Kennedy/Jenks Consultants
303 Second Street, Suite 300 South
San Francisco, California 94107
415-243-2150
FAX: 415-896-0999

DRAFT

Potable Reuse Exploratory Plan (PREP) Initial Study

27 July 2017

Prepared for

Silicon Valley Clean Water
San Francisco Public Utilities Commission

In Partnership with

Bay Area Water Supply and Conservation Agency
California Water Service Company

K/J Project No. 1668011.01

DAWN TAFFLER

Prof Engineering

STAMP

Prepared by

Dawn Taffler, PE, LEED AP
Melanie Tan, PE

Reviewed by

Craig Lichty, PE
Jean Debroux, PhD
Mark Minkowski, PE

Table of Contents

Table of Contents (cont'd)

List of Tables

List of Figures

Executive Summary

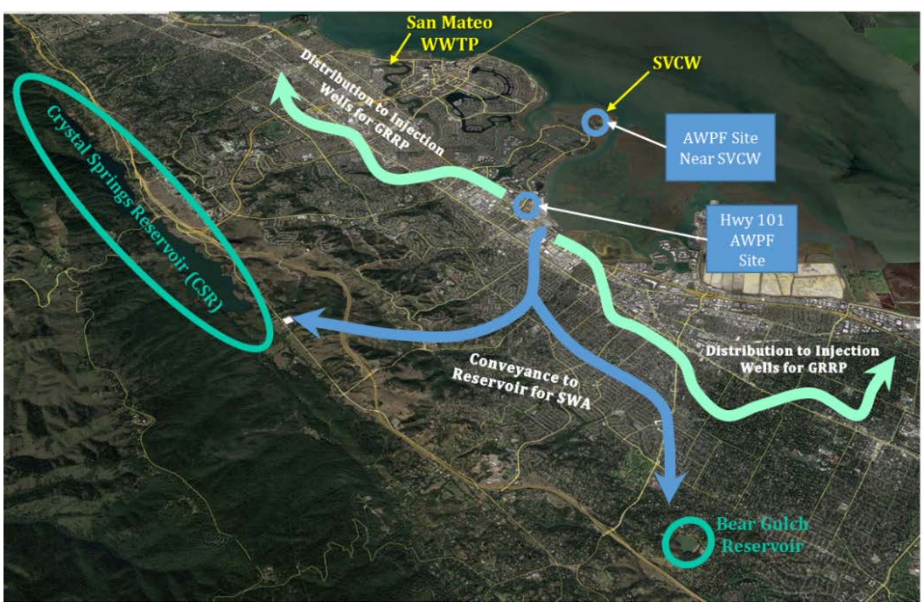
The Potable Reuse Exploratory Partnership (PREP) was formed by the Bay Area Water Supply and Conservation Agency (BAWSCA), California Water Service Company (Cal Water), City & County of San Francisco acting by and through the Public Utilities Commission (SFPUC), and Silicon Valley Clean Water (SVCW) to initiate a dialog about potable reuse opportunities in Silicon Valley. During the course of this study, the City of Redwood City and the City of San Mateo expressed interest in participating to investigate regional potable reuse opportunities. Together, the PREP parties recognize that regional collaboration offers opportunities to resolve multiple water supply and wastewater issues, while realizing the benefits of shared infrastructure, asset recovery, economies of scale and a more competitive strategy to pursue funding.

This summary report, herein referred to as the ***PREP Initial Study***, documents the first-step by the PREP Parties to consider potable reuse alternative concepts on the San Francisco Peninsula. A preliminary screening of alternatives was performed to provide the PREP Parties sufficient information to determine whether to proceed with continued exploration of, and investment in, potable reuse through this partnership.

Alternatives Development and Evaluation

The PREP Initial Study evaluates a Groundwater Reuse Replenishment (GRRP) in the San Mateo Plain Basin and Surface Water Augmentation (SWA) at Crystal Spring Reservoir (CSR) and Bear Gulch Reservoir (Figure ES-1). A direct potable reuse was not considered as part of this initial work.

Figure ES-1: Potable Reuse Concepts



Two potential sources of supply were evaluated:
(1) effluent from the SVCW facility and
(2) effluent from the San Mateo Wastewater Treatment Plant (WWTP),
for additional treatment at an advanced water purification facility (AWPF) located near the SVCW facility or near the San Carlos Airport (herein referred to as the Hwy 101 Site).

The AWPF train is assumed to consist of microfiltration/ ultrafiltration (MF/UF) as pretreatment prior to reverses osmosis (RO) system, followed an advanced oxidation process (AOP). This combination of treatment processes, also referred to as Full Advanced Treatment (FAT) in the GRR Regulations, is assumed to be sufficient for a GRRP or SWA, though it is recognized that additional treatment steps may be required based on site specific conditions. All projects assume brine discharge via connection to the existing SVCW outfall to the Bay.

The following alternatives were developed:

- **Alternative 1: GRR in the San Mateo Plain Basin** would involve full advanced treatment and conveyance of up to 6 mgd of purified water for groundwater replenishment via direct injection. Requires siting up to 18 new injection wells with 9 new extraction wells that can meet regulatory requirements for underground retention time (2 to 6 months).
- **Alternative 2: SWA in Crystal Springs Reservoir** would involve full advanced treatment and conveyance of 6 mgd or 12 mgd of purified water for augmentation at CSR. Requires meeting a theoretical retention time in the reservoir of 60 to 180 days, sufficient dilution and addressing other site-specific reservoir requirements, such as nutrient loading.
- **Alternative 3: SWA in Bear Gulch Reservoir** would involve full advanced treatment and conveyance of 6 mgd of purified water for augmentation at Bear Gulch Reservoir. Removed from further consideration because initial evaluations found that that reservoir is too small and does not have the configuration to meet regulatory requirements for a SWA project.

Sub-alternatives were developed to assess various combinations of treatment capacity, treatment location, and potential cost savings from repurposing existing infrastructure and reusing abandoned assets.

Table ES-1 summarizes the conceptual-level costs for the alternatives that were evaluated. Construction costs include loaded facility costs for treatment, pipelines, pump stations, storage tanks, groundwater wells and other facilities necessary to develop each project. Annual operations and maintenance (O&M) costs include energy, labor, chemicals, maintenance and repair. Unit life cycle costs represent annualized construction costs plus O&M costs divided by the recycled water delivered over the life of the project to obtain a uniformly derived unit cost of water.

Table ES-1: Summary of Alternative Opinion of Probable Costs

Alternative	Alt 1 - GRRP San Mateo Plain	Alt 2a - SWA Crystal Springs Res	Alt 2b - SWA Crystal Springs Res
Purified Water Delivered (AFY)	6,720	6,720	13,440
Purified Water Delivered (mgd)	6	6	12
Total Construction Cost ($)	$370 to $371	$265 to $322	$376 to $456
Annual O&M Cost ($mil/year)	$15 to $16	$11 to $12	$17 to $19
Unit Life Cycle Cost ($/AF)	**$4,900**	**$3,200 to $3,700**	**$2,500 to $2,800**
Unit Life Cycle Cost ($/gal)	**$0.015**	**$0.01 to $0.011**	**$0.008 to $0.009**
Unit Life Cycle Cost ($/CCF)	**$11.2**	**$7.5 to $8.2**	**$5.6 to $6.4**

Units: AFY = acre-feet per year, mgd = million gallons per day, $/AF = dollars per acre-foot, $/gal = dollars per gallon, $/CCF = dollars per hundred cubic feet (of puriried water delivered).

The GRR Alternative has a higher level of uncertainty in the cost estimate, because aquifer capacity and well siting challenges would likely restrict the amount of purified water that could be recharged and recovered; potentially increasing unit life cycle costs. In addition, siting new injection/extraction wells could require securing between 5 and 10 acres of available land in Silicon Valley in specific, geologically preferable locations and with suitable separation to existing wells to meet travel time requirements, which would be both challenging and costly.

The SWA at Crystal Springs Alternatives assume the same treatment as a GRRP, but do not bear the added costs to build and operate wells. Costs for nutrient removal were not included due to uncertainty related to water quality requirements and treatment preferences; however nutrient reduction would likely be required. When comparing a 12 mgd to a 6 mgd SWA project, the capital and O&M costs are higher for the larger facility, but the unit life cycle costs decrease by 25%, illustrating the economics of scale of a larger project.

Alternative projects that repurpose infrastructure and reuse abandoned pipelines realize a 10% overall project savings from those that assumed construction of all new pipelines; demonstrating opportunities to reduce costs and impacts associated with constructing new facilities when regional partners work together.

Summary

Overall, a regional GRRP or SWA Project could provide an integrated approach to:

1. Enhance water supply reliability for water purveyors on the San Francisco Peninsula.
2. Reduce discharge to the San Francisco Bay - helping wastewater discharges proactively address pending, and uncertain, stringent discharge requirements.
3. Create a multi-agency project with multiple economic, environmental and social benefits that would be more likely to garner attention for potential grant and low interest loans and funding.

Based on the initial findings from the PREP Initial Study, it appears possible that an IPR project could offer benefits for the Bay Area water and wastewater utilities; the environment, local communities and the Silicon Valley economy.

If the PREP Parties agree to proceed, additional studies are warranted to evaluate groundwater capacity, confirm the ability to meet anticipated SWA regulations, evaluate pipeline alignments and facility siting, and initiate outreach to the community to gain social acceptance for reuse.

Section 1 Introduction

The Potable Reuse Exploratory Partnership (PREP) was formed to initiate a dialog about potable reuse opportunities in Silicon Valley. This summary report documents the first-step by the PREP Parties to perform an initial screening of potable reuse alternatives on the San Francisco Peninsula. The information herein was developed to provide sufficient information for the Parties to determine whether to proceed with continued exploration of, and investment in, potable reuse through this partnership.

1.1 Background

The Partnership includes the Bay Area Water Supply and Conservation Agency (BAWSCA), California Water Service Company (Cal Water), City & County of San Francisco acting by and through the Public Utilities Commission (SFPUC), and Silicon Valley Clean Water (SVCW). During the course of the Study, the City of Redwood City and the City of San Mateo expressed interest in participating in the exploration of regional potable reuse opportunities; providing supporting information to support the Study in April 2017 and an initial commitment to join the Partnership in June 2017. The Partnership will be referred collectively herein as the "Parties" and singularly as a "Party". The Parties have agreed to conduct regional activities, including the preparation of a Potable Reuse Exploratory Plan (PREP), in an inclusive manner that improves water supply reliability in the region. A map showing the overall study area and the service areas of the study partners is shown in Figure 1-1.

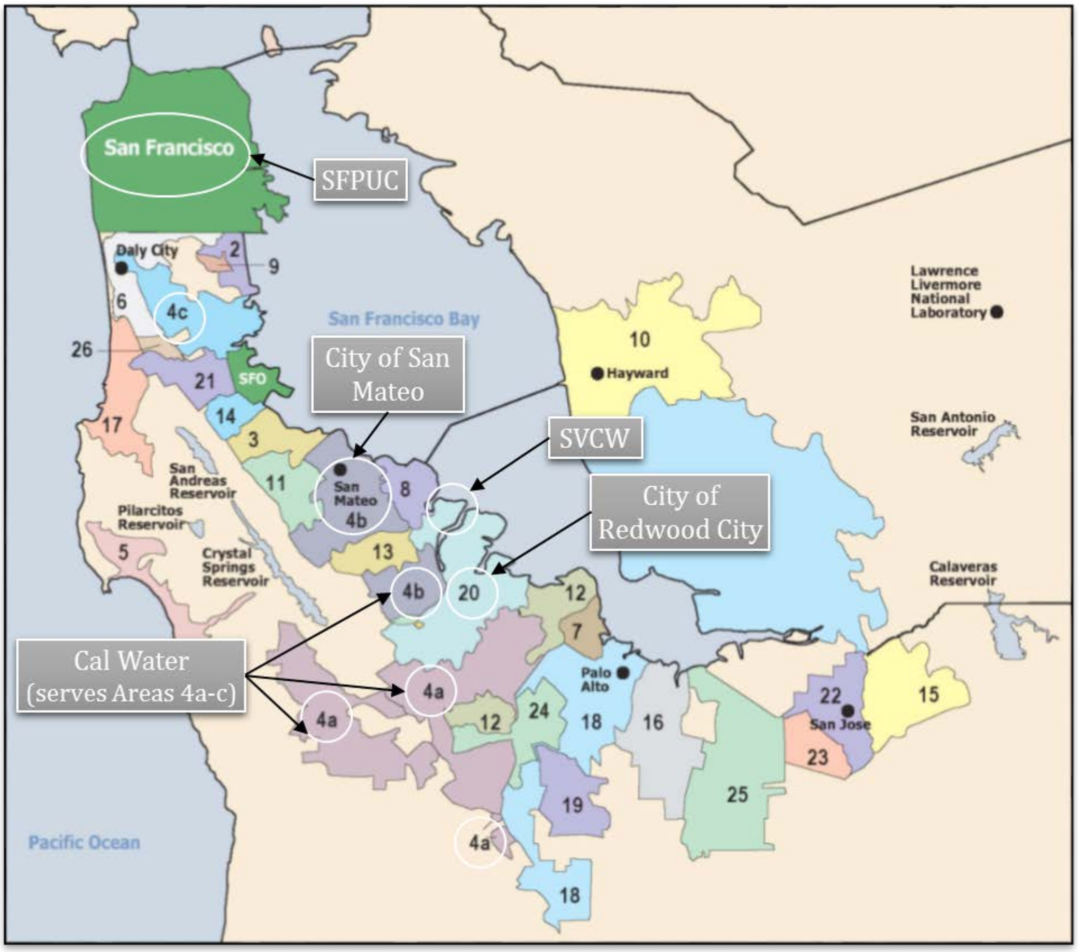
> **Looking to the Future**
> The PREP Initial Study is the first step to exploring the viability of a potable reuse project that could provide benefits for the Bay Area water and wastewater utilities; the environment, local communities and the Silicon Valley economy.

Developing a new drought-resistant, local water supply would help address water supply shortfalls during droughts, while maintaining the quality of life within the local community and Silicon Valley's vital regional economy.

Future regulations, from the San Francisco Regional Water Quality Control Board (Regional Board), to reduce the concentration of nutrients in effluent are anticipated to impact all wastewater discharges to the San Francisco Bay. Recycled water offers a pathway to reduce the quantity of effluent discharged and potentially reduce future capital cost expenditures for nutrient compliance treatment facilities.

The PREP Initial Study provides a preliminary alternative evaluation to assess regional opportunities for Bay Area water and wastewater utilities to work together to create a potable reuse project that has the potential to benefit the environment, local communities and the Silicon Valley economy.

Figure 1-1: Study Area and PREP Parties



Map source: BAWSCA Member Agencies

1.2 Study Objective and Goal

The **objective** of the PREP Initial Study is to perform an initial screening of potable reuse opportunities and summarize the findings in a summary report for the PREP Parties.

The **goal** of this effort is to provide sufficient information for the Parties to determine whether to proceed with continued exploration of, and investment in, potable reuse through this partnership. This summary report could be loosely referred to as a "decision tool" that the Parties can bring to their respective boards to justify and guide the next steps for evaluating potable reuse.

The PREP Initial Study focuses two types of Indirect Potable Reuse (IPR) projects; (1) Groundwater Reuse Replenishment Project (GRRP) and (2) Surface Water Augmentation (SWA), that the Parties may consider in developing an expanded recycled water program.

As regulations for Direct Potable Reuse (DPR) are anticipated in subsequent years, DPR is not evaluated as part of this effort.

Section 2 Wastewater Supply

Two potential sources of supply are evaluated as part of the PREP Initial Study: (1) effluent from the Silicon Valley Clean Water facility and (2) effluent from the San Mateo Wastewater Treatment Plant (WWTP). A brief description of these facilities, available flows for reuse, and water quality considerations are included in this section.

2.1 Potential Sources of Supply

The SVCW facility and the San Mateo WWTP are located approximately four miles apart, in the cities of Redwood City and San Mateo, respectively, as depicted in Figure 2-1.

Figure 2-1: Potential Source Water Supply

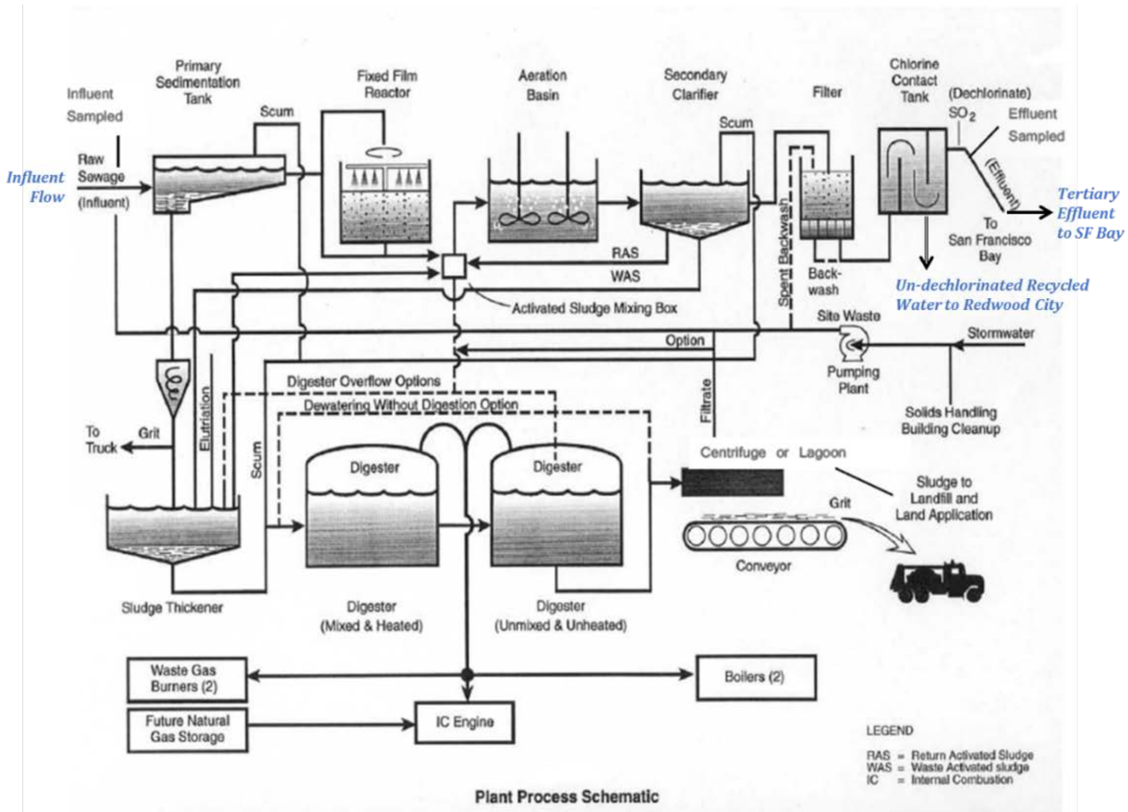
2.1.1 Silicon Valley Clean Water (SVCW)

SVCW's Wastewater Conveyance System takes wastewater from each of the JPA member agencies (Belmont, San Carlos, Redwood City, and West Bay Sanitary District) collection systems and pumps the wastewater to its wastewater treatment plant located adjacent to San Francisco Bay at the northeast end of Redwood Shores. The individual members of the JPA own and operate the sanitary sewer collection systems within their respective jurisdictions, and West Bay Sanitary District (WBSD) also owns the existing Flow Equalization Facility (FEF), which can be used to store their wastewater during wet weather conditions. SVCW owns and operates the wastewater treatment plant (WWTP) as well as the conveyance system force main and pump stations that convey the raw wastewater to the treatment plant.

SVCW is a water resource recovery facility meeting the highest technical, environmental, and safety standards in California. Built in 1980, the SVCW facility enables wastewater to be recycled using state-of-the-art biological treatment. Clean water is available for reuse, and the fragile ecosystem of the San Francisco Bay is protected for current and future generations to enjoy[1]. The SVCW WWTP uses an advanced, two stage biological treatment facility where sewage passes through physical and biological processes, which result in high quality effluent being discharged to the deep-water channel of the San Francisco Bay. A SVCW process schematic is shown in Figure 2-2.

SVCW is successfully producing recycled water for Redwood City's Phase 1 project that meets Title 22 of the California Code of Regulations (CCR) for unrestricted non-potable uses. The facilities constructed on SVCW's site include tertiary treatment and disinfection, pumping and storage improvements. Some future filtration and storage improvements are planned for the expansion of Redwood City's system.

Figure 2-2: Silicon Valley Clean Water Process Schematic



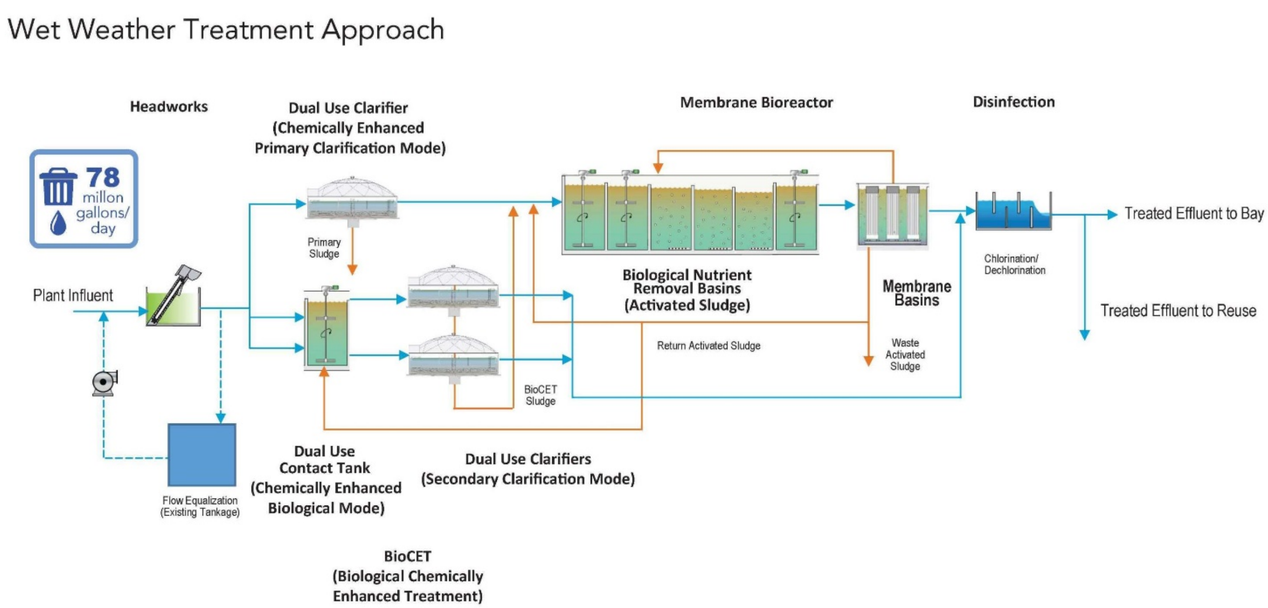
[1] http://www.svcw.org/facilities/sitePages/wastewater%20treatment.aspx

2.1.2 San Mateo

The San Mateo WWTP serves more than 130,000 people and businesses in the City of San Mateo's service area. The current treatment plant uses bacteria to remove organic material and toxins from the wastewater it treats. Sewage arrives at the plant through a series of pipelines and pump stations, which then pass through a series of physical and biological processes. The resulting high-quality effluent is discharged to the deep-water channel of the Bay.

As part of the City of San Mateo's Clean Water Program, the City has embarked on a project to upgrade the existing secondary treatment facilities to replace aging infrastructure, meet current and future regulatory requirements and ensure wet-weather capacity[2]. This program aligns with the city's sustainability goals to explore water reuse, resource recovery and incorporation of sustainable materials. The WWTP improvements will include new Biological Nutrient Removal B (BNR) Basins and a new Membrane Bioreactor (MBR) system in addition to other supporting treatment processes. By effectively treating wastewater at an advanced biological treatment facility, the future plant will help keep San Francisco Bay environmentally clean and safe. A schematic of the proposed treatment approach is shown in Figure 2-3.

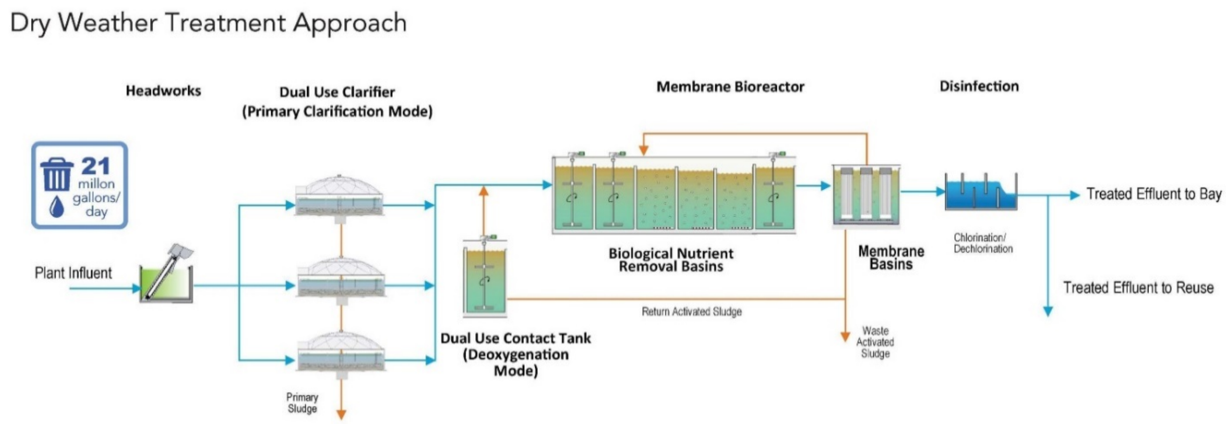
Figure 2-3: San Mateo WWTP Proposed Process Schematic



Source: CH2M, 2017

[2] http://www.cleanwaterprogramsanmateo.org/

Figure 2-3: San Mateo WWTP Proposed Process Schematic (con't)



Source: CH2M, 2017

2.2 Available Flows

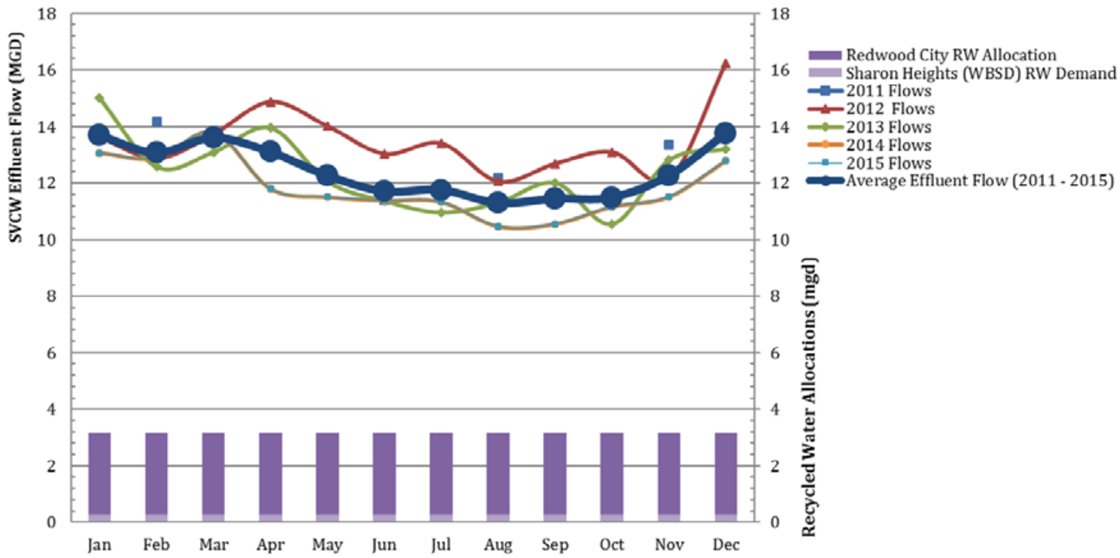
The assumed available flow for a potable reuse project is estimated based on the effluent at each plant during dry weather periods, less existing recycled water commitments.

2.2.1 SVCW Available Flow

SVCW has a permitted Average Dry Weather Flow (ADWF) capacity of 29 mgd and a Peak Wet Weather Flow capacity of 71 mgd. From 2011 to 2015, the average monthly influent flow was approximately 13.1 mgd, with the average monthly influent flow dropping to 11.8 mgd in July (dry weather flow). Daily effluent flows during the month based on grab samples reported as part of SVCW's Annual Self-Monitoring Reports were also analyzed. The average daily effluent flow was approximately 12.5 mgd, with the average daily effluent flow dropping to 11.3 mgd in August (dry weather flow). The average monthly influent flow and the average daily effluent flow for each month of during 2011 to 2015 are shown in Figure 2-4.

Since 2015 is the driest year during the 5-year period, effluent flow during the dry weather months of July to October 2015, or about 11.4 mgd, was used to estimate the amount of effluent potentially available for reuse. Of this amount, about 2.89 mgd has been allocated for non-potable uses by Redwood City. Another 0.28 mgd may be conveyed to West Bay Sanitary District for reuse. This leaves approximately 8.1 mgd of effluent available for reuse as shown in Figure 2-4.

Figure 2-4: SVCW Monthly Effluent Flows (2011 – 2015)



Note: hourly dry weather flows were not evaluated as part of this effort and should be further assessed in conjunction with equalization storage to estimate the minimum potential daily supply of available effluent.

Assuming a 25% rejection rate from an Advanced Water Purification Facility (AWPF) that employs micro-filtration (MF) and reverse osmosis (RO), the amount of purified water available for potable reuse would be about 6.2 mgd. Additional discussion of treatment requirements and AWPF processes are provided in Sections 3 and 4, respectively. To be conservative, it is assumed that 6 mgd of purified water would be available for a potable reuse project derived from SVCW effluent.

2.2.2 San Mateo Available Flow

The San Mateo WWTP has a permitted Average Dry Weather Flow (ADWF) capacity of 21 mgd and a Peak Wet Weather Flow capacity of 78 mgd (Figure 2-3). Currently, the facility treats an average annual flow of 12 mgd with an average dry weather flow of approximately 9 mgd. The City does not currently have a recycled water program; however, they are in the process of completing a Recycled Water Master Plan to assess future non-potable reuse opportunities within the City's service area. Since San Mateo has a similar dry weather flow as SVCW, it is assumed that the new MBR facility could provide 8 mgd tertiary effluent, with the potential to contribute an additional 6 mgd of purified water for a regional potable reuse project.

2.3 Wastewater Quality

2.3.1 SVCW Wastewater Water Quality

The SVCW effluent consistently meets the requirements set forth in their discharge permit (Order No. R2-2012-0062; National Pollutant Discharge Elimination System (NPDES) permit No. CA 0038369) from the San Francisco Bay Regional Water Quality Control Board[3]. SVCW could provide

[3] http://www.waterboards.ca.gov/rwqcb2/board_decisions/adopted_orders/2012/R2-2012-0062.pdf

tertiary effluent or Title 22 effluent depending on the desired water quality to facilitate efficient operation of an AWPF. Table 2-1 lists average water quality for some constituents of interest used to evaluate potable reuse alternatives. Future monitoring and data collection would be required to confirm treatment process requirements and anticipated purified water quality.

2.3.2 San Mateo Wastewater Water Quality

The City of San Mateo's WWTP effluent consistently meets the requirements set forth in their discharge permit (Order No. R2-2012-0006; NPDES No. CA 0037541) from the San Francisco Bay Regional Water Quality Control Board[4]. The City's design team is still in the concept design validation and confirmation phase for the updated BNR and MBR facilities, thus there are no reported water quality data for the future facility. Table 2-1 lists anticipated water quality for some constituents of interest used to evaluate potable reuse alternatives.

2.4 Summary of Source Water Options

The PREP Study began with an intent to explore the use of effluent from the SVCW facility for potable reuse. As regional coordination grew, it became apparent that there are possible economic and operational benefits that could be realized through a combined project that blends effluent from the SVCW facility and the City of San Mateo's planned BNR/MBR tertiary treatment facility. Table 2-1 summarizes the available flows and water quality assumed for SVCW source water and a combined source water with San Mateo.

Table 2-1: Summary of Source Water Options

	Units	SVCW Tertiary Effluent[1]	San Mateo Anticipated Tertiary Effluent[2]	SVCW + San Mateo Combined Tertiary Effluent
Available Tertiary Flow	mgd	8	8	16
Estimated Purified Flow	mgd	6	6	12
TDS	mg/L	1,000	900	950
TSS	mg/L	3.6	5	4.3
Turbidity	NTU	3	0.25	1.5
CBOD/BOD	mg/L	3.2 (CBOD)	5 (BOD)	n/a
Ammonia (as N)	mg/L	42	1	23
Total Nitrogen	mg/L	48	6	27
Total Phosphorus	mg/L	4.1	1	2.6

[1] SVCW Commonly analyzed parameters from 2012-2015 provided to the Regional Board by City to fulfill NPDES general reporting requirements.
[2] Anticipated water quality data provided by CH2M (Ted Couch, 2017)

---

[4] http://www.waterboards.ca.gov/sanfranciscobay/board_decisions/adopted_orders/2013/R2-2013-0006.pdf

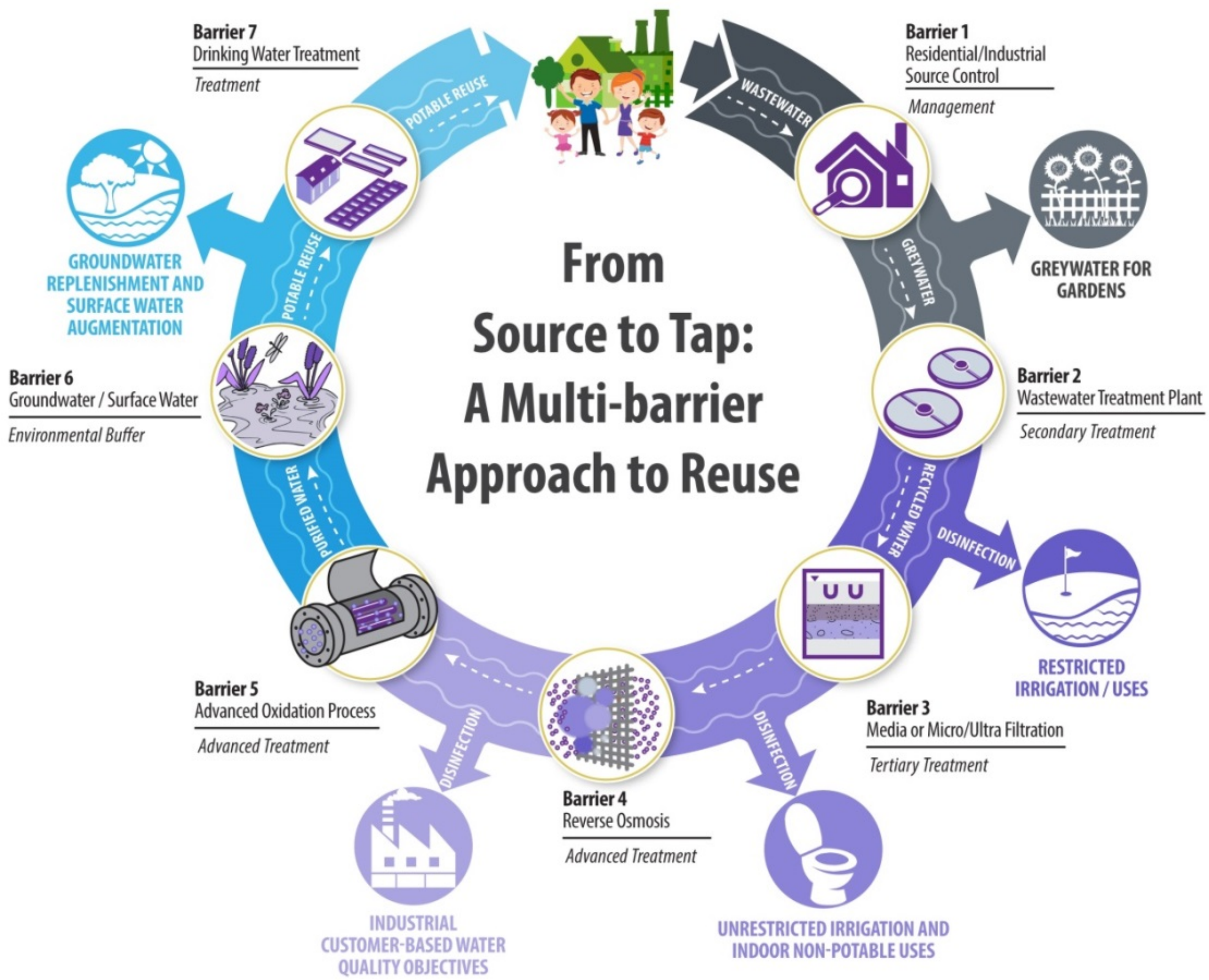
Section 3 Regulatory Overview

This section discusses regulations and treatment requirements for recycled water use to protect public health, including the most recent regulatory landscape for potable reuse.

3.1 Multi-Barrier Approach to Reuse

Recycled water begins as wastewater and undergoes a series of treatment steps, using a multi-barrier approach, to remove organic matter and pollutants. The production and use of recycled water must adhere to strict regulations stipulating the levels of treatment, allowable types of reuse and water quality requirements. Figure 3-1 illustrates the multi-barrier approach to reuse, highlighting the increasing level of treatment necessary to produce the right quality of water for the right use.

Figure 3-1: Multi-Barrier Approach to Reuse



Non-potable reuse refers to the use of tertiary treated municipal wastewater for a specific purpose other than drinking; such as landscape irrigation, industrial uses, and agriculture, or for environmental benefits. Non-potable reuse usually requires an independent "purple pipe" distribution system for conveying recycled water to customers separate from the potable supply. In California, non-potable reuse is ongoing throughout the state for the last century and regulations for non-potable reuse have been in place since the 1970s. As previously noted, SVCW has been producing recycled water for Redwood City's recycled water program since 2000.

Potable reuse refers to the intended use of highly treated or purified municipal wastewater to augment a water supply that is used for drinking and all other purposes. Unplanned potable reuse, where one community draws raw water supplies downstream from discharges from wastewater treatment plants, is regulated by federal discharge requirements. Planned potable reuse involves a more formal public process and regulatory consultation program to implement and the regulations in California for the indirect and direct use of recycled water are at varying stages of development.

Indirect potable reuse (IPR) is the purposeful introduction of tertiary treated recycled water or highly purified recycled water into an untreated drinking water supply source, such as groundwater in an aquifer or surface water in a large reservoir. For groundwater replenishment, the recycled water may require blending with a diluent water, at a specified blending ratio, and meet a minimum travel time between the point of addition and extraction. For surface water augmentation, purified water must meet defined retention time and dilution ratios in the reservoir prior to retreatment at a drinking water treatment plant. Regulations for groundwater replenishment using recycled water became effective on June 18, 2014 and draft recycling criteria for surface water reservoir augmentation were released on July 21, 2017 and are anticipated to be approved by the end of 2017.

Direct potable reuse (DPR) is the purposeful introduction of highly purified recycled water into a raw water supply; upstream of a drinking water treatment plant or directly into the potable water supply distribution system downstream of a water treatment plant. Currently, DPR is not yet included as an allowable use in California, though a draft report on the feasibility of developing uniform water recycling criteria for direct potable reuse was released on September 7, 2016 and is anticipated to be finalized by December 31, 2016.

The PREP Initial Study explores opportunities for IPR via groundwater replenishment and surface water augmentation. The following sections focus on regulatory and treatment requirements for these types of potable reuse projects.

3.2 Overview of Treatment Processes for Potable Reuse

Table 3-1 summarizes treatment processes considered for potable reuse. The AWPF process assumed for implementation of each potable reuse alternative is described as part of the alternatives development in Section 4.

Table 3-1: Summary of Treatment Technologies

Treatment Process	Description
Tertiary Filtration	A wastewater post-treatment process that provides filtration to remove remaining suspended solids and other pollutants using sand or media filtration.
Microfiltration / Ultrafiltration (MF/UF)	A membrane-based, pressure-driven separation process that provides a barrier to the passage of solids and microorganisms. MF/UF does not remove salts (i.e., Total Dissolved Solids (TDS)) or other dissolved constituents like ammonia. For potable reuse applications, the primary goal of MF/UF is to provide pre-treatment for the reverse osmosis (RO) membranes, and to remove suspended particulate matter.
Membrane Bioreactors (MBR)	A MBR combines a bioreactor and microfiltration into one-unit process. The microfiltration membrane (cassette) is submerged in the bioreactor and water flows through the membrane either by vacuum or by gravity.
Reverse Osmosis (RO)	A membrane-based, high pressure-driven separation process that provides a barrier to the passage of particles, colloids, organics, bacteria and pathogens, and the vast majority of dissolved salts. RO produces a very low-TDS product stream and a high-TDS concentrate stream. Initially, RO was considered to be completely effective at removing all pathogens and chemicals; however, with improving analytical methods, a few trace organic compounds have been detected in RO permeate. This gave rise to the required advanced oxidation process following RO (discussed below).
Ultraviolet (UV) Disinfection	Treatment by applying a broad spectrum of radiation with intense peaks at certain wavelengths. UV light penetrates an organism's cell walls and disrupts the cell's genetic material, making reproduction impossible. With the proper dosage, UV irradiation has proven to be an effective disinfectant for bacteria, protozoa, and virus in water, while not contributing to the formation of disinfection byproducts (DBPs).
UV-based Advanced Oxidation Process (AOP)	Treatment by applying light in the presence of an auxiliary oxidant that has been added to the wastewater, such as hydrogen peroxide, ozone or chlorine. Photo-excited oxidants quickly degrade to form highly reactive free radicals, which are strong oxidants capable of degrading most natural and synthetic organic compounds present in wastewater. The design of a UV-AOP typically requires UV doses in great excess of those needed for disinfection alone.
Ozone	To generate ozone (O_3), energy is added to oxygen (O_2), splitting the molecules into individual atoms which then collide with oxygen forming ozone. Ozone is then bubbled into water where it oxidizes compounds directly or forms hydrogen peroxyl (HO_2) and hydroxyl (OH) radicals, which oxidize certain contaminants.

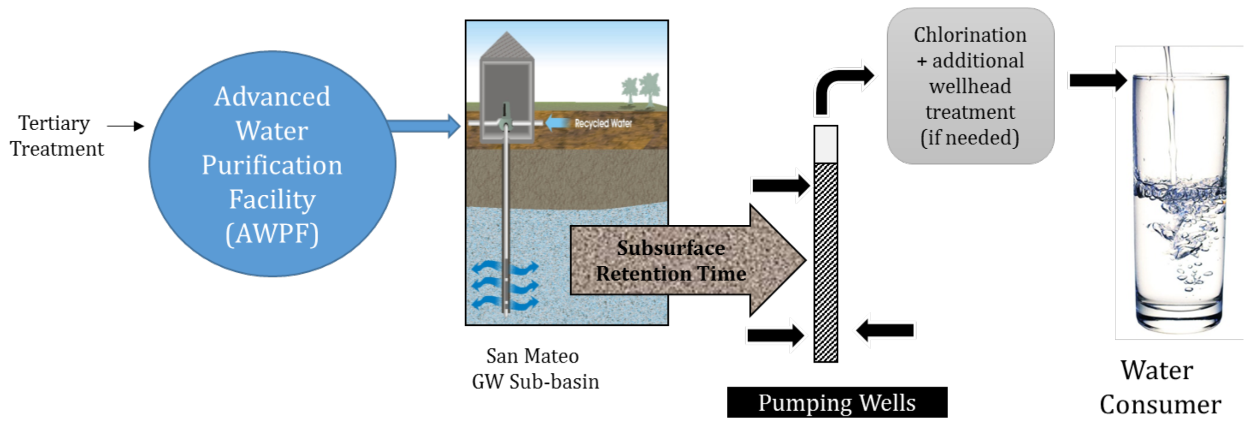
Treatment Process	Description
Biological activated carbon (BAC)	A biologically enhanced carbon process that combines ozonation and granular activated carbon (GAC) to remove dissolved organics through adsorption by the activated carbon and biodegradation by bacteria attached on the activated carbon. Biologically activated carbon (BAC) has not been used in a full-scale potable reuse project in California to date, but is currently being pursued for the City of San Diego's SWA project.
Chlorine-based Disinfection	The most common disinfection technology in wastewater treatment and reuse. Chlorine inactivates a diverse group of pathogens, including viruses, and residual chlorine prevents pathogen re-growth during storage and distribution. Free chlorine disinfection can be implemented to achieve virus and *Giardia* credits at multiple places in a potable reuse treatment train. Currently, California water recycling regulations do not differentiate between free and combined chlorine disinfection.

3.3 Groundwater Replenishment Reuse (GRRP)

A **Groundwater Replenish Reuse Project (GRRP)** entails adding recycled water to a groundwater aquifer, where it mixes and assimilates with native groundwater, thus providing an environmental buffer (and sometimes additional treatment) prior to extraction and use as a source of domestic water supply.

The GRRP concept being evaluated involves directly injecting advanced treated recycled water (or purified water) into the groundwater basin via injection wells. Once in the subsurface, the purified water would comingle with local groundwater and be stored in the local aquifer. Groundwater would then be extracted via existing or new production wells to meet drinking water needs. Figure 3-2 depicts the GRRP concept. The PREP Initial Study assumes direct injection of purified water in the San Mateo Sub-basin, which is further discussed in Section 4.3.

Figure 3-2: GRRP Concept



3.3.1 GRRP Regulations

The first draft GRR regulations were published in 1976, and soon after the Water Factory 21 at Orange County Water District (OCWD) became the first subsurface injection GRR project. Nearly 40 years later, California Senate Bill 918 (SB 918) mandated that the GRR regulations be finalized by December 2013 and the final GRR regulations were published in June 2014. GRR is the only form of potable reuse currently in practice in California, with seven projects providing approximately 200 mgd of potable reuse water and more than a dozen projects in the planning to design-level phase.

Groundwater replenishment requirements are described in terms of (1) surface spreading and (2) direct injection. Both GRR options are governed by the GRR Regulations. Due to space limitations and hydrogeologic conditions in the San Francisco Peninsula, the focus of this section is on regulations related to subsurface or direct injection projects.

For direct injection, the GRR Regulations mandate full advanced treatment and a minimum retention time in the groundwater basin of 2 months between the point of injection and extraction; though no existing regulated GRRP facilities currently operate with a retention time under 6 months. The direct injection of recycled water does not require a source of diluent water, thus the demand of a GRRP is limited by the amount of recycled water available and/or the capacity of the groundwater aquifer to receive recycled water while meeting the minimum travel time requirements. A summary of GRR Regulations for direct injection is provided in Table 3-2.

Table 3-2: Summary of GRR Regulations for Direct Injection

Water Quality Limits for Recycled Water	**Treatment and Diluent Requirements**
≥ 12-log virus reduction ≥ 10-log *Giardia* cyst reduction ≥ 10-log *Cryptosporidium* oocyst reduction Drinking water MCLs (except for nitrogen) ≤ 10 mg/L total nitrogen Action levels for lead and copper	Direct Injection with full advanced treatment Oxidation, RO, AOP No Diluent water required
Other Selected Requirements	
Treatment train shall consist of at least 3 separate treatment processes to achieve the pathogenic (microorganism) control For each pathogen (i.e., *V/G/C*), a separate treatment process may be credited with no more than 6-log reduction, with at least 3 processes each being credited with no less than 1.0-log reduction ≥ 2-month retention (response) time underground Performance Requirements for RO (minimum salt rejection, permeate TOC within specific limits)	

Notes: MCL = maximum contaminant level, TOC = Total Organic Carbon
The treatment technologies listed do not include the full range of advanced treatment processes available to achieve FAT (i.e. Microfiltration (MF), ozone, decarbonation, etc.). Also, an alternative treatment approach to meeting the GRR Regulations may be approved if the project can demonstrate to the DDW that the proposed alternative can reliably meet all water quality objectives and assures at least the same level of protection of public health.

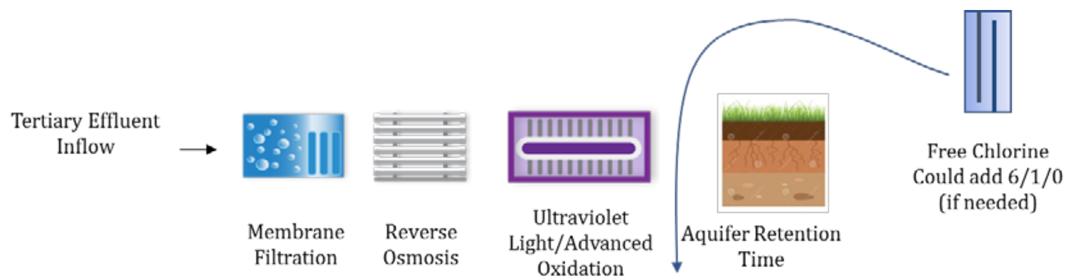
3.3.2 GRRP Treatment Requirements

In subsurface/direct injection, recycled water that has gone through a full advanced treatment process, at an AWPF, is directly injected into the saturated groundwater zone, bypassing Soil Aquifer Treatment (SAT). The SWRCB allocates treatment credits—calculated as log reduction values or LRVs—on a case-by-case basis for each project. Factors that may influence the LRV credited for a given unit process include the type of monitoring provided and the performance of the unit process.

The implementation of full advanced treatment (i.e. MF, RO and an AOP) allows for the use of up to 100% recycled water (e.g. no dilution requirement) and as little as a 2-month minimum retention time, if the 12/10/10 microbial log-removal for virus, Giardia, or Cryptosporidium (V/G/C) requirements is met. The GRR Regulations have specific requirements for the RO and AOP technologies employed in an AWPF. Each RO membrane element must achieve a minimum and average sodium chloride rejection of 99.0% and 99.2%, respectively. The initial RO permeate TOC must be less than 0.25 mg/L and must not exceed 0.5 mg/L over the long term; based on a 20-week running average of all TOC results and the average of the last four TOC results.

Anticipated pathogen removal credits for a MF, RO, UV/AOP treatment train for a GRRP are illustrated are shown in Figure 3-3.

Figure 3-3: Anticipated Log-Reduction for each GRRP Treatment Step



Pathogen	MF	RO	UV/AOP	RT	Total	Log Removal Requirement
Virus	0	1.5 – 2	6	4 - 6	11.5 – 13.5	12
Giardia	4	1.5 – 2	6	0	11.5 – 12	10
Cryptosporidium	4	1.5 – 2	6	0	11.5 – 12	10

Other requirements may include nutrient reduction based on groundwater quality objectives and compliance with regulated compounds such as:

- NDMA ~ 10 ng/L California notification limit
- Other Chemicals of Emerging Concern (CECs) with regulatory notification limits
- Title 22 drinking water primary and secondary MCL's
- Disinfection Byproducts – i.e. HAAs, THMs, chlorite

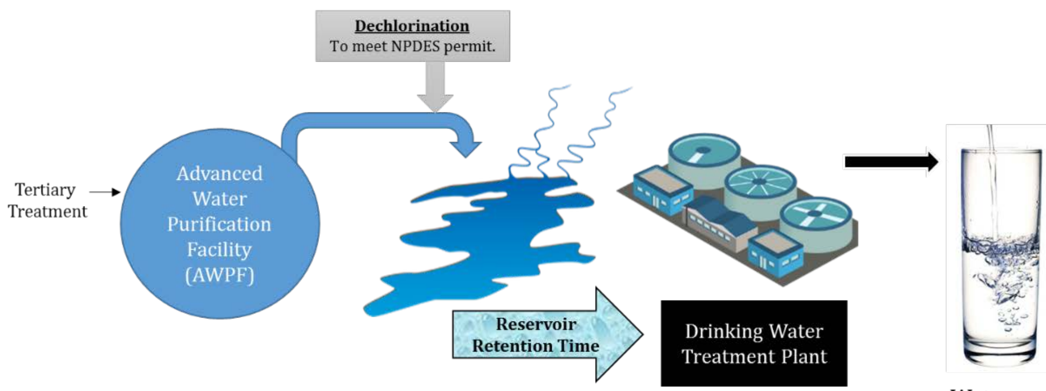
3.4 Surface Water Augmentation (SWA) Requirements

A recycled water reservoir augmentation project, also referred to as **Surface Water Augmentation (SWA)** project, involves the use advance treated recycled water for augmenting a reservoir that is designated as a source of municipal water supply.

The viability of a SWA project would depend on the dilution ratio and the retention time achievable in the reservoir. No SWA projects currently exist in California, although two are moving forward in southern California: (1) Pure Water San Diego[5] and (2) East County Advanced Water Purification Program[6].

The SWA concept is depicted in Figure 3-4. The PREP Initial Study explores augmentation with purified water in two reservoirs located in the San Francisco Bay Area: (1) Crystal Springs Reservoir, and (2) Bear Gulch Reservoir. The evaluation of these reservoirs is further discussed in Section 4.3.

Figure 3-4: SWA Concept



3.4.1 SWA Regulations

The previously mentioned California Senate Bill 918 (SB 918) set out a reuse goals to develop uniform criteria for SWA by December 2016. The draft SWA regulations were released on July 21, 2017 (SBDDW-16-02)[7]. The period for public comment on these draft SWA regulations is open until September 2017 and further modifications may be made prior to adoption. It is anticipated that the SWA regulations will be adopted by the end of 2017.

[5] https://www.sandiego.gov/water/purewater/
[6] http://eastcountyawp.com/
[7] http://waterboards.ca.gov/drinking_water/certlic/drinkingwater/Surface_Water_Augmentation_Regulations.shtml

A SWA project is defined as a project that plans to use recycled municipal wastewater for augmenting a reservoir that is designated as a source of domestic water supply. Based on the most recent publicly available draft SWA regulations, the requirements include achieving:

1) An initial minimum theoretical retention time no less than 180 days (calculated as total monthly volume divided by total monthly outflow); however, an alternative minimum theoretical retention time less than 180 days but no less than 60 days may be considered for approval.

2) A dilution requirement in the reservoir of 100:1 (one percent by volume), or 10:1 (ten percent by volume) with an additional 1-log microbial pathogen treatment, to demonstrate the percent of recycled water withdrawn from the reservoir, by volume, during any 24-hour period.

The draft SWA includes an "alternatives clause", similar to the GRR Regulations. The intent of an "alternatives clause" is to provide adaptability to offer alternative permitting pathways for innovative projects that build off the expanding knowledge base (Trussell 2016). Alternative approaches could apply to the treatment train, monitoring plan or approaches used to demonstrate meeting minimum retention time (as noted in item 1 above). The Draft SWA regulations include language that allows for alternative approaches if it can be demonstrated to the State Board that the proposed alternative provides equivalent of better performance. Written approval from the State Board would be requested prior to implementation and in some cases a public hearing may be required.

In addition, the draft SWA regulations establish requirements for:

- recycled water source control,
- treatment and pathogen removal,
- demonstration testing,
- operations and maintenance,
- effluent and process monitoring and reporting,
- reliability and redundancy,
- identification and responses to failure events,
- reservoir dilution, retention, tracer studies and monitoring, and
- public comment and notification.

A SWA project would likely be implemented within two key permits:

- a DDW drinking water supply permit, and
- a National Pollutant Discharge Elimination System (NPDES) permit issued by the San Francisco Bay Regional Water Quality Control Board on behalf of the U.S. Environmental Protection Agency (EPA).

Current DDW drinking water supply permits implement applicable state and federal drinking water requirements and establishes the conditions under which a water supplier acquires, stores, treats, monitors, and distributes public water supply. Modification of the drinking water supply permit would be required as part of implementing a SWA project.

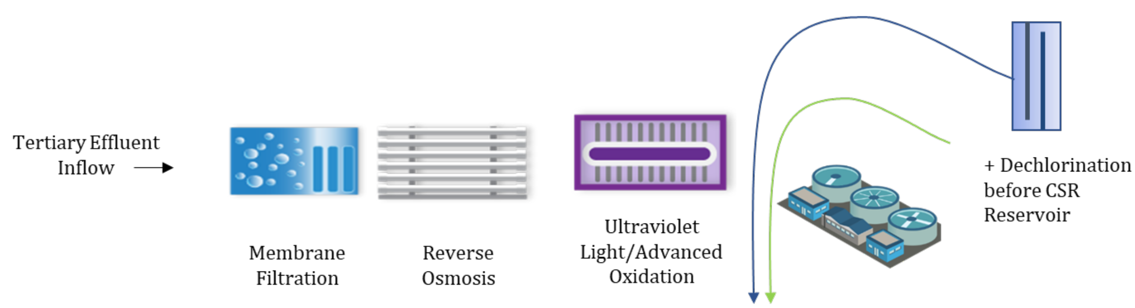
The RWQCB regulates discharges of recycled water to surface waters on behalf of the EPA through the issuance of NPDES permits. NPDES permits implement applicable state and federal water quality standards, policies, provisions, and prohibitions. The NPDES permit would also incorporate applicable DDW recycled water and SWA requirements.

3.4.2 SWA Treatment Requirements

The anticipated treatment requirements for SWA are similar to, but less stringent than the GRR regulations with regard to pathogenic microorganism control. The recycled water must be treated by full advanced treatment (i.e. MF, RO and an AOP) prior to delivery to the reservoir. The treatment train must achieve a minimum of 8/7/8 microbial log-removal for virus, Giardia, or Cryptosporidium (V/G/C), with at least two separate treatment processes credited with no less than 1.0-log removal, and no separate treatment process credited with more than 6-log removal. The draft SWA regulations require that any 24-hour input of recycled water into the reservoir must be mixed such that water withdrawn for use as drinking water never contains more than 1% recycled water.

For those projects where recycled water delivered to the reservoir during any 24-hour period makes up 10% of water withdrawn for use as drinking water, the recycled water treatment train must be achieve an additional 1-log removal (i.e., 9/8/9) with at least three separate treatment processes credited with no less than 1.0-log removal. In addition, although alternative minimum reservoir retention times as low as 60 d may be considered, SWA projects with minimum retention times less than 120 d must provide an additional 1-log treatment. Anticipated pathogen removal credits for a MF, RO, UV/AOP treatment train for a SWA project are illustrated are shown in Figure 3-5.

Figure 3-5: Anticipated Log-Reduction for Each SWA Treatment Step



Pathogen	MF	RO	UV/AOP	Total	Log Removal Requirement*
Virus	0	1.5 – 2	6	7.5 – 8	8 – 10
Giardia	4	1.5 – 2	6	11.5 – 12	7 – 9
Cryptosporidium	4	1.5 – 2	6	11.5 – 12	8 – 10

*Anticipated based on Draft SWA criteria. Removal requirement would be function of dilution achieved in the reservoir, reservoir retention time, and site-specific conditions. Removal credits at a drinking water treatment plant (4/3/2 V/G/C) were previously included in the total LRV requirement in for prior versions of the draft SWA regulations.

Section 4 Development of Alternatives

This section describes the development of potable reuse alternatives at a concept-level to provide a preliminary understanding of the viability and costs of a project in the San Francisco Bay Area. The PREP Initial Study explores potable reuse concepts for groundwater replenishment reuse and surface water augmentation. Three alternative concepts are developed:

- **Alternative 1:** GRR in the San Mateo Plain Basin
- **Alternative 2:** SWA in Crystal Springs Reservoir
- **Alternative 3:** SWA in Bear Gulch Reservoir

Section 3 introduced potable reuse concepts and their treatment requirements. The following sections describe the AWPF assumptions, GRR and SWA infrastructure requirements and conveyance considerations to repurpose existing assets, reuse abandoned resources and utilize existing Right-of-Ways (ROW) where possible.

4.1 Advanced Water Purification Facility (AWPF)

As discussed in Section 3, for indirect potable reuse, additional treatment processes are added beyond secondary or tertiary treatment to remove dissolved solids and other contaminants. An AWPF provides the additional steps to purify recycled water. The specific combination of treatment processes needed for a given project will depend on the quality of the treated wastewater and the intended use. The following sections discuss the treatment capacity, additional treatment processes, AWPF locations and brine disposal considerations assumed for the alternative evaluation.

4.1.1 Treatment Capacity

The available wastewater supply and seasonality of wastewater flows can limit the capacity of a recycled water project. As shown on Figure 2-4, monthly wastewater flows at the SVCW facility generally increase during the winter wet weather season, from December to March, and are at their lowest during summer months. Although an AWPF could be sized to treat the peak winter flow, this would require a very large treatment facility with shutdown procedures to take membranes off-line and institute preservation protocols for periods when source water flows are low. This results in larger capital investment and a higher unit life cycle cost. Operating the AWPF at a relatively constant flow year-round is preferable to keep treatment facility costs down and to simply operations.

Consistency helps efficiency

Operating an AWPF at a relatively constant flow year-round is preferable to keep treatment facility costs down and to simply operations.

As discussed in Section 2, it is assumed that a potable reuse project would receive up to 8 mgd of tertiary effluent from the SVCW facility and up to 8 mgd from the City of San Mateo's future BNR/MBR facility.

4.1.2 Treatment Process

For the alternatives evaluation, the AWPF train is assumed to consist of microfiltration/ ultrafiltration (MF/UF) as pretreatment prior to reverses osmosis (RO) system. The next step would employ an advanced oxidation process (AOP), which typically combines UV treatment with addition of hydrogen peroxide (H_2O_2) or ozone with H_2O_2 to degrade most natural and synthetic organic compounds. A process train using Ozone and Biologically Activated Carbon (BAC) as the primary removal processes, is not considered, though this alternative treatment train is sometimes pursued as an alternative to RO in areas where brine disposal is extremely costly or not an option.

This combination of treatment processes, also referred to as Full Advanced Treatment (FAT) in the GRR Regulations, is assumed to be sufficient for a GRRP or SWA. As discussed in Section 3, additional treatment steps may be required based on site specific conditions, including but not limited to:

- ✓ **Free chlorine addition** at the AWPF to provide additional log-removal credits for Virus or Giardia if the aquifer retention time or reservoir dilution credits are insufficient.
- ✓ **Well head treatment** at the production well if water quality in at the point of extraction is below drinking water standards.
- ✓ **Dechlorination** prior to discharge into the reservoir to meet surface water requirements.
- ✓ **Nutrient removal** before or after the AWPF process to reduce nutrients prior to discharge into the reservoir to meet surface water requirements.

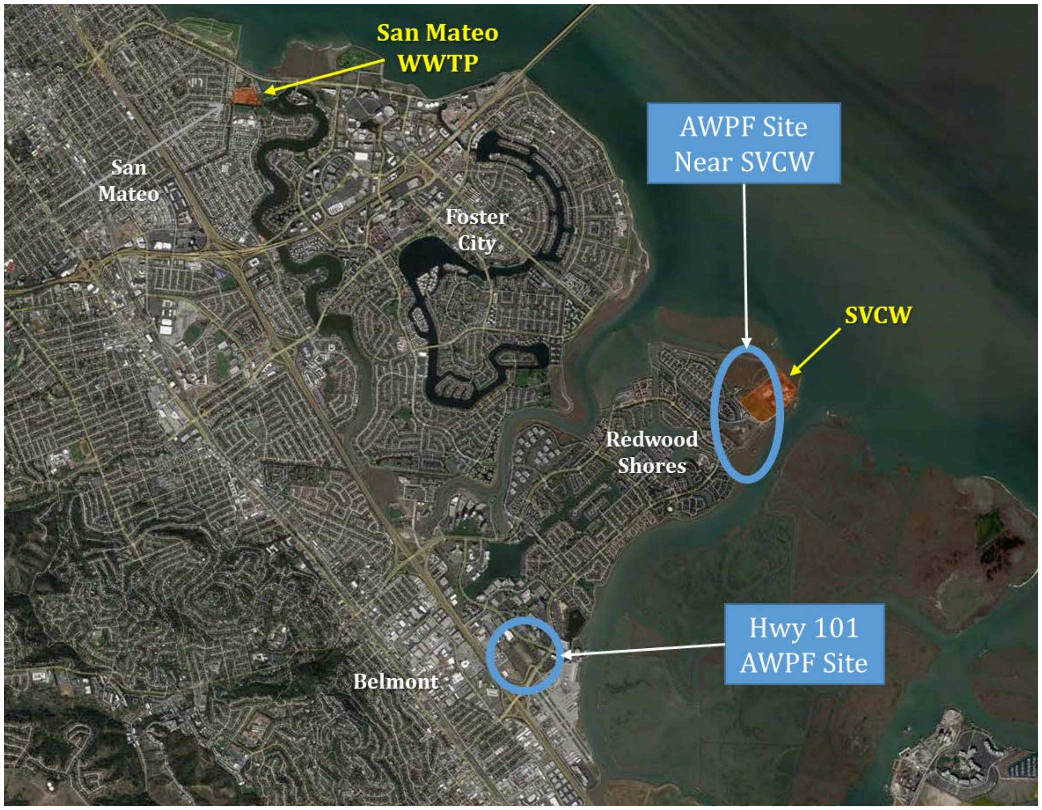
Evaluation of additional treatment requirements and processes would be performed in future phases of a potable reuse program to provide the appropriate level of treatment and to optimize treatment process design.

4.1.3 Treatment Location

For the purpose of the PREP Initial Study it is assumed that the AWPF facility would be located near the SVCW facility or at a site near the San Carlos Airport (herein referred to as the Hwy 101 Site), as shown in Figure 4-1. Based on initial discussions with SVCW, it is assumed that the AWPF would be an independent facility from SVCW. This could prove to be beneficial in terms of the potential positive public perception due to separation of wastewater and purified water systems.

The AWPF site near the SVCW would require less pumping and shorter pipelines to convey tertiary effluent to the AWPF and brine from the AWPF as compared to the Hwy 101 site. The cost to purchase or lease land for the AWPF has not been explored as part of this work. A siting study would be conducted to compare the benefits and limitations of these and other nearby sites prior to identification of a preferred AWPF site. Future discussions and agreements between the PREP Parties would determine preferences for ownership, operation and maintenance of the AWPF.

Figure 4-1: Potential AWPF Treatment Locations



4.1.4 Brine Disposal

The advanced treatment of wastewater for potable reuse using a RO membrane would produce a brine or concentrate for disposal. It is assumed that brine would be blended with tertiary effluent and discharged via the SVCW's existing ocean outfall pipeline to the San Francisco Bay.

Several issues would need to be resolved to confirm the viability of discharging brine via the existing outfall. These include, but are not limited to demonstrating the ability to meet existing and future permit water quality requirements, addressing potential toxicity issues, and demonstrating adequate blending ratios for dilution. Some considerations are discussed below:

- The anticipated total dissolved solids (TDS) concentration of brine from the AWPF could be on the order of 6,000 and 7,000 mg/L TDS, which is approximately 25 percent of the TDS of the South San Francisco Bay. The TDS of the blended discharge would depend on the amount of tertiary effluent available for dilution, which would be limited in summer months when the majority of the effluent would be purified for reuse.
- Nutrient concentrations would be higher in the brine, which may require nutrient removal prior to discharge.
- Toxicity requirements may also influence the ability and approach to discharge brine, particularly during summer months when brine dominates the outfall discharge flow.

- Although concentrations may increase due to the reduced discharge; because the water is initially being diverted from discharge prior to purification, the concentrate would not add any additional mass to the discharge.

Some of these issues may be addressed through the design of an engineered diffuser that utilizes discharge mixing nozzles to rapidly disperse brine into the surrounding water to achieve the background salinity and meet toxicity requirements within the initial zone of dilution. This approach has been used successfully for salinity management pipeline outfalls throughout California. Other issues may require innovative treatment technologies. Further analysis of brine disposal would be performed as part of a future study based on the capacity of the AWPF and volume of brine generated.

4.2 Groundwater Replenishment Opportunities (Alternative 1)

4.2.1 San Mateo Plain Groundwater Subbasin

The San Mateo Plain Groundwater Subbasin (SMPGW Subbasin) includes 37,700 acres located on the eastern edge of the San Francisco Peninsula between San Francisco Bay and the Santa Cruz Mountains. The SMPGW Subbasin consists of a trough of unconsolidated alluvial sediments that follows the line of San Francisquito Creek. Groundwater flow is generally from the west-southwest to east-northeast from the Santa Cruz Mountains towards San Francisco Bay. The groundwater aquifer is unconfined at higher elevations and confined or semi-confined at lower elevations close to San Francisco Bay (EKI 2017).

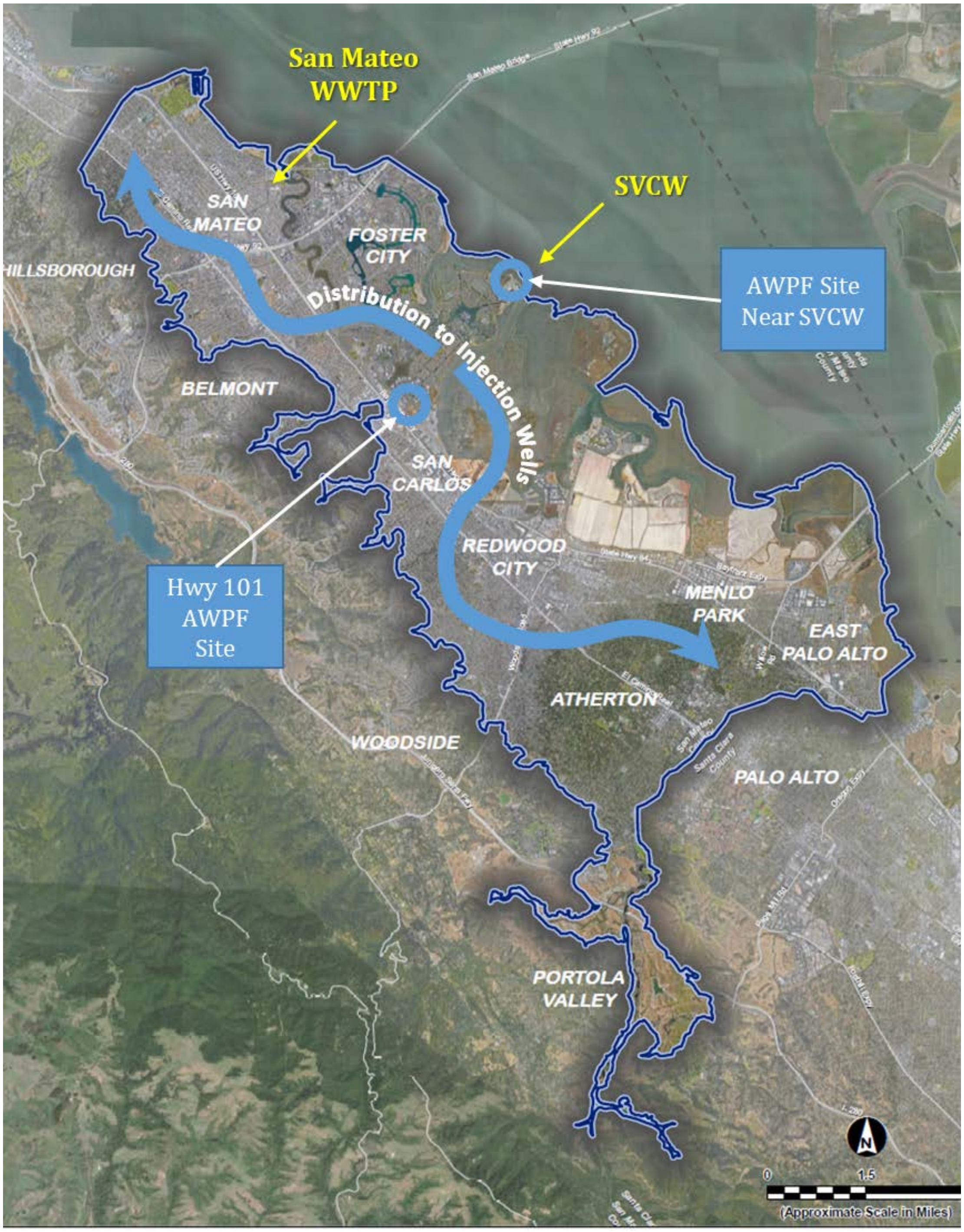
The San Mateo Plain Groundwater Basin Assessment Preliminary Report (EKI 2017) characterizes the SMPGW Subbasin as considered to be full and stable. Water quality in the basin is considered to be adequate for municipal and irrigation uses, but there are potential aesthetic concerns with the groundwater. Many wells have levels of total dissolved solids (TDS) that exceed the secondary maximum contaminant level (SMCL) of 500 parts per million, with deep wells generally having lower TDS concentrations than shallow wells. Most wells also have levels of iron and/or manganese above the SMCLs of 0.3 mg/L (iron) and 0.05 mg/L (manganese). SMCLs are for nuisance chemicals and are based on aesthetic considerations rather than health risks.

The San Mateo Plain Groundwater Basin Assessment Preliminary Report is the first phase of a multi-phase evaluation of hydrogeologic conditions. The recently completed Phase 1 includes the review and analysis of existing data. The future Phase 2 will gather and compile additional data to fill the gaps and Phase 3 will utilize the data to evaluate different basin conditions scenarios through the development and transient calibration of the SMPGW Model (EKI 2017). Once completed, the SMPGW Model and findings from the three phase studies would be instrumental in simulating GRR alternatives to validate basin capacity and simulate underground retention time.

4.2.2 GRRP Concept and Assumptions

Figure 4-2 illustrates the GRR concept for Alternative 1 and Table 4-1 lists the assumptions applied to develop the alternative.

Figure 4-2: GRR Concept In San Mateo Plain Groundwater Subbasin



Base map Source: SMGB Assessment Prelim Report (Jan 2017); Figure 1-1

Table 4-1: GRRP Assumptions

Parameter	Assumption	Notes
Available Supply of Purified Water for Recharge	6 mgd	Assumption based on available tertiary effluent from SVCW and advanced treatment. Groundwater basin capacity and available sites for injection sites may further limit GRRP capacity.
Average Well Yield Achieved in San Mateo Plain Sub-basin	0.75 mgd	Extraction well yields in the basin range from 0.4 mgd to 1.7 mgd. Yields would vary between well, depending on local conditions.
Number of Extraction Wells	8 wells	Assumes the average yield of each well is 0.75 mgd
Number of Injection Wells	16 wells	Assumes the average injection well can achieve half of the extraction rate (0.375 mgd)
Estimated Radius Required to Achieve > 6 Months Travel	2,000 feet	Based on a Drinking Water Source Assessment and Protection (DWSAP) Zone Approach in the Westside Basin; a radius of 600 feet was estimated to have a travel time of 6 months and a 2,000-foot radius was estimated to have a 2-year travel time (Kennedy/Jenks 2015). Assumed a 2,000-foot radius to provide a conservative estimation given uncertainty regarding hydraulic properties in the basin.
Length of Pipeline Needed	10-15 miles	Assumes the injection and extraction wells are to be sited using the above radii between wells and potentially near major water supply pipelines. No well sites nor pipeline alignments have been identified as part of this effort.

Note: Initial assumptions provided by Adrianne Carr, Ph.D. - Senior Water Resources Specialist (BAWSCA)

4.2.3 Alternative 1: GRR in the San Mateo Plain Basin

Key components of Alternative 1 are summarized below:

- **Description:** A GRRP would involve advanced treatment of recycled water near SVCW or at the Hwy 101 site and conveyance of purified water for groundwater replenishment via direct injection in the San Mateo Plain Subbasin.
- **Source Water:** SVCW tertiary effluent (8 mgd)
- **Project Size:** 6 mgd (6,720AFY) purified water for GRR
- **Uses**: Groundwater replenishment in the San Mateo Plain Groundwater Basin
- **Treatment Facilities:** AWPF near SVCW or at the Hwy 101 site employing full advanced treatment with MF, RO and UV/AOP. Brine discharge via connection to SVCW outfall to the Bay. Costs for wellhead treatment are not included
- **Other Infrastructure:**
    - **Pump Stations:** SVCW to AWPF (tertiary effluent), AWPF to GRR Wells (purified water), AWPF to SVCW Outfall (brine)

- **Pipelines:** SVCW to AWPF (tertiary effluent), AWPF to GRR Wells (purified water), AWPF to SVCW Outfall (brine)
- **Storage:** Equalization prior to AWPF and product water tank prior to GRR
- **Groundwater Wells:** 18 injection wells (includes 2 back-up wells), 9 extraction wells (includes 1 back-up well) 18 monitoring wells and associated buildings.

Due to uncertainty related to well siting, a potential pipeline alignment has not been identified for this alternative. Details about facility costs are provided in Section 5.

Future studies and groundwater modeling would be conducted to:

- Identify sites for injection and extraction wells
- Identify pipeline alignments
- Confirm groundwater basin capacity
- Demonstrate required travel time from point of injection to extraction
- Identify the need for wellhead treatment

4.3 Surface Water Augmentation Opportunities (Alternatives 2 & 3)

The SWA concept would convey purified water to Crystal Springs Reservoir (CSR) or Bear Gulch Reservoir (Figure 4-3) where it would be combined with surface water in the reservoir. After storage, waters would be transported downstream to a surface water treatment facility for treatment and conveyance to drinking water users through the existing potable water distribution system. The following sections describe the analysis of the suitability of CSR or Bear Gulch Reservoir to meet the anticipated SWA requirements discussed in Section 3.4.

4.3.1 SWA in Crystal Springs Reservoir

Crystal Springs Reservoir consists of Upper Crystal Springs Dam and Reservoir, and Lower Crystal Springs Dam and Reservoir, and are part of SFPUC's Hetch Hetchy Regional Water System (Figure 4-4). Water from the Crystal Spring reservoirs is pumped through the Crystal Springs pump station to San Andreas Reservoir before being pumped and treated at Harry Tracy Water Treatment Plant (WTP). Crystal Springs and San Andreas reservoirs are owned and operated by SFPUC and store local watershed water as well as water from the Hetch Hetchy Regional Water System.

Crystal Springs Reservoir's geometry (58,000 acres), capacity (17,750 million gallons) and existing infrastructure make this reservoir an ideal candidate for IPR via reservoir augmentation. The elongated shape is beneficial for meeting an extended retention time. The large capacity provides for dilution even at high augmentation rates. There is an existing dechlorination system and discharge facility at the Puglas Water Temple (Figure 4-4) at the southern end of CSR and an existing water treatment plant (Harry Tracey WTP) at the northern end of the two-reservoir system (CSR + San Andreas Reservoir), which could be utilized for a SWA project.

Figure 4-3: SWA Reservoir Options

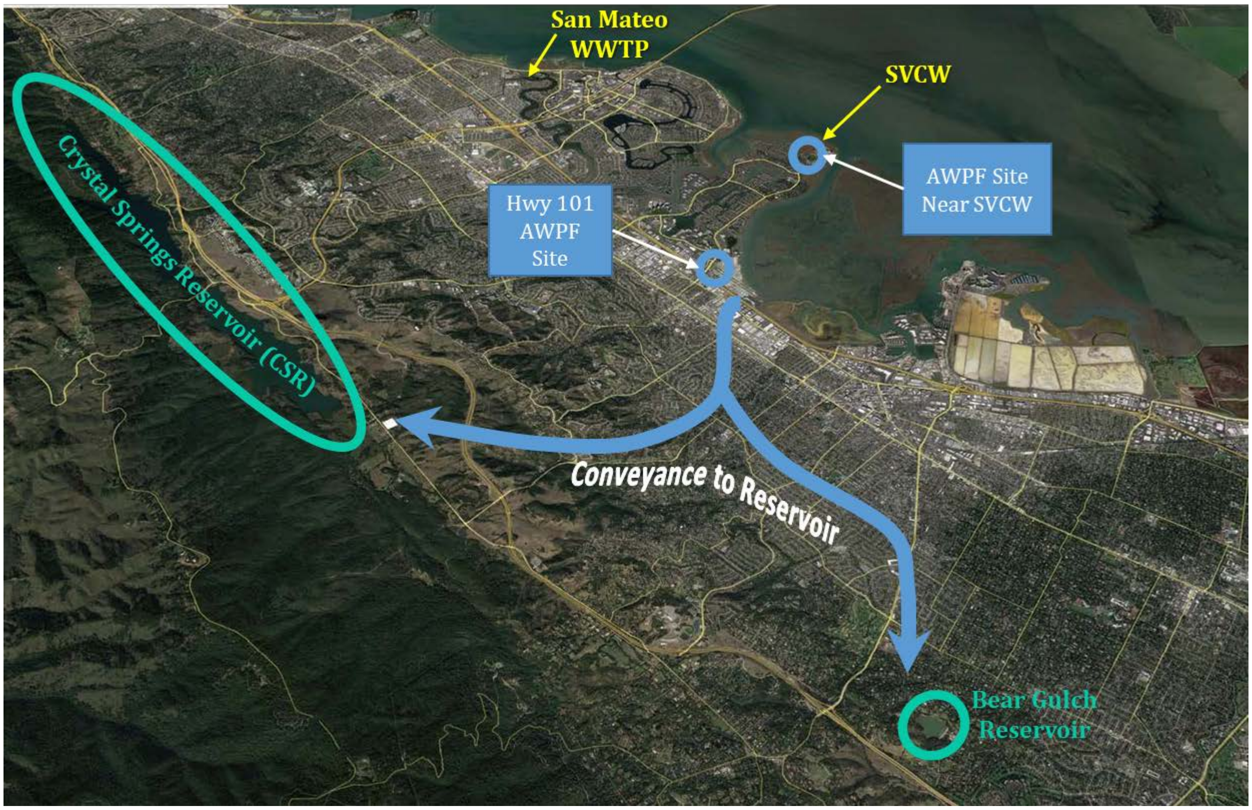


Figure 4-4: Hetch Hetchy Regional Water System

The following sections provide a high-level evaluation of estimated retention times, dilution and source water quality to assess the ability of a SWA at CSR to meet anticipated regulations.

4.3.1.1 CSR Retention Time Evaluation

SWA regulation requirements for reservoir retention times have not yet been established; however, based on the draft regulations (July 2017), required minimum theoretical reservoir retention times would likely be 180 days; with flexibility for an alternative minimum theoretical retention time as low as 60 days upon State Board approval. Per draft SWA regulations, theoretical retention times are to be calculated at the end of each month based on the reservoir conditions of that month.

Reservoir retention time is defined as the total volume of the reservoir (V) divided by the total flow out of the reservoir (Q) during a given time period. For the purpose of this evaluation a conservative retention time is calculated using the minimum reservoir volume divided by the maximum measured reservoir outflow (Table 4-2). DDW has not yet released guidance on what constitutes reservoir outflow. For the purpose of this evaluation, reservoir outflow (Q) is defined as the sum of maximum flow to the Harry Tracey WTP and typical wet year releases from CSR.

As shown in Table 4-2, the average retention time for the CSR only and CSR plus San Andreas Reservoir volumes would be 16 months (480 days) and 22 months (660 days), respectively. Conservative estimates of the minimum reservoir retention time are 4 months (120 days) and 5 months (150 days), respectively, however this extreme condition would have to last for the majority of a month which is unlikely. Based on this evaluation CSR would easily meet the anticipated minimum retention time criteria of 180 days for most scenarios and would be well above the 60-day alternative minimum theoretical retention time even in extreme conditions.

Table 4-2: Summary of CSR Retention Time Evaluation

	Crystal Springs	Crystal Springs + San Andreas	Notes
Storage (MG)	17,750	23,950	Reservoir operating level is to maintain volume of storage
Average Retention (Months)	16	22	Reservoir operating level divided by average flow to Harry Tracy WTP (31.5) + average release from CSR (3.5 mgd)
Minimum Retention[1] (Months)	4	5	Reservoir operating level divided by max flow to Harry Tracy WTP (140 mgd) + wet year release from CSR (3.9 mgd)

Source: Reservoir volumes and outflow rates from discussion with SFPUC on 22 Feb 2017.
[1] The maximum flow of 140 mgd far exceeds the daily water demand in the Hetchy Hetchy system and would likely occur only in extreme conditions for a short duration. This extreme condition would have to last for the majority of a month in order to result in theoretical retention times as low as those shown.

A SWA project may also need to demonstrate that the possibility of short-circuiting in the reservoir would be minimal or could be controlled. Given the geometry of CSR, with a long fetch between the inlet and outlet, it appears there would be a significant period of time for purified flows to travel from the point of augmentation to the San Andreas Reservoir to the Drinking Water Treatment Plant, minimizing the risk of short circuiting.

4.3.1.2 CSR Dilution Evaluation

Initial draft regulations for SWA propose pathogen removal requirements that are dependent on the reservoir's ability to dilute off-spec discharge flows. As discussed in Section 3.4.2, standard pathogen removal requirements (i.e. 8/7/8 log removal for V/G/C) are based on achieving a 100:1 (or 1 %) dilution of a 24-h discharge of purified water. If a reservoir achieves only 10:1 (10%) dilution of a 24-h discharge of purified water, pathogen removal requirements are increased by a factor of 10 (i.e., 9/8/9 log removal for V/G/C).

The actual capacity of a reservoir to dilute off-spec discharge flows is dependent on several factors:

- Discharge facility location and depth,
- Design of the discharge facility,
- Reservoir hydrodynamics (i.e. mixing), and
- Weather (i.e. wind and runoff) conditions.

Discharge facility alternative design studies and reservoir modeling and tracer studies would be required to determine the practical amount of dilution provided by CSR in a 24-hour period.

For the purpose of the PREP Initial Study, theoretical dilution ratios are computed as reservoir volume divided by the quantity of purified water delivered during the prior 24-hour period. Table 4-3 summarizes the theoretical dilution ratios at purified discharge flow rates of 6 and 12 mgd for two reservoir scenarios, CSR only and CSR plus San Andreas Reservoir. Assuming complete mixing (i.e. 100% dispersion of purified water throughout the entire reservoir volume), dilution ratios equal to or greater than 1,500:1 would be theoretically possible. For comparison, the maximum theoretical purified water augmentation rates possible while still achieving dilution ratios of 100:1 and 10:1 would be hundreds of mgd and thousands of mgd, respectively, orders of magnitude higher than the proposed project purified discharge rates of 6 and 12 mgd.

Purified water discharged during any 24-hour period would only mix with a portion of the reservoir volume, so actual dilution of a 24-hour pulse discharge would be significantly less than the theoretical dilutions computed under assumed complete mix conditions. Although actual dilution ratios are anticipated to be somewhat lower than the theoretical dilution ratios presented in Table 4-3, because proposed purified discharge flows are so small relative to reservoir storage volumes, it should be possible to design a system capable of achieving dilution ratios of 100:1 or greater under all operating conditions. It is therefore anticipated that the project would only need meet the proposed standard (i.e. 8/7/8) pathogen removal requirements.

Table 4-3: Summary of CSR Dilution Evaluation

	Crystal Springs		Crystal Springs + San Andreas	
Reservoir Volume (MG)	17,750		23,941	
Purified Water Augmentation (mgd)	6	12	6	12
Purified Water as % Reservoir Volume (discharged in the prior 24 hours)	0.03%	0.07%	0.03%	0.05%
Theoretical Dilution Ratio	3,000 : 1	1,500 : 1	4,000 : 1	2,000 : 1
Max Theoretical Purified Water Augmentation Rate (mgd)				
100 : 1	178		239	
10 : 1	1,775		2,394	

4.3.1.3 CSR Water Quality Considerations

Nutrients levels present in the purified water discharge to the CSR may require further treatment to meet future permit water quality requirements. As described in Section 4.1.2, the AWPF train is assumed to consist of MF/UF, followed by a RO system and an AOP. Phosphorus removal by reverse osmosis is typically more than 99%, while nitrogen removal, particularly ammonia nitrogen, is less efficient (typically around 90%). Nutrients are not well removed by AOP. Increasing nitrogen loads in the CSR could increase risk of algal blooms, which in turns raises the risk of cyanotoxins occurring in the reservoir during the summer months. Thus, closer examination of nutrient concentrations and loading limitations would be needed to determine the level of treatment required.

Table 4-4 contrasts nutrient levels present in SVCW effluent and San Mateo effluent before and after RO treatment against existing nutrient levels present in the CSR. Actual nutrients limits for a SWA would depend on site-specific conditions. Preliminary observations are:

- Treatment would be required to reduce purified water nitrogen concentrations to or below reservoir concentrations.
- Blending SVCW source water with San Mateo's anticipated water quality would reduce nutrient concentrations and could decrease the amount of nutrient reduction required.
- With RO treatment, total phosphorus loading for either SWA scenario would likely not present a degradation risk to CSR.
- Even with RO treatment, ammonia levels in the purified discharge to the reservoir are estimated to be approximately one to two orders of magnitude higher than reservoir conditions.
- Modification of the biological treatment process at SVCW to full or partial denitrification would further reduce nitrogen loading to the CSR. Nutrient removal may also be accomplished in the purified water stream.

- Any volume of purified water added to the reservoir would contribute mass loading to the reservoir.

Table 4-4: Summary of CSR Water Quality Considerations

Nutrient	Existing Conditions		Source Water Quality				Regulatory Limit	
	Upper Crystal Springs	Lower Crystal Springs	Surface Water Augmentation	Purified Flow Rate (mgd)	Dry Season Average (mg/L)	Estimated RO Product*	Drinking Water**	SWA Criteria
Ammonia as N (mg/L)	0.01 to 0.28	0.01 to 0.45	**SVCW**	6	42	4.2	No Direct Standard	TBD *(likely related to existing/ ambient conditions)*
			SVCW and San Mateo	12	23	2.3		
Total P (mg/L)	0.03 to 0.3	0.04 to 0.63	**SVCW**	6	4	0.04	No Direct Standard	
			SVCW and San Mateo	12	2.6	0.02		

Sources: SVCW effluent water quality (BACWA Group Annual Report 2016 for); Crystal Springs data provided by SFPUC on 3/8/17; San Mateo estimated Ammonia at 1 mg/L and Total P at 1 mg/L per CH2M.
* **RO Product:** Assumes 90% removal of Ammonia; 99% removal of Total P.
** **Drinking Water:** standards provided by California State Water Boards
http://www.waterboards.ca.gov/centralvalley/water_issues/drinking_water_policy/summary_table.pdf

4.3.2 Alternative 2: SWA in Crystal Springs Reservoir

Key components of Alternative 2 are summarized below:

- **Description:** A SWA project would involve advanced treatment of recycled water near SVCW or at the Hwy 101 site and conveyance of purified water for augmentation at CSR.
- **Source Water:** SVCW tertiary effluent (8 mgd) or Combined SVCW + San Mateo tertiary effluent (16 mgd).
- **Project Size:** 6 mgd (6,720AFY) purified water or 12 mgd (13,440 AFY)
- **Uses**: Augmentation of CSR.
- **Treatment Facilities:** AWPF near SVCW or at the Hwy 101 site employing full advanced treatment with MF, RO and UV/AOP. Brine discharge via connection to SVCW outfall to the Bay. Costs for nutrient removal and dechlorination are not included.
- **Other Infrastructure:**
    - o **Pump Stations:** SVCW to AWPF (tertiary effluent), AWPF to CSR (purified water), AWPF to SVCW Outfall (brine).
    - o **Pipelines:** SVCW to AWPF (tertiary effluent), AWPF to CSR (purified water), AWPF to SVCW Outfall (brine).
    - o **Storage:** Equalization prior to AWPF and product water tank prior to SWA.
    - o **Discharge Facility:** Expansion or modification to SFPUC's existing discharge facility at the Pulgas Water Temple.

A discussion of a potential pipeline alignment is discussed in Section 4.4. Details about facility costs are provided in Section 5.

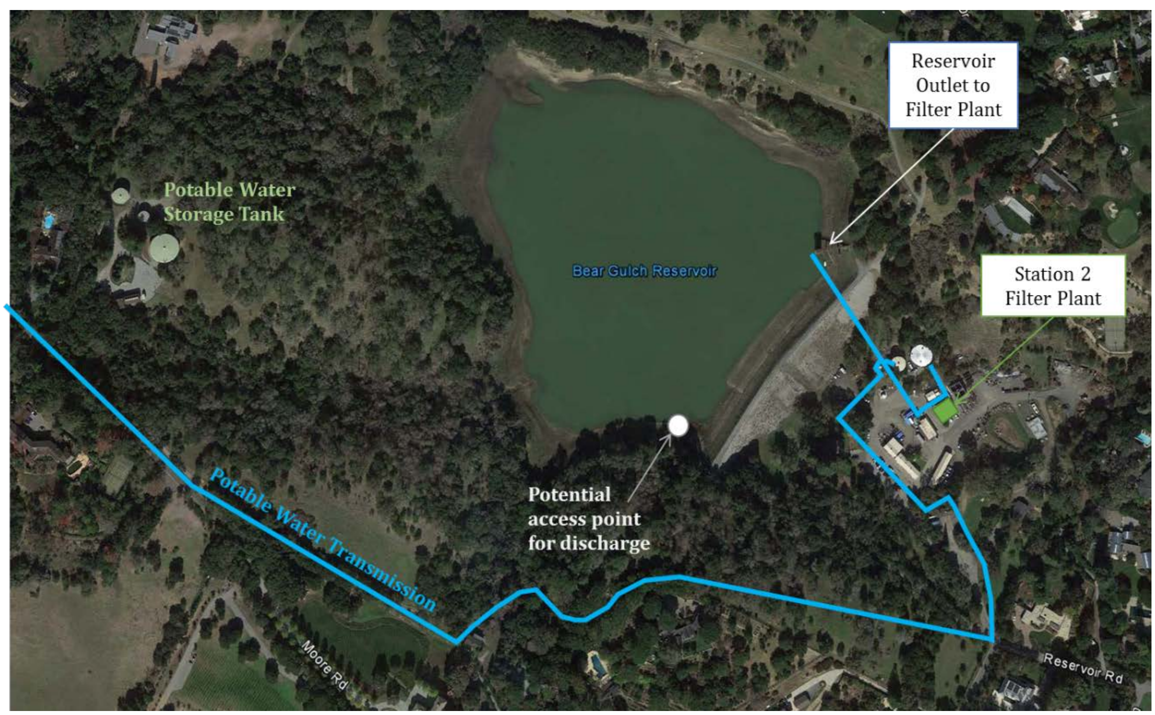
Future studies would be conducted to:

- ✓ Evaluate pipeline alignments
- ✓ Perform limnologic modeling and tracer studies
- ✓ Assess nutrient mass loading and/or concentration limits/impacts for the reservoir
- ✓ Evaluate nutrient removal technologies based on anticipated limits
- ✓ Demonstrate ability to meet the SWA water quality criteria (TBD) and other site-specific reservoir requirements
- ✓ Address water rights issues (if-any)
- ✓ Evaluate purified water discharge facility designs

4.3.3 SWA in Bear Gulch Reservoir

Bear Gulch is a small reservoir, located in a residential area in Atherton, owned and operated by the California Water Service Company (CalWater). The reservoir provides 20% of water supply for the cities of Menlo Park, Atherton, Portola Valley and Woodside. Bear Gulch is filled via runoff from Santa Cruz Mountains captured by Woodside Diversion Dam and water diverted from the lower portion of Bear Gulch Creek near Manzanita Rd. in Woodside. Stored water is conveyed from the reservoir outlet to the Station 2 Filter Plant (shown in Figure 4-5), which is also owned by CalWater. The only outflow is through the Filter Plant or drain used only for emergencies. Treated water is then distributed via a potable water transmission pipeline to 18,000 customer connections in the Bear Gulch System (Tenera Environmental, 2011).

Figure 4-5: Bear Gulch Reservoir

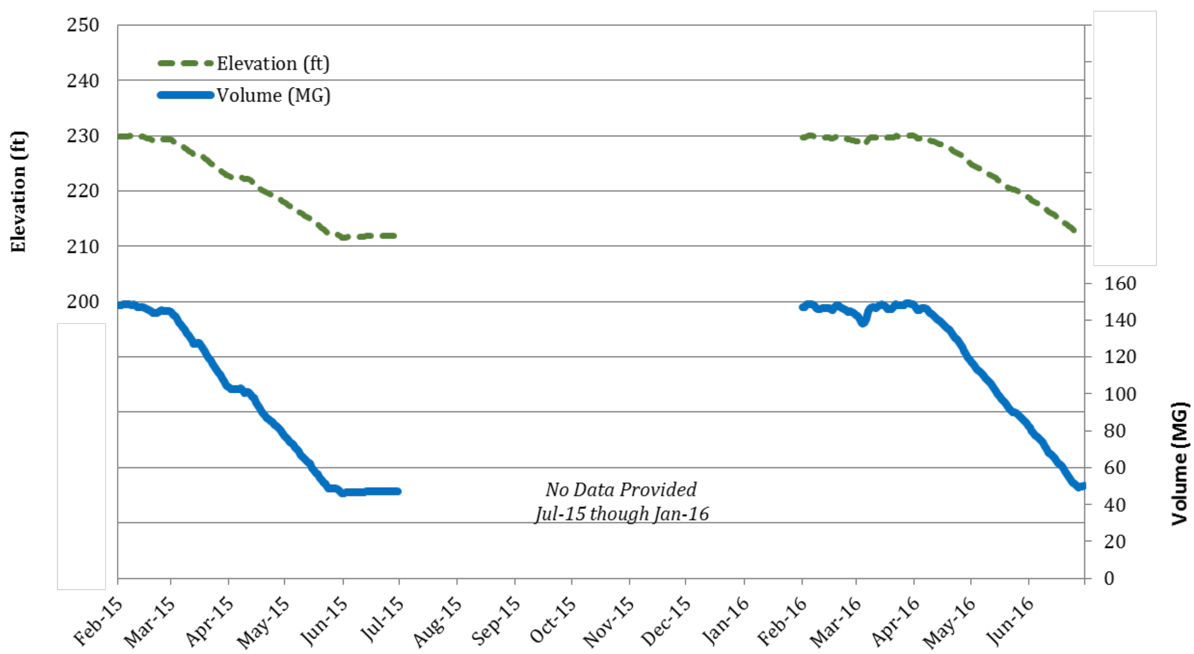


The current capacity of Bear Gulch is 166 million gallons (MG), with a maximum operating elevation capacity of 143 MG and an emergency base level capacity of 50 MG, at which point the filtration plant is shut down. The reservoir must be operated such that the water surface elevation does not drop more than 0.3 feet per day, including evaporation. In the summer months, the typical outflow is 1.4 mgd when the reservoir is more than 50 MG. Winter outflows can range from 2 to 2.5 mgd. Storage data for the reservoir, provided by CalWater for 2015 and 2016, is illustrated in Figure 4-6.

Unlike Crystal Springs Reservoir, the Bear Gulch Reservoir is not ideal for SWA because of its circular geometry (~22-acre surface area) and limited capacity (166 MG or 510 AF), which would make achieving dilution and retention time challenging. Though there would be room to augment the reservoir in the summer months, there is no additional capacity in the winter months because the outflow from the reservoir is limited by the plant working capacity, plus there is a decreased demand for water during off-irrigation months.

In terms of available infrastructure, the existing water treatment facility (Station 2 Filter Plant) and potable transmission line could be utilized for a SWA project, but a new discharge facility would be needed.

Figure 4-6: Bear Gulch Reservoir 2015-2016 Data



The following sections provide a high-level evaluation of estimated retention times, dilution and source water quality to estimate the ability of a SWA project at Bear Gulch Reservoir to meet anticipated regulations.

4.3.3.1 Bear Gulch Retention Time Evaluation

As described in Section 4.3.1.1, reservoir retention time is defined as the total volume of the reservoir (V) divided by the total flow out of the reservoir (Q) during a given time period. For the purpose of this evaluation, reservoir outflow (Q) was defined as the production rate of the Station 2 filtration plant. The capacity of the Station 2 filtration plant is 6 mgd, with an average production between 2 and 3 mgd during the early spring and summer. The filter plant is shut off when the reservoir level reaches 50 MG.

As shown in Table 4-5, estimates of minimum and average reservoir retention times for the Bear Gulch Reservoir are ≤ 1 month (30 days) and ≤ 2 months (60 days), respectively. Given the shape of the reservoir, with a short fetch and a potential point of augmentation located close to the outlet (Figure 4-5), there would be an increased risk of shot-circuiting.

Based on this evaluation Bear Gulch would not meet the draft SWA required minimum theoretical reservoir retention times of180 days nor an alternative minimum theoretical retention time of 60 days.

Table 4-5: Summary of Bear Gulch Retention Time Evaluation

Percent of Operating Range	Bear Gulch Volume (MG)	Min Detention Time (a) (months)	Average Detention Time (b) (months)
100%	149	1	2
80%	128	1	2
60%	108	1	2
40%	87	0	1
20%	67	0	1
0%	46	0	1

Source: Bear Gulch Reservoir elevation and volume data from 2015 to 2016 provided by Cal Water.

(a) Based on the maximum outflow rate, corresponding to the Station 2 filtration plant capacity of 6 mgd.
(b) Based on the average Station 2 filtration plant production rate of 2 mgd.

4.3.3.2 Bear Gulch Dilution Evaluation

Table 4-6 summarizes theoretical dilution factors for Bear Gulch Reservoir at purified discharge flow rates of 6 and 12 mgd for two reservoir scenarios. Theoretical dilution ratios were computed as Reservoir volume divided by the quantity of purified water delivered during the prior 24-hour period. As discussed in Section 4.3.1.2, Purified water discharged during any 24-hour period would only mix with a portion of the reservoir volume, so actual dilution of a 24-hour pulse discharge would be significantly less than the theoretical dilutions computed under assumed complete mix conditions. The actual dilution would depend on the type and location of the discharge facilities, weather conditions, withdrawal flows, and reservoir hydrodynamics.

Standard pathogen removal requirements (i.e. 8/7/8 log removal) are based on achieving a 100:1 dilution of a 24-hour discharge or purified water. If a reservoir achieves only 10:1 dilution of a 24-

hour discharge of purified water, pathogen removal requirements are increased by a factor of 10 (i.e., 9/8/9 log removal).

Bear Gulch Reservoir would meet 10:1 dilution requirements under most of the operating range for a purified water discharge flow of 6 mgd. Bear Gulch Reservoir would not meet 10:1 dilution requirements for a combined purified water discharge flow of 12 mgd.

Table 4-6: Summary of Bear Gulch Dilution Evaluation

Existing Reservoir Conditions		Purified Water Augmentation (6 MGD)		Purified Water Augmentation (12 MGD)	
Percent of Operating Range	Bear Gulch Volume (MG)	Percent of reservoir volume that has been discharged within the prior 24 hours	Dilution	Percent of reservoir volume that has been discharged within the prior 24 hours	Dilution
100%	149	4%	25 : 1	48%	2 : 1
80%	128	5%	21 : 1	56%	2 : 1
60%	108	6%	18 : 1	67%	1 : 1
40%	87	7%	15 : 1	83%	1 : 1
20%	67	9%	11 : 1	108%	1 : 1
0%	46	13%	8 : 1	157%	1 : 1

4.3.3.3 Bear Gulch Water Quality Considerations

No data on existing nutrient levels in Bear Gulch Reservoir are available at the time of this study. Historically, the reservoir has had issues with blue green algae, which were resolved by the addition of bottom aeration in 2015. This indicates that the water body may be sensitive to nutrient loads. Without reservoir water quality data, it is not possible to determine whether purified water from SVCW and/or San Mateo (see Table 4-4) would impact existing water quality.

4.3.4 Alternative 3: SWA in Bear Gulch Reservoir

Alternative 3 was removed from further consideration because initial evaluations found that the detention time would be less than 60 days, the alternative theoretical minimum detention time for a SWA project, as defined in the draft SWA regulations. A project that delivers recycled water to a surface water reservoir, with the reservoir providing some benefits, but lacking the full complement of benefits provided by IPR with SWA, would be considered direct potable reuse (DPR) through raw water augmentation, signifying no environmental buffer of significance.

No Buffer; No IPR

If the calculated detention time is less than SWA minimum required time; a project would be considered DPR through raw water augmentation, signifying no environmental buffer of significance.

4.4 Conveyance Considerations

Conveyance is a critical component of any recycled water system and often accounts for a large percentage of capital costs for a project. Repurposing existing infrastructure offers a unique opportunity to reduce costs and impacts associated with constructing new facilities. This section discusses the potential to reuse pipelines owned by SVCW, utilize existing recycled water facilities owned by the City of Redwood City and leverage existing SFPUC facilities and the right-of-way for their Bay Division pipelines to save money and reduce environmental and community impacts.

4.4.1 Repurpose SVCW Abandoned Pipelines

The SVCW has embarked on the SVCW Tunnel Project to replace a failing sewer force main with 17,600 feet of gravity pipeline in a 15-foot tunnel deep under Redwood Shores. Upon completion of the project in 2022, some of the existing 54" and 48" pipelines will be abandoned (Figure 4-7). This creates an opportunity to repurpose these valuable assets by installing and/or suspending a new pipeline within the abandoned pipe, as described below:

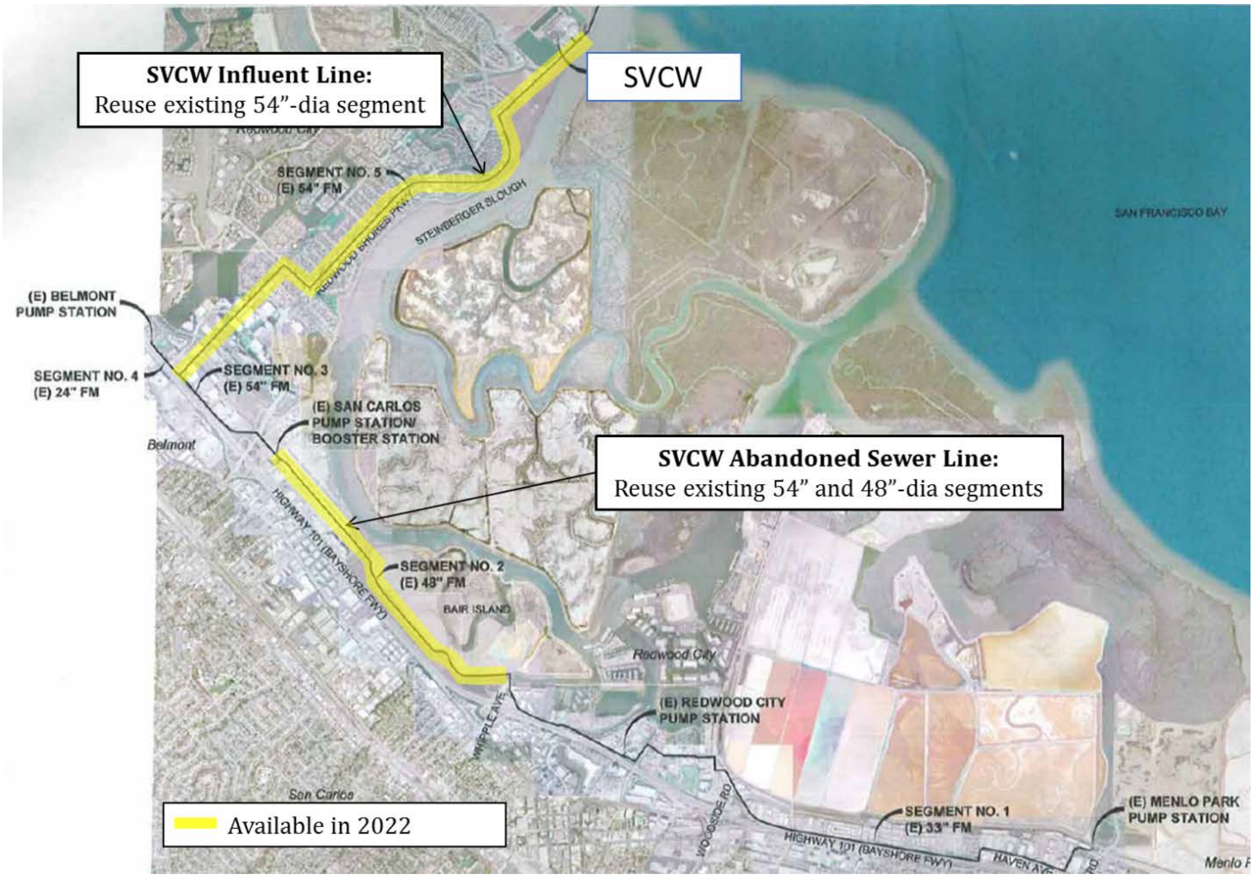
- **SVCW Influent Line:** is a 54-inch pipeline that will be abandoned in 2022. This segment is approximately three miles in length, and traverses through the Redwood Shores area, a community that is particularly sensitive to new construction. One, or possibly two, pipelines could be slip-lined into the abandoned pipeline and supported inside to convey purified water to the place of use, tertiary effluent to the AWPF at the Hwy 101 site, and/or brine back to the SVCW outfall.

- **SVCW Abandoned Sewer Line:** includes 48-inch to 54-inch pipeline segments that are also slated to be abandoned in 2022 after the SVCW Tunnel Project is complete. This segment is approximately 1.6 miles in length, and passes through an environmentally sensitive segment of Bayshore Freeway (Hwy 101) parallel to Blair Island, which would be a challenging stretch to lay new pipeline.

For the purpose of the PREP Initial Study, sub-alternatives are developed for Alternative 1 and 2 to assess the cost implications of repurposing these pipelines by installing a purified water, tertiary effluent and/or brine pipeline within an abandoned segment to avoid new trenching or costly micro-tunneling. A discussion of cost assumptions is provided in Section 5. Future study would be needed to confirm cost implications and risks.

> **Existing Assets can get a Second Chance**
> Repurposing existing infrastructure and abandoned assets offer a unique opportunity to reduce costs and impacts associated with constructing new facilities.

Figure 4-7: Reuse of Abandoned SVCW Pipelines



4.4.2 Utilize Redwood City Existing Infrastructure

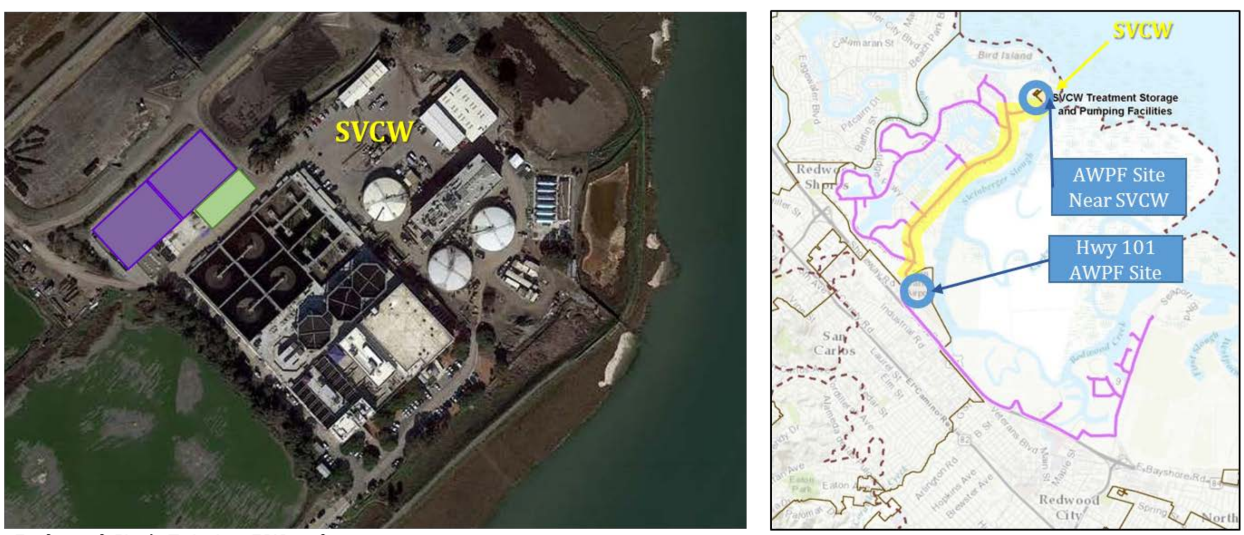
Redwood City's Recycled Water Program was first introduced to the community in 2000, with a small trial in Redwood Shores. The program later expanded along the eastern edge of Hwy 101 from Redwood Shores to the Greater Bayfront Area, as shown in Figure 4-8. Redwood City owns and operates two 2.1-million-gallon storage tanks, a 1-million-gallon chlorine contact tank and a distribution pump station at the SVCW facility and 17 miles of distribution pipelines to serve non-potable reuse customers.

Based on initial discussions with Redwood City, there is a potential opportunity to utilize their existing recycled water tanks (Figure 4-8) for source water equalization prior to the AWPF (if-needed). This would be a mutually beneficial opportunity to resolve water quality issues in the tanks due to stagnant water and underutilized capacity, while reducing costs associated with new equalization storage. Repurposing the tanks to provide equalization would likely require a revision of the recycled water Distribution Pump Station (DPS) control strategy, which has taken the City several years to tune to its current operations, as well as modification of the current contract arrangement between SVCW and Redwood City. Structural modifications to the tank(s) would also be needed to install a new outlet to convey flow to a new pump station that would send the stored water to the AWPF site, which could be near SVCW or at the Hwy 101 site.

Another opportunity to utilize available capacity in the Redwood City recycled water system would be to send excess Title 22 flow from SVCW to a AWPF at the Hwy 101 Site via the existing purple pipes in Redwood Shores, shown by the highlighted segment in Figure 4-8. This would eliminate the need for 3 miles of new pipeline, reducing costs and impacts to the Redwood Shores community. A brine pipeline would still be needed to send RO reject water from the AWPF back to the SVCW outfall.

For the purpose of the PREP Initial Study, it is assumed that the Redwood City tanks could be modified to be used for influent equalization prior to the AWPF, located near SVCW or at the Hwy 101 site. The Redwood Shores recycled water pipeline would only be utilized for an alternative project that sends Title 22 flow from SVCW to a AWPF at the Hwy 101. This would apply for sub-alternatives developed for Alternative 1 and 2. A discussion of cost assumptions is provided in Section 5. Future study would be needed to confirm cost implications and risks.

Figure 4-8: Redwood City Recycled Water Infrastructure



Redwood City's Existing RW tanks
- two (2) 2.1 MG recycled water tanks
- one (1) 1 MG chlorine contact tank

— Redwood City's RW Pipelines

4.4.3 SFPUC Alignment and Infrastructure Considerations

As the owner and operator of the Hetch Hetchy Regional Water System, including Crystal Springs Reservoir, SFPUC could leverage opportunities existing right-of-way's (ROWs) and existing infrastructure at CSR to reduce costs for a SWA Project. Appendix A includes a list of considerations, provided by SFPUC, for estimating preliminary pipeline routing and costs to Crystal Springs. In general, it was recognized that it would be possible to co-locate a potable reuse transmission pipeline in the SFPUC's ROW from the Redwood City area to CSR. Major exclusions noted by SFPUC include the need to steer clear of Bay Division Pipeline (BDP) #5 and find an alternative path around the Pulgas Tunnel.

Specific pipeline separation preferences include a 15-ft horizontal separation between pipelines and a 5-ft of vertical clearance between pipelines; however, it was noted that SFPUC would allow for some leniencies where obstacles need to be avoided for short runs of pipe. Current DDW guideline recommend a 4-ft to 10-ft horizontal and 1-ft vertical separation between pipelines with flexibility per coordination with entity.

Other design and construction considerations and preferences include the following:

- Design life should be at least 75 years without issues.
- Minimum cover over a new pipe is 4-ft, unless special approval is given.
- Cathodic protection required to protect new and existing lines.
- Earthquake and pressure design criteria to meet standards established by WSIP.
- Other specifics related to appurtenances, valves, I&C, etc.
- No materials that require future painting are allowed.
- Must protect the existing lines from construction loads.

As previously mentioned in Section 4.3.1, SFPUC owns and operates the Pulgas Dechloramination Facility and a discharge facility that delivers Hetch Hetchy flows to CSR. Purified water could potentially run through these facilities to save costs and avoid the need to build a new dechlorination system.

For the purpose of the PREP Initial Study, it is assumed that an alignment could be identified that would provide sufficient separation from BDP #5 and would not utilize the Pulgas Tunnel. Contingencies are included to address other considerations and preferences noted by SFPUC, recognizing that future studies would be needed to confirm alignments, construction methods and costs. This would apply for sub-alternatives developed for alternative 2 only. A discussion of cost assumptions is provided in Section 5.

4.4.4 Proposed Alignment to CSR

Based on the conveyance considerations discussed in this section, a proposed alignment to Crystal Springs Reservoir is illustrated in Figure 4-9. A discussion of cost assumptions is provided in Section 5. Table 4-7 provides and overview of conveyance considerations related to the repurposing of abandoned assets and construction of new pipelines.

The alignment and costs to convey tertiary effluent from the San Mateo WWTP to the AWPF has not been included as part of this effort since San Mateo is still in the process of developing their non-potable reuse program which may have the potential serve a dual-purpose conveyance system for a regional potable reuse project.

Figure 4-9: Proposed Alignment to CSR

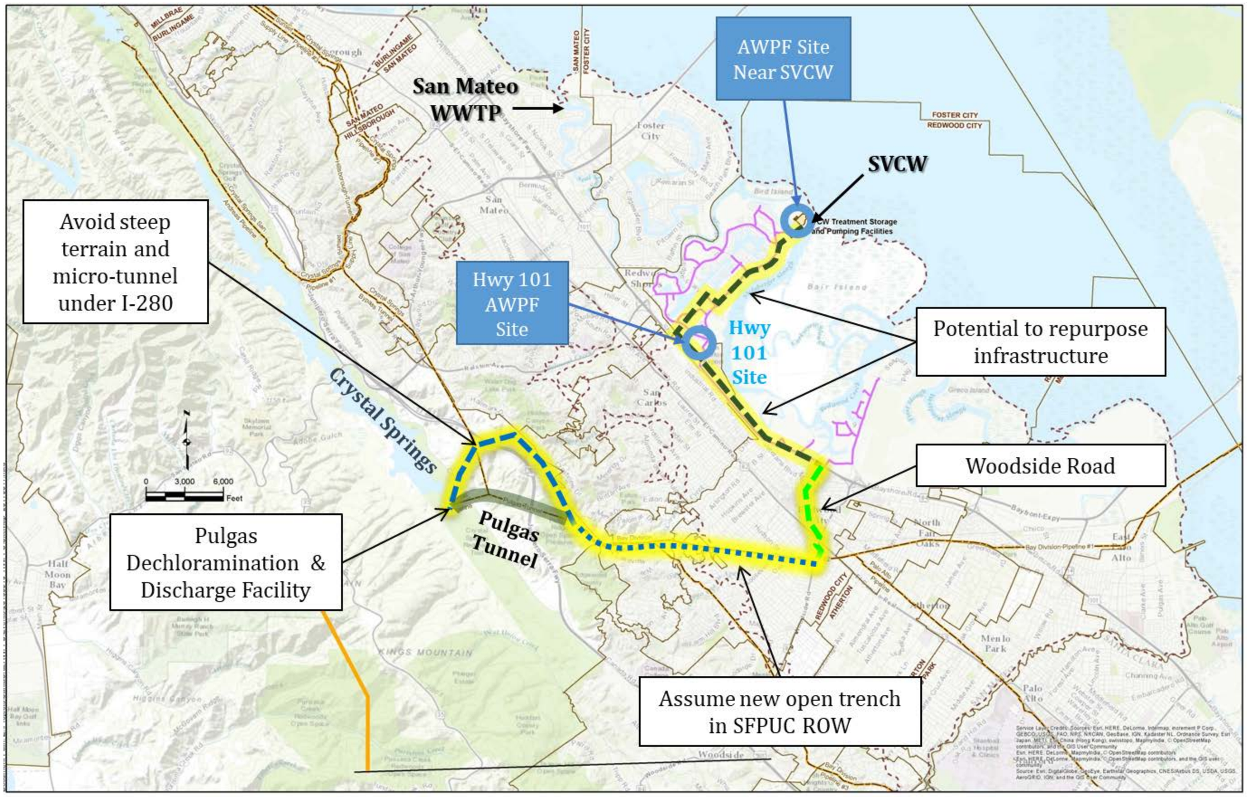


Table 4-7: Overview of Conveyance Considerations

Repurpose Abandoned Pipelines	Construct New Pipelines
Avoids utility conflicts associated with a new trench.	Increased potential for utility conflicts
Reduce public disruption during construction.	Increased public disruption during construction (particularly in Redwood Shores).
Requires receiving/injection pit every 1000-2000 feet to slip-line new pipelines, depending on conditions.	Requires receiving/injection pit every 1000-2000 feet for micro-tunneling segments.
Condition assessment of existing pipeline would impact design /costs for slip-lined pipelines.	Existing utilities and subterranean conditions would affect construction technology and costs.
Potentially to reduce conveyance costs	Potentially higher conveyance costs
Potential to minimize environmental impacts of construction.	Potential for greater environmental impacts (particularly near the Bay).
Existing pipe alignments for SVCW would not be available until after SVCW Tunnel Project completion (2022-2025).	Investigate potential conflicts from other unknown new projects.

Section 5 Project Alternatives Costs

This section describes the engineer's opinion of probable costs developed for the groundwater replenishment and surface water augmentation alternatives developed in Section 4. As shown in Table 5-1, nine sub-alternatives were developed to represent variations in project costs due to the location of the AWPF and repurposing infrastructure.

Table 5-1: Overview of Sub-Alternatives

Alternative	Source Water (Purified Flow)	AWPF Location	Repurpose Infrastructure	Sub Alternative
Alternative 1 GRRP in San Mateo Plain Basin	SVCW (6 mgd)	Near SVCW	- Utilize RWC Tanks at SVCW	1.1
			- Utilize RWC Tanks at SVCW - Repurpose SVCW Pipelines to Shoreway	1.2
		Hwy 101 Site	- Utilize RWC Tanks at SVCW - Repurpose SVCW Pipelines to Shoreway - Utilize RWC Purple Pipe to Hwy 101 Site	1.3
	SVCW + San Mateo (12 mgd)	*Not considered due to GW basin capacity and well siting limitations*		
Alternative 2 SWA Crystal Springs Reservoir	SVCW (6 mgd)	Near SVCW	- Utilize RWC Tanks at SVCW - Use Puglas Dechloramination Facility	2a.1
			- Utilize RWC Tanks at SVCW - Repurpose SVCW Pipelines to Woodside - Use Puglas Dechloramination Facility	2a.2
		Hwy 101 Site	- Utilize RWC Tanks at SVCW - Repurpose SVCW Pipelines to Woodside - Utilize RWC Purple Pipe to Hwy 101 Site - Use Puglas Dechloramination Facility	2a.3
	SVCW + San Mateo (12 mgd)	Near SVCW	- Same as 2a.1	2b.1
			- Same as 2a.2	2b.2
		Hwy 101 Site	- Same as 2a.3	2b.3
Alternative 3 SWA Bear Gulch	SVCW (6 mgd)	*Not considered due to limited detention time in Bear Gulch Reservoir*		
	SVCW + San Mateo (12 mgd)			

RWC = Redwood City

5.1 Engineers Opinion of Capital Cost

The engineer's opinion of probable cost is based on a conceptual level estimate of the capital and operating costs for each alternative considered for the PREP Initial Study. Planning-level opinions of capital, operations and maintenance (O&M), and lifecycle costs are developed to facilitate an economic comparison of the alternatives and sub-alternatives.

Capital, annual and life cycle costs are estimated for each alternative at a Class 5 level, representing Planning to Feasibility level information with an estimated accuracy range between -30 percent and +50 percent, summarized herein.

- **Capital Cost:** Unit capital costs and recent project experience were used to estimate facility costs for treatment, pipelines, pump stations, storage tanks, groundwater wells and other facilities. Additional facility costs for site development, yard piping, electrical, and instrumentation and controls are assigned as a percent of facility costs. Sales taxes, mobilization costs, contractor overhead and profit costs and an estimate contingency are applied to all alternatives. An annual inflation rate is applied to represent anticipated escalation to the mid-point of construction, based on an estimated construction schedule, which differs by alternative.

- **O&M Cost:** The estimated O&M costs include energy cost, labor costs, chemical costs and maintenance costs with a contingency applied to all O&M costs.

- **Life Cycle Unit Cost:** Capital costs are converted to annualized lifecycle costs using basic assumptions about discount rates and life expectancy of project components and added to O&M annual costs to get a Total annualized cost. Total annualized costs are then divided by the recycled water delivered over the life of the project to obtain a uniformly derived unit cost of water in dollars per acre-foot ($/AF), which is also converted to dollars per gallon ($/gal) and dollars per hundred cubic feet ($/CCF).

The following costs are not included in the cost estimated due to the need for additional information, studies and in many cases negotiated agreements to provide a reasonable or justifiable unit cost estimate:

- **Land Acquisition:** for siting an AWPF, groundwater wells, other above ground facilities, including necessary ROW acquisitions, costs are not included due to the uncertainly related to the location and market value of available land. During a PREP workshop, CalWater mentioned a recent purchase of a groundwater well site to be $1 million; however, it was also noted that there were significant other challenges associated with the site that contributed to the increased costs for development. SVCW also noted that Hwy 101 site would likely be leased at $1 mil per year, but that it would depend on the amount of space required and the negotiation with the landowner.

- **Nutrient Removal:** would likely be required for a SWA prior to or after advanced treatment and could also be required for a GRR project. There are a variety of established technologies and new innovative technologies that could be implemented to reduce nutrients prior to reuse, with a wide range of costs. Additional studies would be needed to identify a preferred alternative that would meet the potable reuse requirements, which would need to be further explored with the RWQCB/DDW as well as with SVCW to provide a nexus with their long-term nutrient management objectives. According to a recent Nutrient Regulatory Update, presented at BACWA's Annual meeting[8] the range of cost for nutrient reduction could be $6 to $9 per gallon per day. This could add $48 to $72 million for an 8 mgd AWPF, assuming the influent flow is treated, and double that for a 16 mgd facility. It may also be possible to treat the post-RO water at a lower flow, and potentially lower cost depending on the selected technology.

- **Dechlorination:** it is assumed that the SFPUC Pulgas Dechloramination Facility could be used at no additional capital cost.
- **Reuse of Redwood City Facilities:** it is assumed that there would be no capital costs associated with the use of Redwood City's Title 22 pipelines to convey tertiary flow from SVCW to an AWPF at the Hwy 101 Site. A small cost was included to modify the existing Redwood City Storage tank for use as source water equalization.

Appendix B includes additional information about cost assumptions and provides a detailed opinion of probable cost for each sub-alternative.

5.2 Summary of Sub-Alternative Costs

The engineer's opinion of probable capital, O&M and annualized unit costs for each alternative are summarized in Table 5-2 and Figure 5-1.

- For GRR Sub-Alternatives 1.1, 1.2 and 1.3, the costs are quite similar because most of the pipelines (~15 miles) were undefined and therefore offered fewer opportunities for repurposing assets. There is also a greater amount of uncertainty about the scale of a GRR since groundwater basin capacity and well siting limitations, which would drive the amount of purified water that could be recharged and recovered, would significantly affect unit life cycle costs. In addition, siting new injection/extraction wells could require finding between 5 and 10 acres of available land in Silicon Valley, in the right geologic locations and with suitable separation to meet travel time requirements, which would be both challenging and costly.
- When comparing a 6 mgd GRRP to a 6 mgd SWA, GRRP capital costs are higher due to the number of wells and the O&M costs are higher due to the additional energy and maintenance for those wells. Thus, the unit life cycle costs for GRR are nearly 50% more than for a SWA project.
- When comparing a 12 mgd SWA to a 6 mgd SWA, the capital and O&M costs are higher for the larger facility, but not proportionally for the increased flow due to the scalability of treatment

[8] https://bacwa.org/wp-content/uploads/2017/01/Nutrients-Regulatory-Update-by-HDR.pdf

and conveyance facilities. Thus, the unit life cycle costs decrease by 25%, illustrating the economics of scale to be realized by a larger project.

- Projects that repurpose the SVCW pipelines (Alternatives 2a.2, 2a.3, 2b.2 and 2b.3) realize a 10% overall project savings from those that assumed construction of all new pipelines.

- The location of the AWPF did not significantly influence the overall cost due to the assumption that the existing Redwood City pipeline in Redwood Shores could be used to convey Title 22 flow and the abandoned SVCW influent line could be used to slip-line a brine line. Costs for leasing the Hwy 101 site or purchasing land near SVCW were not included but would both result in additional project costs for any alternative.

Table 5-2: Summary of Sub-Alternative Opinion of Probable Costs

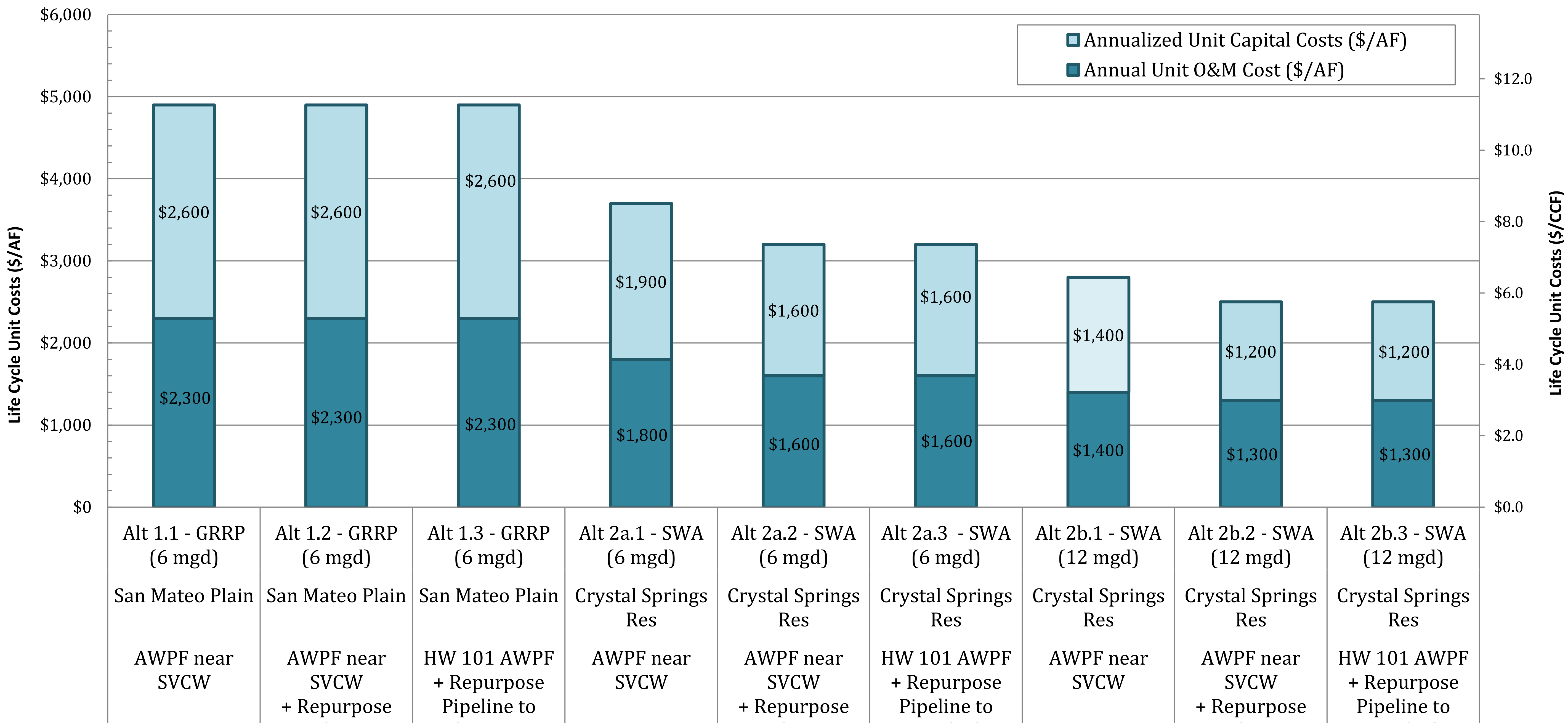
Component	Alternative 1: 6 mgd GRRP in San Mateo Plain			Alternative 2: 6 mgd SWA in Crystal Springs Res			Alternative 3: 12 mgd SWA in Crystal Springs Res		
	Alt 1.1	Alt 1.2	Alt 1.3	Alt 2a.1	Alt 2a.2	Alt 2a.3	Alt2b.1	Alt2b.2	Alt2b.3
	AWPF near SVCW	AWPF near SVCW + Repurpose Pipelines to Shoreway	HW 101 AWPF + Repurpose Pipeline to Shoreway	AWPF near SVCW	AWPF near SVCW + Repurpose Pipelines to Woodside	HW 101 AWPF + Repurpose Pipeline to Woodside	AWPF near SVCW	AWPF near SVCW + Repurpose Pipelines to Woodside	HW 101 AWPF + Repurpose Pipeline to Woodside
Treatment	$108	$108	$108	$110	$110	$110	$177	$177	$177
Pipelines	$137	$136	$136	$194	$137	$138	$254	$174	$177
Pump Station	$10	$10	$11	$12	$12	$13	$17	$17	$20
Storage	$3	$3	$3	$3	$3	$3	$4	$4	$4
Discharge Facility	$0	$0	$0	$3	$3	$3	$4	$4	$4
Groundwater Wells	$113	$113	$113	$0	$0	$0	$0	$0	$0
Total Construction Cost ($)	**$371**	**$370**	**$371**	**$322**	**$265**	**$267**	**$456**	**$376**	**$382**
Annual O&M Cost ($mil/yr)	**$16**	**$15**	**$16**	**$12**	**$11**	**$11**	**$19**	**$17**	**$17**
Purified Water Delivered (AFY)	6,720	6,720	6,720	6,720	6,720	6,720	13,440	13,440	13,440
Purified Water Delivered (mgd)	6	6	6	6	6	6	12	12	12
Unit Life Cycle Cost ($/AF)	**$4,900**	**$4,900**	**$4,900**	**$3,700**	**$3,200**	**$3,200**	**$2,800**	**$2,500**	**$2,500**
Unit Life Cycle Cost ($/gal)	**$0.015**	**$0.015**	**$0.015**	**$0.01**	**$0.01**	**$0.01**	**$0.01**	**$0.01**	**$0.01**
Unit Life Cycle Cost ($/CCF)	**$11.20**	**$11.20**	**$11.20**	**$8.20**	**$7.50**	**$7.50**	**$6.00**	**$6.00**	**$6.00**

Note: Component costs shown are fully loaded to include additional facility capital costs, markups and contingencies, as detailed in Appendix B. Unit life cycled costs represent the sum of annualized capital cost plus annual O&M costs divided by the recycled water delivered over the life of the project to obtain a uniformly derived unit cost of water in dollars per acre-foot ($/AF), dollars per gallon ($/gal) or dollars per hundred cubic feet ($/CCF).

Comparable Advance Treatment Costs

The conceptual-level treatment costs included in the PREP Initial Study are within the range of AWPF's in California that are currently in operation or slated for construction, which indicate capital loaded costs ranging from $9/gal to $16/ gal (adjusted to 2017 dollars).

Figure 5-1: Summary of Life Cycle Costs



Notes: The stacked bars represent the life cycle unit cost for each project (left y-axis).
The purple dots represent the average annual reuse in SCWD's service area.
All costs represent City facilities or the City's proportional share of regional facilities based on flow.

Section 6 Conclusions

The PREP Initial Study provides a high-level evaluation of facilities and costs to implement a regional indirect potable reuse project on the San Francisco Peninsula to provide a local, drought-proof and sustainable water supply and enhance the reliability of the Hetch Hetchy Regional Water System. The intent of this work has been to provide an initial screening of alternatives for the Parties to determine whether to proceed with continued exploration of, and investment in, potable reuse through this partnership.

The costs presented in Section 5 provide a comparison of direct costs incurred to implement an indirect potable reuse project. This section describes some of the other potential benefits, challenges and future efforts, which can help guide the next steps on the path to potable reuse.

6.1 Potential Benefits and Challenges of a Regional IPR Project

Overall, a regional GRRP or SWA project on the San Francisco Peninsula could provide an integrated approach to:

1. Enhance water supply reliability,
2. Reduce discharges to the San Francisco Bay, and
3. Create a multi-agency project with multiple economic, environmental and social benefits.

An IPR Project could provide an integrated approach to resolving multiple issues related to regional water supplies, which could bring together a number of stakeholders in the region. For water providers, replenishing groundwater basins and augmenting surface water reservoirs with a reliable supply can provide more effective management and flexibility for operations. For wastewater providers, an indirect potable reuse program offers an opportunity to proactively address future discharge compliance requirements and create a new revenue source. Working together as a region would also enhance grant and loan funding opportunities and support the regional economy security.

Regional Collaboration Offers an opportunity to resolve multiple water supply and waste issues, while realizing the benefits of shared infrastructure, asset recovery, economies of scale and a more competitive strategy to pursue funding.

Indirect potable reuse projects are inherently scalable due to the modular nature of membrane treatment technologies and the often consistent year-round demand for purified water. Regional projects provide an opportunity to allow phasing larger projects that expand from a backbone system to realize the benefits of economy of scale over the long-term. For example, a regional project could start small, utilizing flows from one WWTP initially to improve non-potable recycled water quality while getting the community comfortable with the AWPF technology. Once indirect potable reuse is initiated, the AWPF could phase up and the facility could add membrane trains to increase capacity as the program expands to multiple source waters and/or places of use. If the initial civil and conveyance infrastructure is upsized to accommodate future growth, the project could realize significant economies of scale in the long-term.

There are, of course, potential and significant challenges to implementing an indirect potable reuse project in the Silicon Valley Region. The high costs required to construct, operate and maintain an AWPF and convey purified water to a place of use can be difficult to justify. Siting facilities, particularly those that are above ground and require ongoing maintenance activities can arouse opposition and NIMBYism and often come with high land acquisition costs. The regulatory requirements to obtain approval for GRR and SWA projects require an extensive permitting process with intensive monitoring and reporting requirements.

Public acceptance and regional partnerships can be both challenging and rewarding. These two topics are discussed in the following sections.

6.2 The Path to Public Acceptance

The community's understanding, acceptance, and comfort level with the health and safety aspects of indirect potable reuse can make or break a project. There is a great deal of existing literature that provides a variety of approaches and suggestions for engaging the community in discussing recycled water issues, including public outreach for potable reuse.

Four prominent studies by the WateReuse Research Foundation, now known as the Water Environment & Reuse Foundation (WE&RF), evaluated and addressed public communication issues for non-potable and potable reuse projects:

- WRRF 13-02 - Model Public Communication Plans for Increasing Awareness and Fostering Acceptance of Potable Reuse – Millan, Tennyson & Snyder
- WRRF-01-004 Public Perceptions of Indirect Potable Reuse - John Rutten
- WRRF 09-07 Pharmaceuticals and Personal Care Products Communications Toolkit – Recycled Water: How safe is it? - Kennedy, Debroux & Millan
- WRRF 03-05 Marketing Nonpotable Recycled Water: A Guidebook for Successful Public Outreach & Customer Marketing – Humphreys

Thoughtful Outreach Early & Often

It is possible to gain social acceptance for potable reuse with a strong outreach effort that begins in the infancy of the program, builds trust through communication, and sustains the conversation through consistent messaging.

There are consistent lessons and recommendations throughout the non-potable and potable reuse outreach literature. These generally suggest beginning outreach early, developing consistent terminology and messaging, having the utility become a source of trusted information, and focusing on water quality rather than its history. Additionally, it is commonly stated that knowledge and understanding of the water treatment process increases acceptance of water reuse. Specifically cited are the benefits derived from using demonstration treatment sites as a tool for informing and educating the public. Use of such sites has been found to be fundamental toward increasing community knowledge and education in understanding the potential of new water resource technologies.

The literature and surveys described above cite many frameworks, steps, principles, and timelines for effective community outreach efforts. Much of this work is synthesized in the recent World Health Organization's publication, "WHO Guidelines for Potable Reuse," particularly the chapter entitled Potable Reuse and the Art of Engagement (published 2017). The PREP Parties can utilize these tools to help define a path to public acceptance of water reuse in Silicon Valley

6.3 Building Regional Commitments

Even with the most willing partners, regional projects require the development of partnerships and agreements, which requires cooperation, coordination and legal support. The MOU between the initial PREP Parties to begin this work was a crucial first step in declaring a regional commitment to proactively reducing wastewater discharges and increasing water supply resiliency. SVCW, SFPUC, BAWSCA and CalWater together agreed to conduct regional activities in an inclusive manner that improves water supply reliability in the region. Within months of initiating the study, Redwood City and San Mateo expressed interest in joining the Parties to explore regional solutions that may offer additional economies of scale and opportunities to share resources and infrastructure.

Timing is important too.
Coordinating and collaborating in lock-step with regional partners shows thoughtful planning and consideration of potential impacts to affected communities.

Together, these Parties have chosen to use the results of this PREP Initial Study to take the next steps to explore regional opportunities for potable reuse. Representatives from each agency have begun to form a Technical Advisory Committee (TAC) to review the findings of the PREP Initial Study, develop priorities and strategies, craft a consistent message, define decisions points, and establish a timeline to further explore regional potable reuse in Silicon Valley.

Based on the initial findings from the PREP Initial Study, it appears possible that an IPR project could offer benefits for the Bay Area water and wastewater utilities; the environment, local communities and the Silicon Valley economy.

If the PREP Parties agree to proceed, additional studies are warranted to evaluate groundwater capacity, confirm the ability to meet anticipated SWA regulations, evaluate pipeline alignments and facility siting, and initiate outreach to the community to gain social acceptance for reuse.

References

Erler & Kainowski Inc (EKI) 2017. San Mateo Plain Groundwater Basin Assessment – Preliminary Report. Prepared for the County of San Mateo. Prepared by EKI, Tod Groundwater and HydroFocus

Kenned/Jenks Consultants, 2015. San Francisco Airport Recycled Water Master Plan. Prepared for the San Francisco International Airport.

Olivieri, A.W., Crook, J., Anderson, M.A., Bull, R.J., Drewes, J.E., Haas, C.N., Jakubowski, W., McCarty, P.L., Nelson, K.L., Rose, J.B., Sedlak, D.L. and Wade, T.J. (2016) Evaluation of the Feasibility of Developing Uniform Water Recycling Criteria for Direct Potable Reuse. Fountain Valley, CA.

Tenera Environmental, 2011. 2010 Bear Gulch Reservoir - Aquatic Ecosystem Evaluation. Prepared for the California Water Service Company

Trussell Technologies, 2016. Potable Reuse: Surface Water Augmentation White Paper on Alternatives Clause. Prepared for WateReuse California for submittal to the State Board

WateReuse Research Foundation (WRRF), 2015. Model Public Communication Plans for Increasing Awareness and Fostering Acceptance of Potable Reuse (WRRF-13-02) – Millan, Tennyson & Snyder

WRRF, 2004. Public Perceptions of Indirect Potable Reuse (WRRF-01-004) - John Rutten

WRRF, 2007. Pharmaceuticals and Personal Care Products Communications Toolkit (WRRF 09-07)– Recycled Water: How safe is it? - Kennedy, Debroux & Millan

WRRF, 2005. Marketing Nonpotable Recycled Water: A Guidebook for Successful Public Outreach & Customer Marketing (WRRF 03-05) - Humphreys

Appendix A: SFPUC Considerations for Estimating Preliminary Pipeline Routing and Cost

Source: SFPUC 4/28/17

Crystal Springs ROW Use for Potable Reuse Water Pipeline
Considerations for Estimating Preliminary Pipeline Routing and Cost

It would be possible to co-locate a potable reuse transmission pipeline in the SFPUC's ROW from the Redwood City area to Crystal Springs Reservoir.

Bay Division Pipelines in ROW

- There are three pipelines (Bay Division 1, 2 and 5) in the ROW on Edgewood Road. In the vicinity of Edgewood Road and Cordilleras Road, the three pipelines converge with two more (Bay Division 3 and 4).
- Five Bay Division pipelines jog NW to Hassler Road where they enter into the Pulgas Tunnel at the horseshoe of Hassler Road.
- Pulgas Tunnel is approximately two miles in length.

Co-locating a potable reuse transmission pipeline in the ROW

- Allow for uncertainty in the project's consideration of alternatives.
- There is a limit to confirming the feasibility of locating a pipeline in the ROW.
- Assuming an 18" transmission pipeline.
- The terrain looks to be challenging in the ROW.
- Would not be able to put the potable reuse transmission pipeline in the tunnel. Would have to open cut around the tunnel area.
- Would need to tunnel under 280.
- Need to steer clear of Bay Division 5
- 15' clear between lines and 5 feet clear between pipeline and boundary.
    - The SFPUC will allow situations where these requirements are not met for short distances, like where the lines cross, or where obstacles are skirted, but at those locations as everywhere, the State's requirements for separation of drinking water pipelines and non-potable water pipelines must be complied with
    - Consider allowing that the location of the drinking water pipelines is only approximately known – this means that separation requirements are not to be violated if the drinking water pipelines are found to occupy a space closer than expected to the proposed pipeline's alignment. In such cases the proposed pipeline must be realigned and/or State-approved measures for separation of potable and non-potable water pipelines must be provided.
- Pulgas Tunnel daylights at Pulgas Water Temple. Pulgas Water Pipeline runs from Water Temple to the Pulgas Dechloramination Facility, then into reservoir.
- SPFUC would own and operate the section of pipeline in the SFPUC's ROW.

There are other special considerations of locating a non-potable water pipeline within the SFPUC's drinking water pipeline ROW:

- Design life and duty – the line should be designed to serve trouble-free for at least 75 years and to withstand heavy pipeline construction loading
- Construction materials – no element of the proposed facility should ever require painting within its lifespan
- ROW – any pipeline project is to confirm and protect the earth cover of existing drinking water pipelines and provide for their structural protection from construction loading, as well as. provide finish grading to assure positive drainage of the entire width of the ROW and provide for proper conveyance of ROW drainage to local storm water systems
- Depth of burial – finished grading is to allow for a minimum of 4' of soil cover to top of proposed pipe, except where shallower installation is specifically confirmed by maintenance engineering analysis
- Appurtenances – all air-release, vacuum relief, blow-off and any fill or sample extraction appurtenances are to be provided with water-tight containment and water-tight drainage to sanitary sewer systems
- Zone valving stations are to allow isolation and drainage of reaches of 2 miles or less
- Monitoring and automation – instrumentation and SCADA is to be provided to monitor pressures in each reach of the proposed pipeline and automatic shutdown in the event of sudden pressure loss
- Corrosion protection – cathodic protection is to be provided to assure design life and, the proposed water pipeline in no way contributes to the corrosion of drinking water pipelines in the ROW
- Earthquake design criteria – seismic hardness and performance criteria of the proposed pipeline are to meet or exceed the standards established for pipelines under WSIP
- Pressure design criteria – transient pressure performance criteria of the proposed pipeline are to meet or exceed the standards established for pipelines under WSIP
- It is likely that there will not be a contiguous ROW for this pipeline, however, it should be obtained.

Operations

- Water Quality would need to meet the requirements in the NPDES permit for Crystal Springs. Requirements are unique and have to do with wildlife and plants. Need to look at the parameters in the permit, and what the quality would be from the Advanced Water Purification Facility.
- Water quality would need to be monitored.
- Could potentially run water through Pulgas Dechloramination facility if necessary.

Appendix B: Engineers Opinion of Probable Costs

This appendix includes a summary of the cost approach and detailed cost sheets for each sub-alternative.

F.1 Capital Cost Assumptions

The following assumptions are applied to estimate facility costs:

- **Distribution Pipelines:** Pipeline costs are based on a unit cost for each pipe size (i.e. dollar per inch-diameter linear foot) using conventional dry trenching techniques based on recently bid projects and professional experience. Costs include material and labor for total pipe segment. Special crossings, such as major intersections and micro-tunneling (trenchless) are included at a higher unit cost.
- **Pump Stations:** Pumping costs were estimated based on brake horsepower requirements, assuming different redundancy factors for different alternatives, pumps and motor control centers located outside and variable speed pumps. Land acquisition costs for pump stations are not included in the cost estimate.
- **Operational Storage:** The unit cost for new storage tanks (concrete and steel) is based on cost curves from RS Means, recently constructed projects in California and from professional experience.
- **Treatment Facility Costs:** Cost estimates for tertiary, MF, RO, UV/AOP and chlorination facilities are provided based on recent project, planning studies and professional experience. Additional unit costs include post treatment and chemical handling, enclosed buildings, and off-site additional costs (i.e. as new access roads, security, lighting, admin building, ancillary facilities, landscaping, etc.).
- **Wells:** Estimated costs for injection, production and monitoring wells are based on unit costs for a typical well based on recently bid projects and professional experience. Building costs for injection and extraction wells are based on unit building costs and a 20 foot by 20-foot footprint. Land acquisition costs for wells are not included.
- **Discharge Facility:** Based on an estimated cost to expand the existing discharge facility near the Pulgas Water Temple.

The following allowances, contingencies and non-contract cost percentages are applied to the **Subtotal Facility Costs:**

- **Additional Facility Capital Costs:** The following percentages are applied to subtotal of treatment, pump station, storage, discharge facility and well costs: site development costs at 5%, yard piping at 5% and Electrical, Instrumentation and Controls (I&C), and Remote (low-tech) Control at 15%.
- **Taxes:** 8.5% is applied to materials (estimated at 40% of the total facility cost).

The following allowances, contingencies and non-contract cost percentages are applied to the **Facility Direct Costs**:

- **Allowance for Unlisted Items:** A markup of 5% for mobilization, bonds and permits, 10% for engineering and design, 5% for environmental/permitting, and 15% for Contractor Overhead and Profit are applied to the facility direct costs.
- **Estimate Contingency:** A markup of 40% of the facility direct costs was added to pay contractors for overruns on quantities, changed site conditions, change orders, etc. Contingencies are considered as funds to be used after construction starts and not for design changes or changes in project planning.

The resulting **Subtotal with Contractor Markups and Contingency** is increased by 2% per year to reflect escalation to midpoint of construction based on project implementation timeline assumptions. The **Project Capital Cost** includes all facility costs, allowances, markups, contingencies and the escalation to the midpoint of construction. Costs are provided in 2017 dollars using the Engineering News-Record Construction Cost Index (ENRCCI) for San Francisco.

F.2 O&M Cost Assumptions

Operations and maintenance (O&M) costs are estimated to include the following items:

- **Energy Cost:** The cost for power varies diurnally and seasonally, thus energy costs are estimated to be $0.20/kWh for continuous treatment and pumping.
- **Labor Costs:** Treatment-related labor is based on full time salary with benefits of $175,000 per year. Labor for other work such as work related to pipelines, pump stations, wells and customer service is based on a full-time salary with benefits of $125,000 per year.
- **Treatment Facility Costs:** Presented in terms of energy, chemicals, labor, maintenance, replacement and repair costs based on level of treatment provided and average operating flow over the year as dictated by each Alternative.
- **Non-treatment Maintenance Costs**: Included based on 1.5% of direct facility costs, excluding treatment costs.
- **Contingency**: A contingency of 10% of the subtotal of O&M costs is also included.

F.3 Engineers Opinion of Probable Costs

This appendix includes detailed cost sheets for the following sub-alternatives:

Groundwater Replenishment Reuse Projects (GRRP):

Alternative 1.1 – GRRP (6 mgd) San Mateo Plain - AWPF near SVCW

Alternative 1.2 – GRRP (6 mgd) San Mateo Plain - AWPF near SVCW
+ Repurpose Pipelines to Shoreway

Alternative 1.3 – GRRP (6 mgd) San Mateo Plain - HW 101 AWPF
+ Repurpose Pipeline to Shoreway

Surface Water Augmentation (SWA) Projects:

Alternative 2a.1 - SWA (6 mgd) Crystal Springs Res - AWPF near SVCW

Alternative 2a.2 - SWA (6 mgd) Crystal Springs Res - AWPF near SVCW
+ Repurpose Pipelines to Woodside

Alternative 2a.3 - SWA (6 mgd) Crystal Springs Res - HW 101 AWPF
+ Repurpose Pipeline to Woodside

Alternative 2b.1 - SWA (12 mgd) Crystal Springs Res - AWPF near SVCW

Alternative 2b.2 – SWA (12 mgd) Crystal Springs Res - AWPF near SVCW
+ Repurpose Pipelines to Woodside

Alternative 2b.3 - SWA (12 mgd) Crystal Springs Res - HW 101 AWPF
+ Repurpose Pipeline to Woodside

Engineers Opinion of Probable Cost
Alt 1.1 - GRRP(6 mgd) San Mateo Plain - AWPF near SVCW

KENNEDY/JENKS CONSULTANTS

Average Annual Influent Flow:	7.84 mgd
Average Annual Product Flow:	6.00 mgd
RW Delivered:	6720 Average Annual Reuse (AFY)
Design Capacity:	4,167 Max Day Demand (gpm)

Study:	Potable Reuse Exploratory Plan (PREP) Decision Tool	**Prepared By:**	MT, DTT
Project:	GRR in San Mateo Plain	**Date Prepared:**	Jun-2017
AWPF Locatic	AWPF near SVCW	**K/J Proj. No.**	1668011.01
Repurpose:	RWC Tank	**ENR**	11,696 *(2017 SF)*
Estimate:	Conceptual Level Cost-Analysis		

Item No.	Description	Qty	Units	Total Costs $/Unit	Total Capital Cost	Est Facility Life	Annualized Capital Cost	Notes/Source
Facility Capital Costs								
1.0	**Treatment**				**40,270,294**			**Assumes AWPF near SVCW**
### ########	Microfiltration	7.8	MGD	$ 1,200,000	9,411,765	**20**	**632,618**	
### ########	Reverse Osmosis	7.1	MGD	$ 1,800,000	12,705,882	**20**	**854,035**	
### ########	Advanced Oxidation Process (includes UV)	6.0	MGD	$ 300,000	1,800,000	**20**	**120,988**	
### ########	Post Treatment and Chem Handling	6.0	MGD	$ 600,000	3,600,000	**50**	**139,916**	
### ########	Building	6.0	MGD	$ 1,250,000	7,500,000	**50**	**291,491**	5,000 SF/mgd
								250 $/SF
### ########	Land Cost	0	SF	$ -	0			Cost of land NOT included in this analysis
### ########	Off-Site Additional Costs			15%	5,252,647			Account for new access roads, security, lighting, admin building, ancillary facilities, landscaping, etc (apply to above treatment facility costs)
### ########	Nutrient Removal			not incl				Assume NOT included at this time
2.0	**Pipelines**				**60,570,180**	**75**	**2,039,275**	**Assumes NEW HDPE pipeline in Trench and/or Microtunneling when needed**
### ########	**AWPF near SVCW to Shoreway (open trench)**	14,340	LF	270	3,871,800			18 in-diameter; flow (mgd) = 6.0
	Major intersections	1,500	LF	720	1,080,000			18 in-diameter; $40 per inch-dia-LF (major intersection)
								300 assume LF per major intersection
### ########	**Shoreway to South GRR Wells (Purified)**							**Assume 75% open trench and 25% microtunneling (for lack of further alignment info)**
	Open Trench Alignments	28,200	LF	180	5,076,000			12 in-diameter; flow (mgd) = 3.0
	Major Intersections	1,500	LF	480	720,000			300 assume LF per major intersection
								12 in-diameter; $40 per inch-dia-LF
	Microtunneling (Trenchless)	9,900	LF	2,040	20,196,000			12 in-diameter; $170 per inch-dia-LF (microtunneling)
	Microtunnelling Jacking Pit (35 ft deep)	5	EA	125,000	618,750			
	Microtunnelling Receiving Pit (35 ft deep)	5	EA	75,000	371,250			
### ########	**Shoreway to North GRR Wells (Purified)**							**Assume 75% open trench and 25% microtunneling (for lack of further alignment info)**
	Open Trench Alignments	28,200	LF	180	5,076,000			12 in-diameter; flow (mgd) = 3.0
	Major Intersections	1,500	LF	480	720,000			300 assume LF per major intersection
								12 in-diameter; $40 per inch-dia-LF
	Microtunneling (Trenchless)	9,900	LF	2,040	20,196,000			12 in-diameter; $170 per inch-dia-LF (microtunneling)
	Microtunnelling Jacking Pit (35 ft deep)	5	EA	125,000	618,750			
	Microtunnelling Receiving Pit (35 ft deep)	5	EA	75,000	371,250			
### ########	Pipeline Constructability (Along Roads)			10%	1,654,380			**Not including microtunneling**
3.0	**Pump Station**				**3,730,000**	**50**	**144,968**	**Assume one PS (with multiple pumps to deliver water north and south)**
### ########	AWPF near SVCW to GRR Wells (Purified)	1	LS	3,150,000	3,150,000			4,167 total flow (gpm); 625 ft (TDH)
### ########	SVCW to AWPF near SVCW (Tertiary)	1	LS	260,000	260,000			5,447 total flow (gpm); 10 ft (TDH)
### ########	AWPF near SVCW to SVCW (Brine)	1	LS	320,000	320,000			4,167 total flow (gpm); 19 ft (TDH)
4.0	**Storage Tank**				**1,060,000**	**50**	**41,197**	**Assume equalization needed for influent and product water**
### ########	Steel Storage Tanks for EQ Tank (prior to AWPF)		MG	not incl				*Per Justin E. - additional storage in RWC tanks at SVCW could be repupropsed for equalization*
	Alternatively convert RWC for use as EQ tank	1	LS	200,000	200,000			*Placeholder cost provided for new connection from RWC tank to AWTF PS*
### ########	Steel Storage Tanks for Product Water Tank	1	MG	860,000	860,000			
5.0	**Groundwater Wells**				**42,030,000**			**Assume typical costs (well siting information unknown)**
### ########	Injection Wells	18	EA	1,100,000	19,800,000	**30**	**1,010,181**	Per BAWSA - assume 16 wells (add +2 backup)
### ########	Monitoring Wells	18	EA	300,000	5,400,000	**20**	**362,965**	Assume one monitoring well per injection well
### ########	Extraction Wells	9	EA	1,000,000	9,000,000	**30**	**459,173**	Per BAWSA - assume 8 wells (add +1 backup)
	Wellhead Treatment		EA					Unknown wellhead treatment requirements (cost not included)
### ########	Well Constructability			15%	5,130,000	**30**	**261,729**	Well building = 400 SF based on 20 ft x 20 ft
### ########	Buildings for Injection/Extraction Wells	27	EA	100,000	2,700,000	**50**	**104,937**	250 $/SF
### ########	Land Cost		EA					Unknown land purchase costs (cost not included)
	Subtotal Facility Costs				**$147,660,474**		**$6,463,474**	
Additional Facility Capital Costs								
6.0	Site Development Costs	@	5%		7,383,024		323,174	% of Subtotal facility costs
								(Includes grading, erosion control, cut/fill, etc.)
7.0	Yard Piping	@	5%		4,354,515		323,174	% of Subtotal facility costs (not inluding pipelines)
8.0	Electrical, I&C, and Remote (high-tech) Control	@	15%		13,063,544		969,521	% of Subtotal facility costs (not inluding pipelines)
	Subtotal Additional Facility Costs				**$24,801,083**		**$1,615,869**	
			Facility Direct Costs		**$172,461,557**		**$8,079,343**	
	Taxes	@	8.50%		5,020,456		219,758	apply taxes to 40% of the Capital Costs for facilities
	Mobilization/Bonds/Permits	@	5%		8,623,078		403,967	% of Facility Direct Costs
	Engineering and Design	@	10%		17,246,156		807,934	% of Facility Direct Costs
	Special Studies	@	0%		0		0	Not included (note that this may be a significant future cost for the program)
	Environmental/Permitting	@	5%		8,623,078		403,967	% of Facility Direct Costs
	Contractor Overhead & Profit	@	15%		25,869,233		1,211,901	% of Facility Direct Costs
	Estimate Contingency	@	40%		68,984,623		3,231,737	% of Facility Direct Costs
Subtotal with Markups and Contingency					**$306,828,180**		**$14,358,608**	
	Escalation to Midpoint of Construction	@	21%		64,433,918		3,015,308	assume 2% percent over 11
								construction start = 2025; end = 2028
			Project Capital Cost Total		**$371,262,098**		**$17,373,915**	
				Annualualized Capital Costs ($/AF)			**$2,585**	project life = 50; interest rate = 3%
				Annualualized Capital Costs ($/gal)			**$0.008**	

Annual Operations and Maintenance Costs

Item No.	Description	Qty	Units	Total Annual Costs $/Unit	Total			Notes
### ########	**Energy Costs**							
								Treatment Operation = 24 hours per day
### ########	Energy - Treatment	6,033,655	KWh	0.20	1,206,731			8760 hours operated per year
								2755 KWH/MG
								Pump Operation = 24 hours per day
								8760 hours operated per year
### ########	Energy - Pumping from AWPF near SVCW to GRR	5,881,464	KWh	0.20	1,176,293			Pump Station Hp = 900 Total Motor HP Required to typical well elevation
	Energy - Injection and Extraction	13,230,000	KWh	0.20	2,646,000			Pump Station Hp = 75 Total Motor HP Required per well
### ########	Energy - Other		KWh	10%	238,302			
### ########	**Chemicals**	6,720	AF	101	675,360			
3.0	**Labor Costs**							
### ########	Labor - AWPF	8.0	staff	175,000	1,050,000			full time staff at $175,000 average salary + benefits per year
### ########	Other Labor (pipeline, PS, wells)	2.0	staff	125,000	375,000			full time staff at $125,000 average salary + benefits per year
4.0	**Maintenance:** Other	@	1.5%		5,568,931			% of capital cost
4.1	Equipment (Maintenance/Replacement/Repair)	6,720	AF	167.40	1,124,928			
5.0	**Contingency**	@	10.0%		1,406,155			% of above O&M costs
			Annual O&M Costs ($/year)		**$15,467,700**			
			Annual Unit O&M Costs ($/AF)		**$2,300**			
			Annual Unit O&M Costs ($/gal)		**$0.007**			

Engineers Opinion of Probable Cost **KENNEDY/JENKS CONSULTANTS**

Alt 1.2 - GRRP(6 mgd) San Mateo Plain - AWPF near SVCW + Repurpose Pipelines to Shoreway

Study:	Potable Reuse Exploratory Plan (PREP) Decision Tool	**Prepared By:**	MT, DTT	**Average Annual Influent Flow:**	7.84 mgd
Project:	GRR in San Mateo Plain	**Date Prepared:**	Jun-2017	**Average Annual Product Flow:**	6.00 mgd
AWPF Locatio	AWPF near SVCW	**K/J Proj. No.**	1668011.01	**RW Delivered:**	6720 Average Annual Reuse (AFY)
Repurpose:	RWC Tank + Repurpose pipelines to Shoreway	**ENR**	11,696 *(2017 SF)*	**Design Capacity:**	4,167 Max Day Demand (gpm)
Estimate:	Conceptual Level Cost-Analysis				

Item No.	Description	Qty	Units	Total Costs $/Unit	Total Capital Cost	Est Facility Life	Annualized Capital Cost	Notes/Source
Facility Capital Costs								
1.0	**Treatment**				**40,270,294**			**Assumes AWPF near SVCW**
### #########	Microfiltration	7.8	MGD	$ 1,200,000	9,411,765	**20**	**632,618**	
### #########	Reverse Osmosis	7.1	MGD	$ 1,800,000	12,705,882	**20**	**854,035**	
### #########	Advanced Oxidation Process (includes UV)	6.0	MGD	$ 300,000	1,800,000	**20**	**120,988**	
### #########	Post Treatment and Chem Handling	6.0	MGD	$ 600,000	3,600,000	**50**	**139,916**	
### #########	Building	6.0	MGD	$ 1,250,000	7,500,000	**50**	**291,491**	5,000 SF/mgd
								250 $/SF
### #########	Land Cost	0	SF	$ -	0			Cost of land NOT included in this analysis
### #########	Off-Site Additional Costs			15%	5,252,647			Account for new access roads, security, lighting, admin building, ancillary facilities, landscaping, etc (apply to above treatment facility costs)
### #########	Nutrient Removal			not incl				Assume NOT included at this time
2.0	**Pipelines**				**60,001,920**	**75**	**2,020,142**	**Assumes repurposing/slip-lining of pipelines near SVCW to Shoreway; then NEW HDPE pipeline in Trench and/or Mic**
### #########	**AWPF near SVCW to Shoreway (repurpose)**							
	Slip Lining (Purified)	15,840	LF	180	2,851,200			18 in-diameter Slipline ($/in-dia-LF)= 10.00
	Major Intersections			not incl				Costs for major intersections not included when microtunneling or sliplining
	Jack and Bore Jacking Pit (30 ft x 12 ft, 11 ft de	8	EA	125,000	990,000			
	Jack and Bore Receiving Pit (30 ft x 12 ft, 11 ft	8	EA	75,000	594,000			
### #########	**Shoreway to South GRR Wells (Purified)**							**Assume 75% open trench and 25% microtunneling (for lack of further alignment info)**
	Open Trench Alignments	28,200	LF	180	5,076,000			12 in-diameter flow (mgd) = 3.0
	Major Intersections	1,500	LF	480	720,000			300 assume LF per major intersection
								12 in-diameter $40 per inch-dia-LF
	Microtunneling (Trenchless)	9,900	LF	2,040	20,196,000			12 in-diameter $170 per inch-dia-LF (microtunneling)
	Microtunnelling Jacking Pit (35 ft deep)	5	EA	125,000	618,750			
	Microtunnelling Receiving Pit (35 ft deep)	5	EA	75,000	371,250			
### #########	**Shoreway to North GRR Wells (Purified)**							**Assume 75% open trench and 25% microtunneling (for lack of further alignment info)**
	Open Trench Alignments	28,200	LF	180	5,076,000			12 in-diameter flow (mgd) = 3.0
	Major Intersections	1,500	LF	480	720,000			300 assume LF per major intersection per inch-dia-LF
								12 in-diameter $40 per inch-dia-LF
	Microtunneling (Trenchless)	9,900	LF	2,040	20,196,000			12 in-diameter $170 per inch-dia-LF (microtunneling)
	Microtunnelling Jacking Pit (35 ft deep)	5	EA	125,000	618,750			
	Microtunnelling Receiving Pit (35 ft deep)	5	EA	75,000	371,250			
### #########	Pipeline Constructability (Along Roads)			10%	1,602,720			**Not including microtunneling**
3.0	**Pump Station**				**3,730,000**	**50**	**144,968**	**Assume one PS (with multiple pumps to deliver water north and south)**
### #########	AWPF near SVCW to GRR Wells (Purified)	1	LS	3,150,000	3,150,000			4,167 total flow (gpm) 625 ft (TDH)
### #########	SVCW to AWPF near SVCW (Tertiary)	1	LS	260,000	260,000			5,447 total flow (gpm) 10 ft (TDH)
### #########	AWPF near SVCW to SVCW (Brine)	1	LS	320,000	320,000			4,167 total flow (gpm) 19 ft (TDH)
4.0	**Storage Tank**				**1,060,000**	**50**	**41,197**	**Assume equalization needed for influent and product water**
### #########	Steel Storage Tanks for EQ Tank (prior to AWTF)		MG	not incl				*Per Justin E. - additional storage in RWC tanks at SVCW could be repupropsed for equalization*
	Alternatively convert RWC for use as EQ tank	1	LS	200,000	200,000			*Placeholder cost provided for new connection from RWC tank to AWTF PS*
### #########	Steel Storage Tanks for Product Water Tank	1	MG	860,000	860,000			
5.0	**Groundwater Wells**				**42,030,000**			**Assume typical costs (well siting information unknown)**
### #########	Injection Wells	18	EA	1,100,000	19,800,000	**30**	**1,010,181**	**Per BAWSA - assume 16 wells (add +2 backup)**
### #########	Monitoring Wells	18	EA	300,000	5,400,000	**20**	**362,965**	**Assume one monitoring well per injection well**
### #########	Extraction Wells	9	EA	1,000,000	9,000,000	**30**	**459,173**	**Per BAWSA - assume 8 wells (add +1 backup)**
	Wellhead Treatment		EA					Unknown wellhead treatment requirements (cost not included)
### #########	Well Constructability			15%	5,130,000	**30**	**261,729**	Well building = 400 SF based on 20 ft x 20 ft
### #########	Buildings for Injection/Extraction Wells	27	EA	100,000	2,700,000	**50**	**104,937**	250 $/SF
### #########	Land Cost		EA					Unknown land purchase costs (cost not included)
	Subtotal Facility Costs				**$147,092,214**		**$6,444,342**	
Additional Facility Capital Costs								
6.0	Site Development Costs	@	5%		7,354,611		322,217	% of Subtotal facility costs
								(Includes grading, erosion control, cut/fill, etc.)
7.0	Yard Piping	@	5%		4,354,515		322,217	% of Subtotal facility costs (not inluding pipelines)
8.0	Electrical, I&C, and Remote (high-tech) Control	@	15%		13,063,544		966,651	% of Subtotal facility costs (not inluding pipelines)
	Subtotal Additional Facility Costs				**$24,772,670**		**$1,611,085**	
			Facility Direct Costs		**$171,864,884**		**$8,055,427**	
	Taxes	@	8.50%		5,001,135		219,108	apply taxes to 40% of the Capital Costs for facilities
	Mobilization/Bonds/Permits	@	5%		8,593,244		402,771	% of Facility Direct Costs
	Engineering and Design	@	10%		17,186,488		805,543	% of Facility Direct Costs
	Special Studies	@	0%		0		0	Not included (note that this may be a significant future cost for the program)
	Environmental/Permitting	@	5%		8,593,244		402,771	% of Facility Direct Costs
	Contractor Overhead & Profit	@	15%		25,779,733		1,208,314	% of Facility Direct Costs
	Estimate Contingency	@	40%		68,745,953		3,222,171	% of Facility Direct Costs
Subtotal with Markups and Contingency					**$305,764,682**		**$14,316,105**	
	Escalation to Midpoint of Construction	@	21%		64,210,583		3,006,382	assume 2% percent over 11
								construction start = 2025 end = 2028
			Project Capital Cost Total		**$369,975,265**		**$17,322,488**	
					Annualualized Capital Costs ($/AF)		**$2,578**	project life = 50 interest rate = 3%
					Annualualized Capital Costs ($/gal)		**$0.008**	

Item No.	Description	Qty	Units	Total Annual Costs $/Unit	Total			
Annual Operations and Maintenance Costs								
### #########	**Energy Costs**							
								Treatment Operation = 24 hours per day
### #########	Energy - Treatment	6,033,655	KWh	0.20	1,206,731			8760 hours operated per year
								2755 KWH/MG
								Pump Operation = 24 hours per day
								8760 hours operated per year
### #########	Energy - Pumping from AWPF near SVCW to GRR	5,881,464	KWh	0.20	1,176,293			Pump Station Hp = 900 Total Motor HP Required to typical well elevation
	Energy - Injection and Extraction	13,230,000	KWh	0.20	2,646,000			Pump Station Hp = 75 Total Motor HP Required per well
### #########	Energy - Other		KWh	10%	238,302			
### #########	**Chemicals**	6,720	AF	101	675,360			
3.0	**Labor Costs**							
### #########	Labor - AWPF	8.0	staff	175,000	1,050,000			full time staff at $175,000 average salary + benefits per year
### #########	Other Labor (pipeline, PS, wells)	2.0	staff	125,000	375,000			full time staff at $125,000 average salary + benefits per year
4.0	**Maintenance:** Other	@	1.5%		5,549,629			% of capital cost
4.1	Equipment (Maintenance/Replacement/Repair)	6,720	AF	167.40	1,124,928			
5.0	**Contingency**	@	10.0%		1,404,224			% of above O&M costs
			Annual O&M Costs ($/year)		**$15,446,467**			
			Annual Unit O&M Costs ($/AF)		**$2,300**			
			Annual Unit O&M Costs ($/gal)		**$0.007**			

Engineers Opinion of Probable Cost — **KENNEDY/JENKS CONSULTANTS**

Alt 1.3 - GRRP(6 mgd) San Mateo Plain - HW 101 AWPF + Repurpose Pipeline to Shoreway

Study:	Potable Reuse Exploratory Plan (PREP) Decision Tool	**Prepared By:**	MT, DTT	**Average Annual Influent Flow:**	7.84 mgd
Project:	GRR in San Mateo Plain	**Date Prepared:**	Jun-2017	**Average Annual Product Flow:**	6.00 mgd
AWPF Locatio	AWPF at HW 101 Site	**K/J Proj. No.**	1668011.01	**RW Delivered:**	6720 Average Annual Reuse (AFY)
Repurpose:	RWC Tank + Repurpose pipelines to Shoreway	**ENR**	11,696 *(2017 SF)*	**Design Capacity:**	4,167 Max Day Demand (gpm)
Estimate:	Conceptual Level Cost-Analysis				

Item No.	Description	Qty	Units	Total Costs $/Unit	Total Capital Cost	Est Facility Life	Annualized Capital Cost	Notes/Source
Facility Capital Costs								
1.0	**Treatment**				**40,270,294**			**Assumes AWPF at HW 101 Site**
### #########	Microfiltration	7.8	MGD	$ 1,200,000	9,411,765	**20**	**632,618**	
### #########	Reverse Osmosis	7.1	MGD	$ 1,800,000	12,705,882	**20**	**854,035**	
### #########	Advanced Oxidation Process (includes UV)	6.0	MGD	$ 300,000	1,800,000	**20**	**120,988**	
### #########	Post Treatment and Chem Handling	6.0	MGD	$ 600,000	3,600,000	**50**	**139,916**	
### #########	Building	6.0	MGD	$ 1,250,000	7,500,000	**50**	**291,491**	5,000 SF/mgd
								250 $/SF
### #########	Land Cost	0	SF	not incl				Cost of land NOT included in this analysis
### #########	Off-Site Additional Costs			15%	5,252,647			Account for new access roads, security, lighting, admin building, ancillary facilities, landscaping, etc (apply to above treatment facility costs)
### #########	Nutrient Removal			not incl				Assume NOT included at this time
2.0	**Pipelines**				**60,233,917**	**75**	**2,027,953**	**Assumes repurposing/slip-lining of pipelines near SVCW to Shoreway; then NEW HDPE pipeline in Trench and/or Microt**
### #########	**SVCW to Shoreway (repurpose)**							
	Tertiary - SVCW to Shoreway (Tertiary)		LF	not incl				Reuse Redwood City purple pipe from SVCW to Hwy 101 (assume delivery to edge of site)
	Brine pipeline material - SVCW to Shoreway (I	15,840	LF	19	38,106			10 in-diameter HDPE Cost ($/LF)= 19.1
	Slip Lining (Brine)	15,840	LF	100	1,584,000			slipline ($/in-dia-LF)= 10
	Major Intersections							Costs for major intersections not included when microtunneling or sliplining
	Jack and Bore Jacking Pit (30 ft x 12 ft, 11 ft d	8	EA	125,000	990,000			
	Jack and Bore Receiving Pit (30 ft x 12 ft, 11 ft	8	EA	75,000	594,000			
### #########	**Shoreway to HW 101 AWPF Site**							
	Shoreway to HW 101 AWPF (Tertiary)	2,000	LF	300	600,000			20 in-diameter flow (mgd) = 7.8
	HW 101 AWPF to Shoreway (Brine)	2,000	LF	150	300,000			10 in-diameter flow (mgd) = 1.8
### #########	**HW 101 AWPF Site to Shoreway**							
	HW 101 AWPF to Shoreway (Purified)	2,000	LF	270	540,000			18 in-diameter flow (mgd) = 6.0
### #########	**Shoreway to South GRR Wells (Purified)**							**Assume 75% open trench and 25% microtunneling (for lack of further alignment info)**
	Open Trench Alignments	28,200	LF	180	5,076,000			12 in-diameter flow (mgd) =
	Major Intersections	1,500	LF	480	720,000			300 assume LF per major intersection
								12 in-diameter $40 per inch-dia-LF
	Microtunneling (Trenchless)	9,900	LF	2,040	20,196,000			12 in-diameter $170 per inch-dia-LF (microtunneling)
	Microtunnelling Jacking Pit (35 ft deep)	5	EA	125,000	618,750			
	Microtunnelling Receiving Pit (35 ft deep)	5	EA	75,000	371,250			
### #########	**Shoreway to North GRR Wells (Purified)**							**Assume 75% open trench and 25% microtunneling (for lack of further alignment info)**
	Open Trench Alignments	28,200	LF	180	5,076,000			12 in-diameter flow (mgd) = 3.0
	Major Intersections	1,500	LF	480	720,000			300 assume LF per major intersection
								12 in-diameter $40 per inch-dia-LF
	Microtunneling (Trenchless)	9,900	LF	2,040	20,196,000			12 in-diameter $170 per inch-dia-LF (microtunneling)
	Microtunnelling Jacking Pit (35 ft deep)	5	EA	125,000	618,750			
	Microtunnelling Receiving Pit (35 ft deep)	5	EA	75,000	371,250			
### #########	Pipeline Constructability (Along Roads)			10%	1,623,811			**Not including microtunneling**
3.0	**Pump Station**				**4,000,000**	**50**	**155,462**	**Assume one PS (with multiple pumps to deliver water north and south)**
### #########	HW 101 AWPF to GRR Wells (Purified)	1	LS	2,540,000	2,540,000			4,167 total flow (gpm) 520 ft (TDH)
### #########	SVCW to HW 101 AWPF (Tertiary)	1	LS	910,000	910,000			5,447 total flow (gpm) 106 ft (TDH)
### #########	HW 101 AWPF to SVCW (Brine)	1	LS	550,000	550,000			1,280 total flow (gpm) 236 ft (TDH)
4.0	**Storage Tank**				**1,060,000**	**50**	**41,197**	**Assume equalization needed for influent and product water**
### #########	Steel Storage Tanks for EQ Tank (prior to AWTF)		MG	not incl				*Per Justin E. - additional storage in RWC tanks at SVCW could be repupropsed for equalization*
	Alternatively convert RWC for use as EQ tank	1	LS	200,000	200,000			*Placeholder cost provided for new connection from RWC tank to AWTF PS*
### #########	Steel Storage Tanks for Product Water Tank	1	MG	860,000	860,000			
5.0	**Groundwater Wells**				**42,030,000**			**Assume typical costs (well siting information unknown)**
### #########	Injection Wells	18	EA	1,100,000	19,800,000	**30**	**1,010,181**	**Per BAWSA - assume 16 wells (add +2 backup)**
### #########	Monitoring Wells	18	EA	300,000	5,400,000	**20**	**362,965**	**Assume one monitoring well per injection well**
### #########	Extraction Wells	9	EA	1,000,000	9,000,000	**30**	**459,173**	**Per BAWSA - assume 8 wells (add +1 backup)**
	Wellhead Treatment		EA					Unknown wellhead treatment requirements (cost not included)
### #########	Well Constructability			15%	5,130,000	**30**	**261,729**	Well building = 400 SF based on 20 ft x 20 ft
### #########	Buildings for Injection/Extraction Wells	27	EA	100,000	2,700,000	**50**	**104,937**	250 $/SF
### #########	Land Cost		EA					Unknown land purchase costs (cost not included)
	Subtotal Facility Costs				**$147,594,211**		**$6,462,646**	
Additional Facility Capital Costs								
6.0	Site Development Costs	@	5%		7,379,711		323,132	% of Subtotal facility costs
								(Includes grading, erosion control, cut/fill, etc.)
7.0	Yard Piping	@	5%		4,368,015		323,132	% of Subtotal facility costs (not inluding pipelines)
8.0	Electrical, I&C, and Remote (high-tech) Control	@	15%		13,104,044		969,397	% of Subtotal facility costs (not inluding pipelines)
	Subtotal Additional Facility Costs				**$24,851,769**		**$1,615,662**	
	Facility Direct Costs				**$172,445,980**		**$8,078,308**	
	Taxes	@	8.50%		5,018,203		219,730	apply taxes to 40% of the Capital Costs for facilities
	Mobilization/Bonds/Permits	@	5%		8,622,299		403,915	% of Facility Direct Costs
	Engineering and Design	@	10%		17,244,598		807,831	% of Facility Direct Costs
	Special Studies	@	0%		0		0	Not included (note that this may be a significant future cost for the program)
	Environmental/Permitting	@	5%		8,622,299		403,915	% of Facility Direct Costs
	Contractor Overhead & Profit	@	15%		25,866,897		1,211,746	% of Facility Direct Costs
	Estimate Contingency	@	40%		68,978,392		3,231,323	% of Facility Direct Costs
Subtotal with Markups and Contingency					**$306,798,668**		**$14,356,769**	
	Escalation to Midpoint of Construction	@	21%		64,427,720		3,014,921	assume 2% percent over 11
								construction start = 2025 end = 2028
	Project Capital Cost Total				**$371,226,389**		**$17,371,690**	
	Annualualized Capital Costs ($/AF)						**$2,585**	project life = 50 interest rate = 3%
	Annualualized Capital Costs ($/gal)						**$0.008**	

Annual Operations and Maintenance Costs

Item No.	Description	Qty	Units	Total Annual Costs $/Unit	Total			
### #########	**Energy Costs**							
								Treatment Operation = 24 hours per day
### #########	Energy - Treatment	6,033,655	KWh	0.20	1,206,731			8760 hours operated per year
								2755 KWH/MG
								Pump Operation = 24 hours per day
								8760 hours operated per year
### #########	Energy - Pumping from HW 101 AWPF to GRR	5,881,464	KWh	0.20	1,176,293			Pump Station Hp = 900 Total Motor HP Required to typical well elevation
	Energy - Injection and Extraction	13,230,000	KWh	0.20	2,646,000			Pump Station Hp = 75 Total Motor HP Required per well
### #########	Energy - Other		KWh	10%	238,302			
### #########	**Chemicals**	6,720	AF	101	675,360			
3.0	**Labor Costs**							
### #########	Labor - AWPF	8.0	staff	175,000	1,050,000			full time staff at $175,000 average salary + benefits per year
### #########	Other Labor (pipeline, PS, wells)	2.0	staff	125,000	375,000			full time staff at $125,000 average salary + benefits per year
4.0	**Maintenance:** Other	@	1.5%		5,568,396			% of capital cost
4.1	Equipment (Maintenance/Replacement/Repair)	6,720	AF	167.40	1,124,928			
5.0	**Contingency**	@	10.0%		1,406,101			% of above O&M costs
	Annual O&M Costs ($/year)				**$15,467,111**			
	Annual Unit O&M Costs ($/AF)				**$2,300**			
	Annual Unit O&M Costs ($/gal)				**$0.007**			

Engineers Opinion of Probable Cost
Alt 2a.1 - SWA (6 mgd) Crystal Springs Res - AWPF near SVCW

KENNEDY/JENKS CONSULTANTS

Study: Potable Reuse Exploratory Plan (PREP) Decision Tool
Project: SWA at Crystal Springs Reservoir
AWPF Locatio AWPF near SVCW
Repurpose: RWC Tank
Estimate: Conceptual Level Cost-Analysis

Prepared By: MT, DTT
Date Prepared: Jun-2017
K/J Proj. No. 1668011.01
ENR 11,696 *(2017 SF)*

Average Annual Influent Flow: 7.84 mgd
Average Annual Product Flow: 6.00 mgd
RW Delivered: 6720 Average Annual Reuse (AFY)
Design Capacity: 4,167 Max Day Demand (gpm)

Item No.	Description	Qty	Units	Total Costs $/Unit	Total Capital Cost	Est Facility Life	Annualized Capital Cost	Notes/Source
Facility Capital Costs								
1.0	**Treatment**				**40,270,294**			**Assumes AWPF near SVCW**
### ########	Microfiltration	7.8	MGD	$ 1,200,000	9,411,765	**20**	**632,618**	
### ########	Reverse Osmosis	7.1	MGD	$ 1,800,000	12,705,882	**20**	**854,035**	
### ########	Advanced Oxidation Process (includes UV)	6.0	MGD	$ 300,000	1,800,000	**20**	**120,988**	
### ########	Post Treatment and Chem Handling	6.0	MGD	$ 600,000	3,600,000	**50**	**139,916**	
### ########	Building	6.0	MGD	$ 1,250,000	7,500,000	**50**	**291,491**	5,000 SF/mgd
								250 $/SF
### ########	Land Cost	0	SF	not incl				Cost of land NOT included in this analysis
### ########	Off-Site Additional Costs			15%	5,252,647			Account for new access roads, security, lighting, admin building, ancillary facilities, landscaping, etc (apply to above treatment facility costs)
### ########	Nutirent Removal			not incl				Costs for Nutrient removal NOT included in this analysis
### ########	Dechlorination			not incl				Assume use of Pulgas Dechlorination Facility (costs NOT included)
2.0	**Pipelines**				**84,086,980**	**75**	**2,831,037**	**Assumes NEW pipeline in Trench**
### ########	**AWPF near SVCW to Shoreway (open trench)**	14,340	LF	270	3,871,800			18 in-diameter flow (mgd) = 6.0
	Major intersections	1,500	LF	720	1,080,000			18 in-diameter $40 per inch-dia-LF (major intersection)
								300 assume LF per major intersection
### ########	**Microtunnel from Shoreway to Woodside Road**							5 assume 10 major intersections
	Microtunneling (Trenchless)	13,600	LF	3,060	41,616,000			
	Microtunnelling Jacking Pit (35 ft deep)	7	EA	125,000	850,000			18 in-diameter $170 per inch-dia-LF (microtenneling)
	Microtunnelling Receiving Pit (35 ft deep)	7	EA	75,000	510,000			18 in-diameter $170 per inch-dia-LF (river xing)
	River Crossing (Trenchless)	500	LF	3,060	1,530,000			Redwood Creek
### ########	**Open Cut Woodside Road to Bay Division 2**							**Assume 50% open trench and 50% microtunneling (for lack of further alignment info)**
	Open Trench Alignments	3,000	LF	270	810,000			18 in-diameter $15 per inch-dia-LF (trench)
	Major Intersections	1,500	LF	720	1,080,000			18 in-diameter $40 per inch-dia-LF (major intersection)
	Microtunneling (Trenchless)	4,500	LF	3,060	13,770,000			18 in-diameter $170 per inch-dia-LF (microtunneling)
	Microtunnelling Jacking Pit (35 ft deep)	2	EA	600,000	1,200,000			
	Microtunnelling Receiving Pit (35 ft deep)	2	EA	500,000	1,000,000			
### ########	**Open Cut from Bay Division 2 to I-280 Tunnel**							
	Open Cut Pipeline	19,000	LF	270	5,130,000			18 in-diameter $15 per inch-dia-LF (trench)
	Major Intersections	1,500	LF	720	1,080,000			18 in-diameter $40 per inch-dia-LF (major intersection)
### ########	**Microtunnel Under I-280**							**Assume microtunneling under I-280**
	Miscellaneous Crossing (Trenchless)	1,500	LF	3,060	4,590,000			18 in-diameter $170 per inch-dia-LF
	Microtunnelling Jacking Pit (35 ft deep)	1	EA	600,000	600,000			
	Microtunnelling Receiving Pit (35 ft deep)	1	EA	500,000	500,000			
### ########	**Open Cut from I-280 Tunnel to Dechlor Facility**	12,000	LF	270	3,240,000			18 in-diameter $15 per inch-dia-LF (trench)
### ########	**Pipeline Constructability**			10%	1,629,180			does not apply to microtunneling
3.0	**Pump Station**				**4,320,000**	**50**	**167,899**	
### ########	AWPF Near SVCW to CSR Discharge Point (Purified)	1	LS	3,740,000	3,740,000			4,200 total flow (gpm) 769 ft (TDH)
### ########	SVCW to AWPF near SVCW (Tertiary)	1	LS	260,000	260,000			5,447 total flow (gpm) 10 ft (TDH)
### ########	AWPF near SVCW to SVCW (Brine)	1	LS	320,000	320,000			4,167 total flow (gpm) 19 ft (TDH)
4.0	**Storage Tank**				**1,060,000**	**50**	**41,197**	**Assume equalization needed for influent and product water**
### ########	Steel Storage Tanks for EQ Tank (prior to AWTF)		MG	not incl				*Per Justin E. - additional storage in RWC tanks at SVCW could be repupropsed for equalization*
	Alternately convert RWC for use as EQ tank	1	LS	200,000	200,000			*Placeholder cost provided for new connection from RWC tank to AWTF*
### ########	Steel Storage Tanks for Product Water Tank	1	MG	860,000	860,000			
5.0	**Discharge Facility**				**1,000,000**	**50**	**38,865**	
### ########	Assume expansion of existing discharge facility	1	LS	1,000,000	1,000,000			**Assume some modification to existing discharge facility near Pulgas Water Temple**
								(downstream of dechlorination faiclity)
	Subtotal Facility Costs				**$130,737,274**		**$5,118,048**	
Additional Facility Capital Costs								
5.0	Site Development Costs	@	5%		6,536,864		255,902	% of Subtotal facility costs
								(Includes grading, erosion control, cut/fill, etc.)
6.0	Yard Piping	@	5%		2,332,515		114,351	% of Subtotal facility costs (not inluding pipelines)
7.0	Electrical, I&C, and Remote (high-tech) Control	@	15%		6,997,544		343,052	% of Subtotal facility costs (not inluding pipelines)
	Subtotal Additional Facility Costs				**$15,866,923**		**$713,304**	
	Facility Direct Costs				**$146,604,197**		**$5,831,352**	
	Taxes	@	8.50%		4,445,067		174,014	apply taxes to 40% of the Capital Costs for facilities
	Mobilization/Bonds/Permits	@	5%		7,330,210		291,568	% of Facility Direct Costs
	Engineering and Design	@	10%		14,660,420		583,135	% of Facility Direct Costs
	Special Studies	@	0%		0		0	Not included (note that this may be a significant future cost for the program)
	Environmental/Permitting	@	5%		7,330,210		291,568	% of Facility Direct Costs
	Contractor Overhead & Profit	@	15%		21,990,629		874,703	% of Facility Direct Costs
	Estimate Contingency	@	40%		58,641,679		2,332,541	% of Facility Direct Costs
Subtotal with Markups and Contingency					**$261,002,411**		**$10,378,880**	
	Escalation to Midpoint of Construction	@	23%		60,030,555		2,387,142	assume 2% percent over 12
								construction start = 2026 end = 2029
	Project Capital Cost Total				**$321,032,966**		**$12,766,022**	
	Annualualized Capital Costs ($/AF)						**$1,900**	project life = 50 interest rate = 3%
	Annualualized Capital Costs ($/gal)						**$0.006**	

Annual Operations and Maintenance Costs

Item No.	Description	Qty	Units	Total Annual Costs $/Unit	Total		Notes
### ########	**Energy Costs**						
### ########	Energy - Treatment	6,033,655	KWh	0.20	1,206,731		Treatment Operation 24 hours per day
							8760 hours operated per year
							2755 KWH/MG
### ########	Energy - Pumping from AWPF near SVCW to CSR	7,188,456	KWh	0.20	1,437,691		Pump Operation = 24 hours per day
							8760 hours operated per year
### ########	Energy - Other		KWh	10%	264,442		Pump Station Hp = 1,100 Total Motor HP Required
### ########	**Chemicals**	6,720	AF	101	675,360		
3.0	**Labor Costs**						
### ########	Labor - AWPF	8.0	staff	175,000	1,050,000		full time staff at $175,000 average salary + benefits per year
### ########	Other Labor (pipeline, PS, wells)	2.0	staff	125,000	375,000		full time staff at $125,000 average salary + benefits per year
4.0	**Maintenance:** Other	@	1.5%		4,815,494		% of capital cost
4.1	Equipment (Maintenance/Replacement/Repair)	6,720	AF	167.40	1,124,928		
5.0	**Contingency**	@	10.0%		1,094,965		% of above O&M costs
	Annual O&M Costs ($/year)				**$12,044,612**		
	Annual Unit O&M Costs ($/AF)				**$1,800**		
	Annual Unit O&M Costs ($/gal)				**$0.005**		

APPENDIX B

Engineers Opinion of Probable Cost — **KENNEDY/JENKS CONSULTANTS**

Alt 2a.2 - SWA (6 mgd) Crystal Springs Res - AWPF near SVCW + Repurpose Pipelines to Woodside

Study:	Potable Reuse Exploratory Plan (PREP) Decision Tool	**Prepared By:**	MT, DTT	**Average Annual Influent Flow:**	7.84 mgd
Project:	SWA at Crystal Springs Reservoir	**Date Prepared:**	Jun-2017	**Average Annual Product Flow:**	6.00 mgd
AWPF Locatio	AWPF near SVCW	**K/J Proj. No.**	1668011.01	**RW Delivered:**	6720 Average Annual Reuse (AFY)
Repurpose:	RWC Tank + Repurpose pipelines to Woodside	**ENR**	11,696 *(2017 SF)*	**Design Capacity:**	4,167 Max Day Demand (gpm)
Estimate:	Conceptual Level Cost-Analysis				

Item No.	Description	Qty	Units	Total Costs $/Unit	Total Capital Cost	Est Facility Life	Annualized Capital Cost	Notes/Source
Facility Capital Costs								
1.0	**Treatment**				**40,270,294**			**Assumes AWPF near SVCW**
### #########	Microfiltration	7.8	MGD	$ 1,200,000	9,411,765	**20**	**632,618**	
### #########	Reverse Osmosis	7.1	MGD	$ 1,800,000	12,705,882	**20**	**854,035**	
### #########	Advanced Oxidation Process (includes UV)	6.0	MGD	$ 300,000	1,800,000	**20**	**120,988**	
### #########	Post Treatment and Chem Handling	6.0	MGD	$ 600,000	3,600,000	**50**	**139,916**	
### #########	Building	6.0	MGD	$ 1,250,000	7,500,000	**50**	**291,491**	5,000 SF/mgd
								250 $/SF
### #########	Land Cost	0	SF	not incl				Cost of land NOT included in this analysis
### #########	Off-Site Additional Costs			15%	5,252,647			Account for new access roads, security, lighting, admin building, ancillary facilities, landscaping, etc (apply to above treatment facility costs)
### #########	Nutirent Removal			not incl				Costs for Nutrient removal NOT included in this analysis
### #########	Dechlorination			not incl				Assume use of Pulgas Dechlorination Facility (costs NOT included)
2.0	**Pipelines**				**59,623,020**	**75**	**2,007,386**	**Assumes repurposing/slip-lining of pipelines near SVCW to Shoreway; then NEW HDPE pipeline in Trench and**
### #########	**AWPF near SVCW to Shoreway (repurpose)**		LF	270	0			18 in-diameter flow (mgd) = 6.0
	Slip Lining (Purified)	15,840	LF	180	2,581,200			18 in-diameter ipline ($/in-dia-LF)= 10.00
	Major Intersections							Costs for major intersections not included when microtunneling or sliplining
	Jack and Bore Jacking Pit (30 ft x 12 ft, 11 ft	8	EA	125,000	990,000			
	Jack and Bore Receiving Pit (30 ft x 12 ft, 11	8	EA	75,000	594,000			
### #########	**New Pipe from Shoreway to start of "Unit 3"**							
	Open Cut Pipeline (Purified)	2,000	LF	270	540,000			18 in-diameter
### #########	**Reuse 54"/48" dia pipeline on Unit 3 and 2 Alignment to Woodside Road**							
	Purified - SVCW to HW 101 AWPF	8,700	LF	60	522,000			18 in-diameter HDPE Cost ($/LF)= 60.0
	Slip Lining (Purified)	8,700	LF	180	1,566,000			18 in-diameter ipline ($/in-dia-LF)= 10.00
	Jack and Bore Jacking Pit (30 ft x 12 ft, 11 ft	4	EA	125,000	500,000			
	Jack and Bore Receiving Pit (30 ft x 12 ft, 11	4	EA	75,000	300,000			
### #########	**Microtunnel remaining sections to Woodside**							18 in-diameter
	Microtunneling (Trenchless)	4,900	LF	3,060	14,994,000			
	Microtunnelling Jacking Pit (35 ft deep)	2	EA	125,000	306,250			18 in-diameter $170 per inch-dia-LF (microtunneling)
	Microtunnelling Receiving Pit (35 ft deep)	2	EA	125,000	306,250			Redwood Creek
	River Crossing (Trenchless)	500	LF	3,060	1,530,000			18 in-diameter $170 per inch-dia-LF (river xing)
### #########	**Open Cut Woodside Road to Bay Division 2**							**Assume 50% open trench and 50% microtunneling (for lack of further alignment info)**
	Open Trench Alignments	3,000	LF	270	810,000			18 in-diameter $15 per inch-dia-LF (trench)
	Major Intersections	1,500	LF	720	1,080,000			18 in-diameter $40 per inch-dia-LF (major intersection)
	Microtunneling (Trenchless)	4,500	LF	3,060	13,770,000			18 in-diameter $170 per inch-dia-LF (microtunneling)
	Microtunnelling Jacking Pit (35 ft deep)	2	EA	600,000	1,200,000			
	Microtunnelling Receiving Pit (35 ft deep)	2	EA	500,000	1,000,000			
### #########	**Open Cut from Bay Division 2 to I-280 Tunnel**							
	Open Cut Pipeline	19,000	LF	270	5,130,000			18 in-diameter $15 per inch-dia-LF (trench)
	Major Intersections	1,500	LF	720	1,080,000			18 in-diameter $40 per inch-dia-LF (major intersection)
### #########	**Microtunnel Under I-280**							**Assume microtunneling under I-280**
	Miscellaneous Crossing (Trenchless)	1,500	LF	3,060	4,590,000			18 in-diameter $170 per inch-dia-LF
	Microtunnelling Jacking Pit (35 ft deep)	1	EA	600,000	600,000			
	Microtunnelling Receiving Pit (35 ft deep)	1	EA	500,000	500,000			
### #########	**Open Cut from I-280 Tunnel to Dechlor Facility**	12,000	LF	270	3,240,000			18 in-diameter $15 per inch-dia-LF (trench)
### #########	**Pipeline Constructability**			10%	1,893,320			does not apply to microtunneling
3.0	**Pump Station**				**4,320,000**	**50**	**167,899**	
### #########	AWPF Near SVCW to CSR Discharge Point (Purified)	1	LS	3,740,000	3,740,000			4,200 total flow (gpm) 769 ft (TDH)
### #########	SVCW to AWPF near SVCW (Tertiary)	1	LS	260,000	260,000			5,447 total flow (gpm) 10 ft (TDH)
### #########	AWPF near SVCW to SVCW (Brine)	1	LS	320,000	320,000			4,167 total flow (gpm) 19 ft (TDH)
4.0	**Storage Tank**				**1,060,000**	**50**	**41,197**	**Assume equalization needed for influent and product water**
### #########	Steel Storage Tanks for EQ Tank (prior to AWTF)		MG	not incl				*Per Justin E. - additional storage in RWC tanks at SVCW could be repupropsed for equalization*
	Alternately convert RWC for use as EQ tank	1	LS	200,000	200,000			*Placeholder cost provided for new connection from RWC tank to AWTF*
### #########	Steel Storage Tanks for Product Water Tank	1	MG	860,000	860,000			
5.0	**Discharge Facility**				**1,000,000**	**50**	**38,865**	
### #########	Assume expansion of existing discharge facility	1	LS	1,000,000	1,000,000			**Assume some modification to existing discharge facility near Pulgas Water Temple**
								(downstream of dechlorination faiclity)
	Subtotal Facility Costs				**$106,273,314**		**$4,294,396**	
Additional Facility Capital Costs								
5.0	Site Development Costs	@	5%		5,313,666		214,720	% of Subtotal facility costs
								(Includes grading, erosion control, cut/fill, etc.)
6.0	Yard Piping	@	5%		2,332,515		114,351	% of Subtotal facility costs (not inluding pipelines)
7.0	Electrical, I&C, and Remote (high-tech) Control	@	15%		6,997,544		343,052	% of Subtotal facility costs (not inluding pipelines)
	Subtotal Additional Facility Costs				**$14,643,725**		**$672,122**	
	Facility Direct Costs				**$120,917,039**		**$4,966,518**	
	Taxes	@	8.50%		3,613,293		146,009	apply taxes to 40% of the Capital Costs for facilities
	Mobilization/Bonds/Permits	@	5%		6,045,852		248,326	% of Facility Direct Costs
	Engineering and Design	@	10%		12,091,704		496,652	% of Facility Direct Costs
	Special Studies	@	0%		0		0	Not included (note that this may be a significant future cost for the program)
	Environmental/Permitting	@	5%		6,045,852		248,326	% of Facility Direct Costs
	Contractor Overhead & Profit	@	15%		18,137,556		744,978	% of Facility Direct Costs
	Estimate Contingency	@	40%		48,366,815		1,986,607	% of Facility Direct Costs
Subtotal with Markups and Contingency					**$215,218,110**		**$8,837,416**	
	Escalation to Midpoint of Construction	@	23%		49,500,165		2,032,606	assume 2% percent over 12
								construction start = 2026 end = 2029
	Project Capital Cost Total				**$264,718,276**		**$10,870,022**	
	Annualualized Capital Costs ($/AF)						**$1,618**	project life = 50 interest rate = 3%
	Annualualized Capital Costs ($/gal)						**$0.005**	

Annual Operations and Maintenance Costs

Item No.	Description	Qty	Units	Total Annual Costs $/Unit	Total		
### #########	**Energy Costs**						
### #########	Energy - Treatment	6,033,655	KWh	0.20	1,206,731		Treatment Operatior 24 hours per day
							8760 hours operated per year
							2755 KWH/MG
### #########	Energy - Pumping from AWPF near SVCW to CSR	7,188,456	KWh	0.20	1,437,691		Pump Operation = 24 hours per day
							8760 hours operated per year
### #########	Energy - Other		KWh	10%	264,442		Pump Station Hp = 1,100 Total Motor HP Required
### #########	**Chemicals**	6,720	AF	101	675,360		
3.0	**Labor Costs**						
### #########	Labor - AWPF	8.0	staff	175,000	1,050,000		full time staff at $175,000 average salary + benefits per year
### #########	Other Labor (pipeline, PS, wells)	2.0	staff	125,000	375,000		full time staff at $125,000 average salary + benefits per year
4.0	**Maintenance:** Other	@	1.5%		3,970,774		% of capital cost
4.1	Equipment (Maintenance/Replacement/Repair)	6,720	AF	167.40	1,124,928		
5.0	**Contingency**	@	10.0%		1,010,493		% of above O&M costs
	Annual O&M Costs ($/year)				**$11,115,419**		
	Annual Unit O&M Costs ($/AF)				**$1,600**		
	Annual Unit O&M Costs ($/gal)				**$0.005**		

APPENDIX B

Engineers Opinion of Probable Cost
Alt 2a.3 - SWA (6 mgd) Crystal Springs Res - HW 101 AWPF + Repurpose Pipeline to Woodside

KENNEDY/JENKS CONSULTANTS

Study:	Potable Reuse Exploratory Plan (PREP) Decision Tool	**Prepared By:**	MT, DTT
Project:	SWA at Crystal Springs Reservoir	**Date Prepared:**	Jun-2017
AWPF Locati	AWPF at HW 101 Site	**K/J Proj. No.**	1668011.01
Repurpose:	RWC Tank + Repurpose pipelines to Woodside	**ENR**	11,696 *(2017 SF)*
Estimate:	Conceptual Level Cost-Analysis		

Average Annual Influent Flow:	7.84	mgd
Average Annual Product Flow:	6.00	mgd
RW Delivered:	6720	Average Annual Reuse (AFY)
Design Capacity:	4,167	Max Day Demand (gpm)

Item No.	Description	Qty	Units	Total Costs $/Unit	Total Capital Cost	Est Facility Life	Annualized Capital Cost	Notes/Source
Facility Capital Costs								
1.0	**Treatment**				**40,270,294**			**Assumes AWPF at HW 101 Site**
### ########	Microfiltration	7.8	MGD	$ 1,200,000	9,411,765	**20**	**632,618**	
### ########	Reverse Osmosis	7.1	MGD	$ 1,800,000	12,705,882	**20**	**854,035**	
### ########	Advanced Oxidation Process (includes UV)	6.0	MGD	$ 300,000	1,800,000	**20**	**120,988**	
### ########	Post Treatment and Chem Handling	6.0	MGD	$ 600,000	3,600,000	**50**	**139,916**	
### ########	Building	6.0	MGD	$ 1,250,000	7,500,000	**50**	**291,491**	5,000 SF/mgd
								250 $/SF
### ########	Land Cost		SF	not incl				Cost of land NOT included in this analysis
### ########	Off-Site Additional Costs			15%	5,252,647			Account for new access roads, security, lighting, admin building, ancillary facilities, landscaping, etc (apply to above treatment facility costs)
### ########	Nutrient Removal			not incl				Costs for Nutrient removal NOT included in this analysis
### ########	Dechlorination			not incl				Assume use of Pulgas Dechlorination Facility (costs NOT included)
2.0	**Pipelines**				**60,152,017**	**75**	**2,025,196**	**Assumes NEW pipeline in Trench**
### ########	**SVCW to Shoreway (repurpose)**							18 in-diameter flow (mgd) = 6.0
	Tertiary - SVCW to Shoreway (Tertiary)		LF	not incl				Reuse Redwood City purple pipe from SVCW to Hwy 101
	Brine pipeline material - SVCW to Shorew	15,840	LF	19	38,106			10 in-diameter HDPE Cost ($/LF)= 19.1
	Slip Lining (Brine)	15,840	LF	100	1,584,000			slipline ($/in-dia-LF)= 10
	Major Intersections							Costs for major intersections not included when microtunneling or sliplining
	Jack and Bore Jacking Pit (30 ft x 12 ft, 11	8	EA	125,000	990,000			
	Jack and Bore Receiving Pit (30 ft x 12 ft, 1	8	EA	75,000	594,000			
### ########	**Shoreway to HW 101 AWPF Site**							
	Shoreway to HW 101 AWPF (Tertiary)	2,000	LF	300	600,000			20 in-diameter flow (mgd) = 7.8
	HW 101 AWPF to Shoreway (Brine)	2,000	LF	150	300,000			10 in-diameter flow (mgd) = 1.8
### ########	**HW 101 AWPF Site to Shoreway**							
	HW 101 AWPF to Shoreway (Purified)	2,000	LF	270	540,000			18 in-diameter flow (mgd) = 6.0
### ########	**New Pipe Shoreway to start of "Unit 3"**							
	Open Cut Pipeline (Purified)	2,000	LF	270	540,000			
### ########	**Reuse 54"/48" dia pipeline on Unit 3 and 2 Alignment to Woodside Road**							
	Purified - SVCW to HW 101 AWPF	8,700	LF	60	522,000			18 in-diameter HDPE Cost ($/LF)= 60.0
	Slip Lining (Purified)	8,700	LF	180	1,566,000			18 in-diameter ipline ($/in-dia-LF)= 10.00
	Jack and Bore Jacking Pit (30 ft x 12 ft, 11	4	EA	125,000	500,000			
	Jack and Bore Receiving Pit (30 ft x 12 ft, 1	4	EA	75,000	300,000			
### ########	**Microtunnel remaining sections to Woodside**							18 in-diameter
	Microtunneling (Trenchless)	4,900	LF	3,060	14,994,000			
	Microtunnelling Jacking Pit (35 ft deep)	2	EA	125,000	306,250			18 in-diameter $170 per inch-dia-LF (microtunneling)
	Microtunnelling Receiving Pit (35 ft deep)	2	EA	125,000	306,250			Redwood Creek
	River Crossing (Trenchless)	500	LF	3,060	1,530,000			18 in-diameter $170 per inch-dia-LF (river xing)
### ########	**Open Cut Woodside Road to Bay Division 2**							**Assume 50% open trench and 50% microtunneling (for lack of further alignment info)**
	Open Trench Alignments	3,000	LF	270	810,000			18 in-diameter $15 per inch-dia-LF (trench)
	Major Intersections	1,500	LF	720	1,080,000			18 in-diameter $40 per inch-dia-LF (major intersection)
	Microtunneling (Trenchless)	4,500	LF	3,060	13,770,000			18 in-diameter $170 per inch-dia-LF (microtunneling)
	Microtunnelling Jacking Pit (35 ft deep)	2	EA	600,000	1,200,000			
	Microtunnelling Receiving Pit (35 ft deep)	2	EA	500,000	1,000,000			
### ########	**Open Cut from Bay Division 2 to I-280 Tunnel**							
	Open Cut Pipeline	19,000	LF	270	5,130,000			18 in-diameter $15 per inch-dia-LF (trench)
	Major Intersections	1,500	LF	720	1,080,000			18 in-diameter $40 per inch-dia-LF (major intersection)
### ########	**Microtunnel Under I-280**							**Assume microtunneling under I-280**
	Miscellaneous Crossing (Trenchless)	1,500	LF	3,060	4,590,000			18 in-diameter $170 per inch-dia-LF
	Microtunnelling Jacking Pit (35 ft deep)	1	EA	600,000	600,000			
	Microtunnelling Receiving Pit (35 ft deep)	1	EA	500,000	500,000			
### ########	**Open Cut from I-280 Tunnel to Dechlor Facility**	12,000	LF	270	3,240,000			18 in-diameter $15 per inch-dia-LF (trench)
### ########	**Pipeline Constructability**			10%	1,941,411			does not apply to microtunneling
3.0	**Pump Station**				**4,900,000**	**50**	**190,441**	
### ########	HW 101 AWPF to CSR Discharge Point (Purified)	1	LS	3,440,000	3,440,000			4,167 total flow (gpm) 756 ft (TDH)
### ########	SVCW to HW 101 AWPF (Tertiary)	1	LS	910,000	910,000			5,447 total flow (gpm) 106 ft (TDH)
### ########	HW 101 AWPF to SVCW (Brine)	1	LS	550,000	550,000			1,280 total flow (gpm) 236 ft (TDH)
4.0	**Storage Tank**				**1,060,000**	**50**	**41,197**	**Assume equalization needed for influent and product water**
### ########	Steel Storage Tanks for EQ Tank (prior to AWTF)		MG	not incl				*Per Justin E. - additional storage in RWC tanks at SVCW could be repupropsed for equalization*
	Alternately convert RWC for use as EQ tank	1	LS	200,000	200,000			*Placeholder cost provided for new connection from RWC tank to AWTF*
### ########	Steel Storage Tanks for Product Water Tank	1	MG	860,000	860,000			
5.0	**Discharge Facility**				**1,000,000**	**50**	**38,865**	
### ########	Assume expansion of existing discharge facility	1	LS	1,000,000	1,000,000			**Assume some modification to existing discharge facility near Pulgas Water Temple**
								(downstream of dechlorination faiclity)
	Subtotal Facility Costs				**$107,382,311**		**$4,334,748**	
Additional Facility Capital Costs								
5.0	Site Development Costs	@	5%		5,369,116		216,737	% of Subtotal facility costs
								(Includes grading, erosion control, cut/fill, etc.)
6.0	Yard Piping	@	5%		2,361,515		115,478	% of Subtotal facility costs (not inluding pipelines)
7.0	Electrical, I&C, and Remote (high-tech) Control	@	15%		7,084,544		346,433	% of Subtotal facility costs (not inluding pipelines)
	Subtotal Additional Facility Costs				**$14,815,174**		**$678,648**	
	Facility Direct Costs				**$122,197,485**		**$5,013,396**	
	Taxes	@	#########		3,650,999		147,381	apply taxes to 40% of the Capital Costs for facilities
	Mobilization/Bonds/Permits	@	5%		6,109,874		250,670	% of Facility Direct Costs
	Engineering and Design	@	10%		12,219,749		501,340	% of Facility Direct Costs
	Special Studies	@	0%		0		0	Not included (note that this may be a significant future cost for the program)
	Environmental/Permitting	@	5%		6,109,874		250,670	% of Facility Direct Costs
	Contractor Overhead & Profit	@	15%		18,329,623		752,009	% of Facility Direct Costs
	Estimate Contingency	@	40%		48,878,994		2,005,358	% of Facility Direct Costs
Subtotal with Markups and Contingency					**$217,496,597**		**$8,920,825**	
	Escalation to Midpoint of Construction	@	23%		50,024,217		2,051,790	assume 2% percent over 12
								construction start = 2026 end = 2029
	Project Capital Cost Total				**$267,520,815**		**$10,972,614**	
	Annualualized Capital Costs ($/AF)						**$1,633**	project life = 50 interest rate = 3%
	Annualualized Capital Costs ($/gal)						**$0.005**	

Annual Operations and Maintenance Costs

Item No.	Description	Qty	Units	Total Annual Costs $/Unit	Total		Notes
### ########	**Energy Costs**						
### ########	Energy - Treatment	6,033,655	KWh	0.20	1,206,731		Treatment Operatior 24 hours per day
							8760 hours operated per year
							2755 KWH/MG
### ########	Energy - Pumping from HW 101 AWPF to CSR	6,534,960	KWh	0.20	1,306,992		Pump Operation = 24 hours per day
							8760 hours operated per year
### ########	Energy - Other		KWh	10%	251,372		Pump Station Hp = 1,000 Total Motor HP Required
### ########	**Chemicals**	6,720	AF	101	675,360		
3.0	**Labor Costs**						
### ########	Labor - AWPF	8.0	staff	175,000	1,050,000		full time staff at $175,000 average salary + benefits per year
### ########	Other Labor (pipeline, PS, wells)	2.0	staff	125,000	375,000		full time staff at $125,000 average salary + benefits per year
4.0	**Maintenance:** Other	@	1.5%		4,012,812		% of capital cost
4.1	Equipment (Maintenance/Replacement/Repair)	6,720	AF	167.40	1,124,928		
5.0	**Contingency**	@	10.0%		1,000,320		% of above O&M costs
	Annual O&M Costs ($/year)				**$11,003,515**		
	Annual Unit O&M Costs ($/AF)				**$1,600**		
	Annual Unit O&M Costs ($/gal)				**$0.005**		

Engineers Opinion of Probable Cost — **KENNEDY/JENKS CONSULTANTS**

Alt 2b.1 - SWA (12 mgd) Crystal Springs Res - AWPF near SVCW

Study:	Potable Reuse Exploratory Plan (PREP) Decision Tool	**Prepared By:**	MT, DTT	**Average Annual Influent Flow:**	15.69 mgd
Project:	SWA at Crystal Springs Reservoir	**Date Prepared:**	Jun-2017	**Average Annual Product Flow:**	12.00 mgd
AWPF Locatio	AWPF near SVCW	**K/J Proj. No.**	1668011.01	**RW Delivered:**	13440 Average Annual Reuse (AFY)
Repurpose:	RWC Tank	**ENR**	11,696 *(2017 SF)*	**Design Capacity:**	8,333 Max Day Demand (gpm)
Estimate:	Conceptual Level Cost-Analysis				

Item No.	Description	Qty	Units	Total Costs $/Unit	Total Capital Cost	Est Facility Life	Annualized Capital Cost	Notes/Source
Facility Capital Costs								
1.0	**Treatment**				**64,746,127**			**Assumes AWPF near SVCW**
### ########	Microfiltration	15.7	MGD	$ 1,000,000	15,686,275	**20**	**1,054,364**	
### ########	Reverse Osmosis	14.1	MGD	$ 1,400,000	19,764,706	**20**	**1,328,499**	
### ########	Advanced Oxidation Process (includes UV)	12.0	MGD	$ 300,000	3,600,000	**20**	**241,977**	
### ########	Post Treatment and Chem Handling	12.0	MGD	$ 500,000	6,000,000	**50**	**233,193**	
### ########	Building	12.0	MGD	$ 937,500	11,250,000	**50**	**437,237**	3,750 SF/mgd
								250 $/SF
### ########	Land Cost	0	SF	not incl				Cost of land NOT included in this analysis
### ########	Off-Site Additional Costs			15%	8,445,147			Account for new access roads, security, lighting, admin building, ancillary facilities, landscaping, etc (apply to above treatment facility costs)
### ########	Nutirent Removal			not incl				Costs for Nutirent removal NOT included in this analysis
### ########	Dechlorination			not incl				Assume use of Pulgas Dechlorination Facility (costs NOT included)
2.0	**Pipelines**				**110,334,016**	**75**	**3,714,722**	**Assumes NEW pipeline in Trench**
### ########	**AWPF near SVCW to Shoreway (open trench)**	14,340	LF	384	5,506,560			24 in-diameter flow (mgd) = 12.0
	Major intersections	1,500	LF	960	1,440,000			24 in-diameter $40 per inch-dia-LF (major intersection)
								300 assume LF per major intersection
### ########	**Microtunnel from Shoreway to Woodside Road**							5 assume 10 major intersections
	Microtunneling (Trenchless)	13,600	LF	4,080	55,488,000			
	Microtunnelling Jacking Pit (35 ft deep)	7	EA	125,000	850,000			24 in-diameter $170 per inch-dia-LF (microtenneling)
	Microtunnelling Receiving Pit (35 ft deep)	7	EA	75,000	510,000			24 in-diameter $170 per inch-dia-LF (river xing)
	River Crossing (Trenchless)	500	LF	4,080	2,040,000			Redwood Creek
### ########	**Open Cut Woodside Road to Bay Division 2**							**Assume 50% open trench and 50% microtunneling (for lack of further alignment info)**
	Open Trench Alignments	3,000	LF	384	1,152,000			24 in-diameter $18 per inch-dia-LF (trench)
	Major Intersections	1,500	LF	960	1,440,000			24 in-diameter $40 per inch-dia-LF (major intersection)
	Microtunneling (Trenchless)	4,500	LF	4,080	18,360,000			24 in-diameter $170 per inch-dia-LF (microtunneling)
	Microtunnelling Jacking Pit (35 ft deep)	2	EA	600,000	1,200,000			
	Microtunnelling Receiving Pit (35 ft deep)	2	EA	500,000	1,000,000			
### ########	**Open Cut from Bay Division 2 to I-280 Tunnel**							
	Open Cut Pipeline	19,000	LF	384	7,296,000			24 in-diameter $18 per inch-dia-LF (trench)
	Major Intersections	1,500	LF	960	1,440,000			24 in-diameter $40 per inch-dia-LF (major intersection)
### ########	**Microtunnel Under I-280**							**Assume microtunneling under I-280**
	Miscellaneous Crossing (Trenchless)	1,500	LF	4,080	6,120,000			24 in-diameter $170 per inch-dia-LF
	Microtunnelling Jacking Pit (35 ft deep)	1	EA	600,000	600,000			
	Microtunnelling Receiving Pit (35 ft deep)	1	EA	500,000	500,000			
### ########	**Open Cut from I-280 Tunnel to Dechlor Facility**	12,000	LF	384	3,240,000			24 in-diameter $18 per inch-dia-LF (trench)
### ########	**Pipeline Constructability**			10%	2,151,456			does not apply to microtunneling
3.0	**Pump Station**				**6,110,000**	**50**	**237,468**	
### ########	AWPF Near SVCW to CSR Discharge Point (Purified)	1	LS	5,470,000	5,470,000			8,300 total flow (gpm) 629 ft (TDH)
### ########	SVCW to AWPF near SVCW (Tertiary)	1	LS	320,000	320,000			10,894 total flow (gpm) 7 ft (TDH)
### ########	AWPF near SVCW to SVCW (Brine)	1	LS	320,000	320,000			2,560 total flow (gpm) 12 ft (TDH)
4.0	**Storage Tank**				**1,612,654**	**50**	**62,677**	**Assume equalization needed for influent and product water**
### ########	Steel Storage Tanks for EQ Tank (prior to AWTF)		MG	not incl				*Per Justin E. - additional storage in RWC tanks at SVCW could be repupropsed for equalization*
	Alternately convert RWC for use as EQ tank	1	LS	200,000	200,000			*Placeholder cost provided for new connection from RWC tank to AWTF*
### ########	Steel Storage Tanks for Product Water Tank	2	MG	706,327	1,412,654			
5.0	**Discharge Facility**				**1,500,000**	**50**	**58,298**	
### ########	Assume expansion of existing discharge facility	1	LS	1,500,000	1,500,000			**Assume some modification to existing discharge facility near Pulgas Water Temple**
								(downstream of dechlorination faiclity)
	Subtotal Facility Costs				**$184,302,798**		**$7,368,434**	
Additional Facility Capital Costs								
5.0	Site Development Costs	@	5%		9,215,140		368,422	% of Subtotal facility costs
								(Includes grading, erosion control, cut/fill, etc.)
6.0	Yard Piping	@	5%		3,698,439		182,686	% of Subtotal facility costs (not inluding pipelines)
7.0	Electrical, I&C, and Remote (high-tech) Control	@	15%		11,095,317		548,057	% of Subtotal facility costs (not inluding pipelines)
	Subtotal Additional Facility Costs				**$24,008,896**		**$1,099,164**	
	Facility Direct Costs				**$208,311,694**		**$8,467,598**	
	Taxes	@	8.50%		6,266,295		250,527	apply taxes to 40% of the Capital Costs for facilities
	Mobilization/Bonds/Permits	@	5%		10,415,585		423,380	% of Facility Direct Costs
	Engineering and Design	@	10%		20,831,169		846,760	% of Facility Direct Costs
	Special Studies	@	0%		0		0	Not included (note that this may be a significant future cost for the program)
	Environmental/Permitting	@	5%		10,415,585		423,380	% of Facility Direct Costs
	Contractor Overhead & Profit	@	15%		31,246,754		1,270,140	% of Facility Direct Costs
	Estimate Contingency	@	40%		83,324,678		3,387,039	% of Facility Direct Costs
Subtotal with Markups and Contingency					**$370,811,760**		**$15,068,823**	
	Escalation to Midpoint of Construction	@	23%		85,286,705		3,465,829	assume 2% percent over 12
								construction start = 2026 end = 2029
	Project Capital Cost Total				**$456,098,465**		**$18,534,652**	
	Annualualized Capital Costs ($/AF)						**$1,379**	project life = 50 interest rate = 3%
	Annualualized Capital Costs ($/gal)						**$0.004**	

Annual Operations and Maintenance Costs

Item No.	Description	Qty	Units	Total Annual Costs $/Unit	Total	Notes
### ########	**Energy Costs**					
### ########	Energy - Treatment	12,067,310	KWh	0.20	2,413,462	Treatment Operation 24 hours per day
						8760 hours operated per year
						2755 KWH/MG
### ########	Energy - Pumping from AWPF near SVCW to CSR	11,109,432	KWh	0.20	2,221,886	Pump Operation = 24 hours per day
						8760 hours operated per year
### ########	Energy - Other		KWh	10%	463,535	Pump Station Hp = 1,700 Total Motor HP Required
### ########	**Chemicals**	13,440	AF	101	1,350,720	
3.0	**Labor Costs**					
### ########	Labor - AWPF	11.0	staff	175,000	1,050,000	full time staff at $175,000 average salary + benefits per year
### ########	Other Labor (pipeline, PS, wells)	2.0	staff	125,000	375,000	full time staff at $125,000 average salary + benefits per year
4.0	**Maintenance:** Other	@	1.5%		6,841,477	% of capital cost
4.1	Equipment (Maintenance/Replacement/Repair)	13,440	AF	157.40	2,115,456	
5.0	**Contingency**	@	10.0%		1,683,154	% of above O&M costs
	Annual O&M Costs ($/year)				**$18,514,690**	
	Annual Unit O&M Costs ($/AF)				**$1,400**	
	Annual Unit O&M Costs ($/gal)				**$0.004**	

APPENDIX B

Engineers Opinion of Probable Cost — **KENNEDY/JENKS CONSULTANTS**

Alt 2b.2 - SWA (12 mgd) Crystal Springs Res - AWPF near SVCW + Repurpose Pipelines to Woodside

Study:	Potable Reuse Exploratory Plan (PREP) Decision Tool	**Prepared By:**	MT, DTT	**Average Annual Influent Flow:**	15.69 mgd
Project:	SWA at Crystal Springs Reservoir	**Date Prepared:**	Jun-2017	**Average Annual Product Flow:**	12.00 mgd
AWPF Locatio	AWPF near SVCW	**K/J Proj. No.**	1668011.01	**RW Delivered:**	13440 Average Annual Reuse (AFY)
Repurpose:	RWC Tank + Repurpose pipelines to Woodside	**ENR**	11,696 *(2017 SF)*	**Design Capacity:**	8,333 Max Day Demand (gpm)
Estimate:	Conceptual Level Cost-Analysis				

Item No.	Description	Qty	Units	Total Costs $/Unit	Total Capital Cost	Est Facility Life	Annualized Capital Cost	Notes/Source
Facility Capital Costs								
1.0	**Treatment**				**64,746,127**			**Assumes AWPF near SVCW**
### #########	Microfiltration	15.7	MGD	$ 1,000,000	15,686,275	**20**	**1,054,364**	
### #########	Reverse Osmosis	14.1	MGD	$ 1,400,000	19,764,706	**20**	**1,328,499**	
### #########	Advanced Oxidation Process (includes UV)	12.0	MGD	$ 300,000	3,600,000	**20**	**241,977**	
### #########	Post Treatment and Chem Handling	12.0	MGD	$ 500,000	6,000,000	**50**	**233,193**	
### #########	Building	12.0	MGD	$ 937,500	11,250,000	**50**	**437,237**	3,750 SF/mgd
								250 $/SF
### #########	Land Cost	0	SF	not incl				Cost of land NOT included in this analysis
### #########	Off-Site Additional Costs			15%	8,445,147			Account for new access roads, security, lighting, admin building, ancillary facilities, landscaping, etc (apply to above treatment facility costs)
### #########	Nutirent Removal			not incl				Costs for Nutrient removal NOT included in this analysis
### #########	Dechlorination			not incl				Assume use of Pulgas Dechlorination Facility (costs NOT included)
2.0	**Pipelines**				**75,626,820**	**75**	**2,546,201**	**Assumes repurposing/slip-lining of pipelines near SVCW to Shoreway; then NEW HDPE pipeline in Trench and**
### #########	**AWPF near SVCW to Shoreway (repurpose)**		LF	384	0			24 in-diameter flow (mgd) = 12.0
	Slip Lining (Purified)	15,840	LF	180	2,581,200			24 in-diameter ipline ($/in-dia-LF)= 10.00
	Major Intersections							Costs for major intersections not included when microtunneling or sliplining
	Jack and Bore Jacking Pit (30 ft x 12 ft, 11 ft	8	EA	125,000	990,000			
	Jack and Bore Receiving Pit (30 ft x 12 ft, 11	8	EA	75,000	594,000			
### #########	**New Pipe from Shoreway to start of "Unit 3"**							
	Open Cut Pipeline (Purified)	2,000	LF	384	768,000			24 in-diameter
### #########	**Reuse 54"/48" dia pipeline on Unit 3 and 2 Alignment to Woodside Road**							
	Purified - SVCW to HW 101 AWPF	8,700	LF	60	522,000			24 in-diameter HDPE Cost ($/LF)= 60.0
	Slip Lining (Purified)	8,700	LF	240	2,088,000			24 in-diameter ipline ($/in-dia-LF)= 10.00
	Jack and Bore Jacking Pit (30 ft x 12 ft, 11 ft	4	EA	125,000	500,000			
	Jack and Bore Receiving Pit (30 ft x 12 ft, 11	4	EA	75,000	300,000			
### #########	**Microtunnel remaining sections to Woodside**							24 in-diameter
	Microtunneling (Trenchless)	4,900	LF	4,080	19,992,000			
	Microtunnelling Jacking Pit (35 ft deep)	2	EA	125,000	306,250			24 in-diameter $170 per inch-dia-LF (microtunneling)
	Microtunnelling Receiving Pit (35 ft deep)	2	EA	125,000	306,250			Redwood Creek
	River Crossing (Trenchless)	500	LF	4,080	2,040,000			24 in-diameter $170 per inch-dia-LF (river xing)
### #########	**Open Cut Woodside Road to Bay Division 2**							**Assume 50% open trench and 50% microtunneling (for lack of further alignment info)**
	Open Trench Alignments	3,000	LF	384	1,152,000			24 in-diameter $18 per inch-dia-LF (trench)
	Major Intersections	1,500	LF	960	1,440,000			24 in-diameter $40 per inch-dia-LF (major intersection)
	Microtunneling (Trenchless)	4,500	LF	4,080	18,360,000			24 in-diameter $170 per inch-dia-LF (microtunneling)
	Microtunnelling Jacking Pit (35 ft deep)	2	EA	600,000	1,200,000			
	Microtunnelling Receiving Pit (35 ft deep)	2	EA	500,000	1,000,000			
### #########	**Open Cut from Bay Division 2 to I-280 Tunnel**							
	Open Cut Pipeline	19,000	LF	384	7,296,000			24 in-diameter $18 per inch-dia-LF (trench)
	Major Intersections	1,500	LF	960	1,440,000			24 in-diameter $40 per inch-dia-LF (major intersection)
### #########	**Microtunnel Under I-280**							**Assume microtunneling under I-280**
	Miscellaneous Crossing (Trenchless)	1,500	LF	4,080	6,120,000			24 in-diameter $170 per inch-dia-LF
	Microtunnelling Jacking Pit (35 ft deep)	1	EA	600,000	600,000			
	Microtunnelling Receiving Pit (35 ft deep)	1	EA	500,000	500,000			
### #########	**Open Cut from I-280 Tunnel to Dechlor Facility**	12,000	LF	384	3,240,000			24 in-diameter $18 per inch-dia-LF (trench)
### #########	**Pipeline Constructability**			10%	2,291,120			does not apply to microtunneling
3.0	**Pump Station**				**6,050,000**	**50**	**235,136**	
### #########	AWPF Near SVCW to CSR Discharge Point (Purified)	1	LS	5,470,000	5,470,000			8,300 total flow (gpm) 629 ft (TDH)
### #########	SVCW to AWPF near SVCW (Tertiary)	1	LS	320,000	320,000			10,894 total flow (gpm) 7 ft (TDH)
### #########	AWPF near SVCW to SVCW (Brine)	1	LS	260,000	260,000			2,560 total flow (gpm) 12 ft (TDH)
4.0	**Storage Tank**				**1,612,654**	**50**	**62,677**	**Assume equalization needed for influent and product water**
### #########	Steel Storage Tanks for EQ Tank (prior to AWTF)		MG	not incl				*Per Justin E. - additional storage in RWC tanks at SVCW could be repupropsed for equalization*
	Alternately convert RWC for use as EQ tank	1	LS	200,000	200,000			*Placeholder cost provided for new connection from RWC tank to AWTF*
### #########	Steel Storage Tanks for Product Water Tank	2	MG	706,327	1,412,654			
5.0	**Discharge Facility**				**1,500,000**	**50**	**58,298**	
### #########	Assume expansion of existing discharge facility	1	LS	1,500,000	1,500,000			**Assume some modification to existing discharge facility near Pulgas Water Temple**
								(downstream of dechlorination faiclity)
	Subtotal Facility Costs				**$149,535,602**		**$6,197,581**	
Additional Facility Capital Costs								
5.0	Site Development Costs	@	5%		7,476,780		309,879	% of Subtotal facility costs
								(Includes grading, erosion control, cut/fill, etc.)
6.0	Yard Piping	@	5%		3,695,439		182,569	% of Subtotal facility costs (not inluding pipelines)
7.0	Electrical, I&C, and Remote (high-tech) Control	@	15%		11,086,317		547,707	% of Subtotal facility costs (not inluding pipelines)
	Subtotal Additional Facility Costs				**$22,258,536**		**$1,040,155**	
	Facility Direct Costs				**$171,794,138**		**$7,237,736**	
	Taxes	@	8.50%		5,084,210		210,718	apply taxes to 40% of the Capital Costs for facilities
	Mobilization/Bonds/Permits	@	5%		8,589,707		361,887	% of Facility Direct Costs
	Engineering and Design	@	10%		17,179,414		723,774	% of Facility Direct Costs
	Special Studies	@	0%		0		0	Not included (note that this may be a significant future cost for the program)
	Environmental/Permitting	@	5%		8,589,707		361,887	% of Facility Direct Costs
	Contractor Overhead & Profit	@	15%		25,769,121		1,085,660	% of Facility Direct Costs
	Estimate Contingency	@	40%		68,717,655		2,895,094	% of Facility Direct Costs
Subtotal with Markups and Contingency					**$305,723,953**		**$12,876,756**	
	Escalation to Midpoint of Construction	@	23%		70,316,509		2,961,654	assume 2% percent over 12
								construction start = 2026 end = 2029
	Project Capital Cost Total				**$376,040,462**		**$15,838,410**	
	Annualualized Capital Costs ($/AF)						**$1,178**	project life = 50 interest rate = 3%
	Annualualized Capital Costs ($/gal)						**$0.004**	

Annual Operations and Maintenance Costs

Item No.	Description	Qty	Units	Total Annual Costs $/Unit	Total	Notes
### #########	**Energy Costs**					
### #########	Energy - Treatment	12,067,310	KWh	0.20	2,413,462	Treatment Operatior 24 hours per day
						8760 hours operated per year
						2755 KWH/MG
### #########	Energy - Pumping from AWPF near SVCW to CSR	11,109,432	KWh	0.20	2,221,886	Pump Operation = 24 hours per day
						8760 hours operated per year
### #########	Energy - Other		KWh	10%	463,535	Pump Station Hp = 1,700 Total Motor HP Required
### #########	**Chemicals**	13,440	AF	101	1,350,720	
3.0	**Labor Costs**					
### #########	Labor - AWPF	11.0	staff	175,000	1,050,000	full time staff at $175,000 average salary + benefits per year
### #########	Other Labor (pipeline, PS, wells)	2.0	staff	125,000	375,000	full time staff at $125,000 average salary + benefits per year
4.0	**Maintenance:** Other	@	1.5%		5,640,607	% of capital cost
4.1	Equipment (Maintenance/Replacement/Repair)	13,440	AF	157.40	2,115,456	
5.0	**Contingency**	@	10.0%		1,563,067	% of above O&M costs
	Annual O&M Costs ($/year)				**$17,193,733**	
	Annual Unit O&M Costs ($/AF)				**$1,300**	
	Annual Unit O&M Costs ($/gal)				**$0.004**	

APPENDIX B

Engineers Opinion of Probable Cost
Alt 2b.3 - SWA (12 mgd) Crystal Springs Res - HW 101 AWPF + Repurpose Pipeline to Woodside

KENNEDY/JENKS CONSULTANTS

Study:	Potable Reuse Exploratory Plan (PREP) Decision Tool	**Prepared By:**	MT, DTT
Project:	SWA at Crystal Springs Reservoir	**Date Prepared:**	Jun-2017
AWPF Locati	AWPF at HW 101 Site	**K/J Proj. No.**	1668011.01
Repurpose:	RWC Tank + Repurpose pipelines to Woodside	**ENR**	11,696 *(2017 SF)*
Estimate:	Conceptual Level Cost-Analysis		

Average Annual Influent Flow:	15.69	mgd
Average Annual Product Flow:	12.00	mgd
RW Delivered:	13440	Average Annual Reuse (AFY)
Design Capacity:	8,333	Max Day Demand (gpm)

Item No.	Description	Qty	Units	Total Costs $/Unit	Total Capital Cost	Est Facility Life	Annualized Capital Cost	Notes/Source
Facility Capital Costs								
1.0	**Treatment**				64,746,127			Assumes AWPF at HW 101 Site
### ########	Microfiltration	15.7	MGD	$ 1,000,000	15,686,275	20	1,054,364	
### ########	Reverse Osmosis	14.1	MGD	$ 1,400,000	19,764,706	20	1,328,499	
### ########	Advanced Oxidation Process (includes UV)	12.0	MGD	$ 300,000	3,600,000	20	241,977	
### ########	Post Treatment and Chem Handling	12.0	MGD	$ 500,000	6,000,000	50	233,193	
### ########	Building	12.0	MGD	$ 937,500	11,250,000	50	437,237	3,750 SF/mgd
								250 $/SF
### ########	Land Cost	0	SF	not incl				Cost of land NOT included in this analysis
### ########	Off-Site Additional Costs			15%	8,445,147			Account for new access roads, security, lighting, admin building, ancillary facilities, landscaping, etc (apply to above treatment facility costs)
### ########	Nutirent Removal			not incl				Costs for Nutrient removal NOT included in this analysis
### ########	Dechlorination			not incl				Assume use of Pulgas Dechlorination Facility (costs NOT included)
2.0	**Pipelines**				76,864,217	75	2,587,862	Assumes repurposing/slip-lining of pipelines near SVCW to Shoreway; then NEW HDPE pipeline in Trench ar
### ########	**AWPF near SVCW to Shoreway (repurpose)**							24 in-diameter flow (mgd) = 12.0
	Tertiary - SVCW to Shoreway (Tertiary)		LF	not incl				Reuse Redwood City purple pipe from SVCW to Hwy 101
	Brine pipeline material - SVCW to Shorew	15,840	LF	50	38,106			14 in-diameter HDPE Cost ($/LF)= 50
	Slip Lining (Brine)	15,840	LF	140	1,584,000			Slipline ($/in-dia-LF)= 10
	Major Intersections							Costs for major intersections not included when microtunneling or sliplining
	Jack and Bore Jacking Pit (30 ft x 12 ft, 11	8	EA	125,000	990,000			
	Jack and Bore Receiving Pit (30 ft x 12 ft, 1	8	EA	75,000	594,000			
### ########	**Shoreway to HW 101 AWPF Site**							
	Shoreway to HW 101 AWPF (Tertiary)	2,000	LF	448	896,000			28 in-diameter flow (mgd) = 15.7
	HW 101 AWPF to Shoreway (Brine)	2,000	LF	210	420,000			14 in-diameter flow (mgd) = 3.7
### ########	**HW 101 AWPF Site to Shoreway**							
	HW 101 AWPF to Shoreway (Purified)	2,000	LF	384	768,000			24 in-diameter flow (mgd) = 12.0
### ########	**New Pipe from Shoreway to start of "Unit 3"**							
	Open Cut Pipeline (Purified)	2,000	LF	384	768,000			24 in-diameter
### ########	**Reuse 54"/48" dia pipeline on Unit 3 and 2 Alignment to Woodside Road**							
	Purified - SVCW to HW 101 AWPF	8,700	LF	60	522,000			24 in-diameter HDPE Cost ($/LF)= 60.0
	Slip Lining (Purified)	8,700	LF	240	2,088,000			24 in-diameter ipline ($/in-dia-LF)= 10.00
	Jack and Bore Jacking Pit (30 ft x 12 ft, 11	4	EA	125,000	500,000			
	Jack and Bore Receiving Pit (30 ft x 12 ft, 1	4	EA	75,000	300,000			
### ########	**Microtunnel remaining sections to Woodside**							24 in-diameter
	Microtunneling (Trenchless)	4,900	LF	4,080	19,992,000			
	Microtunnelling Jacking Pit (35 ft deep)	2	EA	125,000	306,250			24 in-diameter $170 per inch-dia-LF (microtunneling)
	Microtunnelling Receiving Pit (35 ft deep)	2	EA	125,000	306,250			Redwood Creek
	River Crossing (Trenchless)	500	LF	4,080	2,040,000			24 in-diameter $170 per inch-dia-LF (river xing)
### ########	**Open Cut Woodside Road to Bay Division 2**							Assume 50% open trench and 50% microtunneling (for lack of further alignment info)
	Open Trench Alignments	3,000	LF	384	1,152,000			24 in-diameter $18 per inch-dia-LF (trench)
	Major Intersections	1,500	LF	960	1,440,000			24 in-diameter $40 per inch-dia-LF (major intersection)
	Microtunneling (Trenchless)	4,500	LF	4,080	18,360,000			24 in-diameter $170 per inch-dia-LF (microtunneling)
	Microtunnelling Jacking Pit (35 ft deep)	2	EA	600,000	1,200,000			
	Microtunnelling Receiving Pit (35 ft deep)	2	EA	500,000	1,000,000			
### ########	**Open Cut from Bay Division 2 to I-280 Tunnel**							
	Open Cut Pipeline	19,000	LF	384	7,296,000			24 in-diameter $18 per inch-dia-LF (trench)
	Major Intersections	1,500	LF	960	1,440,000			24 in-diameter $40 per inch-dia-LF (major intersection)
### ########	**Microtunnel Under I-280**							Assume microtunneling under I-280
	Miscellaneous Crossing (Trenchless)	1,500	LF	4,080	6,120,000			24 in-diameter $170 per inch-dia-LF
	Microtunnelling Jacking Pit (35 ft deep)	1	EA	600,000	600,000			
	Microtunnelling Receiving Pit (35 ft deep)	1	EA	500,000	500,000			
### ########	**Open Cut from I-280 Tunnel to Dechlor Facility**	12,000	LF	384	3,240,000			24 in-diameter $18 per inch-dia-LF (trench)
### ########	**Pipeline Constructability**			10%	2,403,611			does not apply to microtunneling
3.0	**Pump Station**				7,280,000	50	282,941	
### ########	HW 101 AWPF to CSR Discharge Point (Purified)	1	LS	5,470,000	5,470,000			8,334 total flow (gpm) 625 ft (TDH)
### ########	SVCW to HW 101 AWPF (Tertiary)	1	LS	1,260,000	1,260,000			10,894 total flow (gpm) 59 ft (TDH)
### ########	HW 101 AWPF to SVCW (Brine)	1	LS	550,000	550,000			2,560 total flow (gpm) 17 ft (TDH)
4.0	**Storage Tank**				1,612,654	50	62,677	Assume equalization needed for influent and product water
### ########	Steel Storage Tanks for EQ Tank (prior to AWTF)		MG	not incl				*Per Justin E. - additional storage in RWC tanks at SVCW could be repupropsed for equalization*
	Alternately convert RWC for use as EQ tank	1	LS	200,000	200,000			*Placeholder cost provided for new connection from RWC tank to AWTF*
### ########	Steel Storage Tanks for Product Water Tank	2	MG	706,327	1,412,654			
5.0	**Discharge Facility**				1,500,000	50	58,298	
### ########	Assume expansion of existing discharge facility	1	LS	1,500,000	1,500,000			Assume some modification to existing discharge facility near Pulgas Water Temple (downstream of dechlorination faiclity)
	Subtotal Facility Costs				$152,002,998		$6,287,046	
Additional Facility Capital Costs								
5.0	Site Development Costs	@	5%		7,600,150		314,352	% of Subtotal facility costs (Includes grading, erosion control, cut/fill, etc.)
6.0	Yard Piping	@	5%		3,756,939		184,959	% of Subtotal facility costs (not inluding pipelines)
7.0	Electrical, I&C, and Remote (high-tech) Control	@	15%		11,270,817		554,878	% of Subtotal facility costs (not inluding pipelines)
	Subtotal Additional Facility Costs				$22,627,906		$1,054,189	
	Facility Direct Costs				$174,630,905		$7,341,236	
	Taxes	@	#########		5,168,102		213,760	apply taxes to 40% of the Capital Costs for facilities
	Mobilization/Bonds/Permits	@	5%		8,731,545		367,062	% of Facility Direct Costs
	Engineering and Design	@	10%		17,463,090		734,124	% of Facility Direct Costs
	Special Studies	@	0%		0		0	Not included (note that this may be a significant future cost for the program)
	Environmental/Permitting	@	5%		8,731,545		367,062	% of Facility Direct Costs
	Contractor Overhead & Profit	@	15%		26,194,636		1,101,185	% of Facility Direct Costs
	Estimate Contingency	@	40%		69,852,362		2,936,494	% of Facility Direct Costs
Subtotal with Markups and Contingency					$310,772,185		$13,060,922	
	Escalation to Midpoint of Construction	@	23%		71,477,603		3,004,012	assume 2% percent over 12
								construction start = 2026 end = 2029
	Project Capital Cost Total				$382,249,788		$16,064,934	
	Annualualized Capital Costs ($/AF)						$1,195	project life = 50 interest rate = 3%
	Annualualized Capital Costs ($/gal)						$0.004	

Annual Operations and Maintenance Costs

Item No.	Description	Qty	Units	Total Annual Costs $/Unit	Total		Notes
### ########	**Energy Costs**						
### ########	Energy - Treatment	12,067,310	KWh	0.20	2,413,462		Treatment Operatior 24 hours per day
							8760 hours operated per year
							2755 KWH/MG
### ########	Energy - Pumping from HW 101 AWPF to CSR	11,109,432	KWh	0.20	2,221,886		Pump Operation = 24 hours per day
							8760 hours operated per year
### ########	Energy - Other		KWh	10%	463,535		Pump Station Hp = 1,700 Total Motor HP Required
### ########	**Chemicals**	13,440	AF	101	1,350,720		
3.0	**Labor Costs**						
### ########	Labor - AWPF	11.0	staff	175,000	1,050,000		full time staff at $175,000 average salary + benefits per year
### ########	Other Labor (pipeline, PS, wells)	2.0	staff	125,000	375,000		full time staff at $125,000 average salary + benefits per year
4.0	**Maintenance:** Other	@	1.5%		5,733,747		% of capital cost
4.1	Equipment (Maintenance/Replacement/Repair)	13,440	AF	157.40	2,115,456		
5.0	**Contingency**	@	10.0%		1,572,381		% of above O&M costs
	Annual O&M Costs ($/year)				$17,296,187		
	Annual Unit O&M Costs ($/AF)				$1,300		
	Annual Unit O&M Costs ($/gal)				$0.004		