Enterococcus, E. coli, Total Coliforms.
[3]GMA- Alkalinity, Bromide, Calcium, Carbonate, Chloride, Fluoride, Hardness, Total Dissolved Solids.
[4]Nutrients- Ammonia, Nitrate-Nitrite, Nitrate, Nitrite, Phosphorous, Total Nitrogen.
[5]Organics One- EPA Methods: 525.2, 531.1 ,547, 555; Perchlorate
[6]Organics Two- EPA Method 524; Perchlorate
[7]Metals- Aluminum, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Nickel, Potassium, Selenium, Silver, Sodium, Thallium, Vanadium, Zinc


reservoir_sampling_sites
spillway elevation, 714 ft
operational high water line, 706 ft
contours, 10 ft
0
500
1,000 Feet
1 inch = 400 feet 1:4,800
N
MMA
MMB
MMC
MM Wx
outlet tower
inflow, not used
treatment plant
treatment plant return flow
and imported water inflow