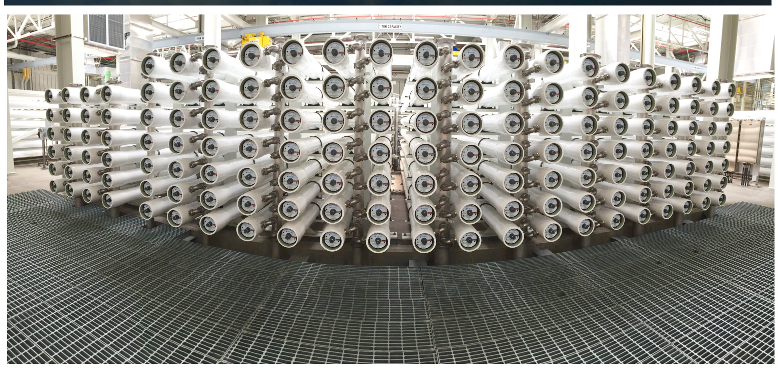
Santa Fe Irrigation District Est. 1923

San Elijo Joint Powers Authority

San Dieguito Water District

Potable Reuse Feasibility Study



March 2016

Trussell Technologies Inc
380 Stevens Ave., Suite 308
Solana Beach, CA 92075

In association with

RMC water and environment

Executive Summary

California faces an unprecedented set of challenges with regard to water management that is driven by population growth, severe droughts, and climate change. To address these growing challenges, water agencies are developing new local, sustainable water supplies that reduce reliance on imported water. Although many approaches are being pursued to provide a clean, affordable, and local drinking water supply, potable reuse is a highly attractive and cost-effective option that is available year-round and can be safely accomplished with today's technologies. In fact, California is already a worldwide leader in potable reuse practice with 50 years of history and over 200 MGD of recycled water being treated to a level that is safe for potable consumption today. This document provides the results of a potable reuse feasibility study for a partnership project between the Santa Fe Irrigation District, the San Dieguito Water District, and the San Elijo Joint Powers Authority.

Summary of Technical Memorandums

Three technical memorandums have been prepared that provide:

Technical Memorandum 1 – A summary of existing potable reuse projects in California, the evolution of the Division of Drinking Water's regulations governing potable reuse, and the timeline for the development of new regulations for surface water augmentation as well as the feasibility of direct potable reuse. While the 2014 groundwater recharge regulations matured over several decades, the surface water augmentation regulations are legislated for completion by the end of 2016 without the benefit of experience from an operating project. The 2014 groundwater recharge regulations directly benefited from potable reuse projects of different sizes and types that have been in operation since the 1960s in Los Angeles County and the 1970s in Orange County. The information being considered to develop surface water augmentation regulations originated from the City of San Diego's pursuit of reservoir augmentation in the San Vicente Reservoir. Along with a surface water augmentation regulation, the drinking water industry will have a decision on whether direct potable reuse is feasible in California by the end of 2016.

Technical Memorandum 2 - A description of an ultimate potable reuse project that could deliver 4 MGD of advance treated water from the San Elijo Water Reclamation Facility to the San Dieguito reservoir for an estimated cost of $1520/AF. Assuming that the project proceeds in a timely manner and the challenges outlined below are successfully overcome, first water could be delivered by 2025. The ultimate project does not meet the draft regulatory criteria for a surface water augmentation project and may need to be permitted as a form of direct potable reuse. This ultimate project is building on the concept developed for the City of San Diego's pursuit of a project to augment Miramar Lake and provides the greatest volume of water at the lowest cost, but also faces the most significant challenges; challenges that must be further studied to refine the project cost and ultimate capacity. In fact, this project dedicates the capacity of the San Elijo Water Reclamation Facility to the production of purified water for delivery to San Dieguito Reservoir. This means that additional engineering studies are required to: (1) evaluate the feasibility of securing additional wastewater flow to the San Elijo Water Reclamation Facility, (2) determine how existing non-potable recycled water demands from the San Elijo Water Reclamation Facility can be met, as well as (3) identify the necessary improvements and develop costs for converting the San Elijo Water Reclamation Facility to a biological nutrient removal facility. Another critical component of furthering the development of a potable reuse project is to determine the governance and organizational structure to demonstrate the required Technical, Managerial, and Financial (TMF) Assessment to the Division of Drinking Water. It is recommended that the pursuit of the ultimate project build off of the City of San Diego's permitting efforts for Miramar Lake, which should be largely completed by the end of 2018.

Technical Memorandum 3 - A description of a short-term potable reuse project that could be developed to deliver 1 MGD of advance treated water from the San Elijo Water Reclamation Facility to the San Dieguito reservoir within the next six years for an expected cost of $1890/AF. This project will conform to the existing draft criteria for surface water augmentation regulations.

Existing 30-Inch Pipeline

A significant benefit offered to these projects (ultimate and short-term) is the opportunity to significantly reduce conveyance costs by rehabilitating an existing low-pressure 30-inch line from the San Elijo Water Reclamation Facility up to the San Dieguito Reservoir. The San Dieguito Water District owns this existing pipeline. Many reservoir augmentation projects are faced with significant conveyance costs that approach the construction cost of the advanced treatment facilities. It is important to highlight that this existing infrastructure allows potable reuse projects to the San Dieguito Reservoir to provide cost-effective water, even at the smaller capacities considered in this study. Since slip lining the existing pipeline has significantly less impact on the environment, the environmental impacts of construction will also be significantly reduced. However, several sections of open cut pipeline construction will still be required and must be considered in the environmental permitting.

Study Conclusions

The primary conclusion of this feasibility study is that a surface water augmentation project could be permitted with the Division of Drinking Water that is cost-effective, ranging between $1500/AF and $2000/AF. However, there are significant challenges associated with each project that need further study and development. Examples of some key challenges identified in these documents are:

1) **Utility size, coordination and governance:** Establish a governance structure between SFID, SDWD, and SEJPA for this project – a regulatory

requirement for permitting authorities is that the participating parties have the *Technical, Managerial, and Financial* resources dedicated to ensure success.

2) **Wastewater supply**: additional wastewater flows need to be identified to provide adequate source water to meet the 4 MGD potable reuse goals
3) **Replacing recycled water commitments**: replacement sources for the existing non-potable recycled water customers need to be identified, given that all of the flow from SEWRF would be allocated for the Advanced Water Purification Facility (AWPF)
4) **Source control**: expanding wastewater flows into SEWRF will require additional evaluation of source control and industrial pre-treatment programs
5) **Improvements to SEWRF**: modifications to the SEWRF are needed prior to the implementation of the AWPF, and will likely be important drivers for schedule
6) **Reservoir modeling**: modeling of the SDR is required to demonstrate the hydraulics and to quantify dilution and mixing within the reservoir
7) **Modification of SDR operation**: To maximize the benefit of SDR for potable reuse, modifications of the current reservoir operation will be needed. The draft SWA regulations focus on two main functions of the reservoir: dilution and retention time. Providing adequate mixing of the AWPF water in the reservoir will be critical to achieve sufficient dilution within the reservoir and ensure the treatability of the water in Badger WFP. We can also maximize the retention time of purified water in the reservoir by (1) reducing other influent flow sources and (2) increasing the reservoir capacity. Currently, SDR is used for pre-treatment of Lake Hodges water prior to Badger WFP. Improvements at Lake Hodges that eliminate the need for pre-treatment at SDR would increase the available retention time for AWPF water and offer significant advantages for the reservoir augmentation project. Dredging would also increase SDR capacity and increase the retention time for potable reuse.

Recommendations

The formation of a Program Management Team (PMT) is recommended to support the development of a potable reuse project that maximizes the use of existing facilities and integrates new facilities to ensure water supply reliability of each agency's service area. As a minimum, the PMT would be comprised of staff and consultants from engineering, finance/grant, operations, public outreach, and water resources that have related experience in potable reuse and water supply development projects. The PMT would oversee: 1) the regulatory permitting process, 2) necessary studies to support environmental permitting and project development, 3) development of preliminary design documentation, 4) development of request for proposals to assist with the procurement of final design firms, 5) public outreach activities, 6) identification of funding sources, and 7) assist in the development of a governance structure for jointly constructed/operated potable reuse projects. This approach allows the agencies to proceed in a timely manner to accomplish the projects developed in this feasibility study while continuing to meet customer demands and provide existing services. Both the City of San Diego and Padre Dam Municipal Water District are following similar approaches for the development of their potable reuse programs.

San Dieguito Water District, San Elijo Joint Powers Authority, and Santa Fe Irrigation District have demonstrated leadership in strategically working together on other joint water supply projects that resulted in the development of: 1) a Title 22 recycled water treatment and distribution infrastructure and 2) jointly owned and operated surface water treatment and distribution systems for potable water. This past collaboration and integration of facilities provides a foundation for the PMT as they evaluate the cost effective development and operation of future potable reuse project(s).

List of Attached Technical Memorandums

Technical Memorandum #1 – Status of Potable Reuse in California

Finalized in May 2015

Length 20 pages

Technical Memorandum #2 – Ultimate Potable Reuse Project

Finalized in October 2015

Length 54 pages

Technical Memorandum #3 – Near-Term Potable Reuse Project

Finalized in March 2016

Length 26 pages

Potable Reuse Feasibility Study

Technical Memo #1: Status of Potable Reuse in California

May 2015

Prepared for:

Santa Fe Irrigation District
San Dieguito Water District
San Elijo Joint Powers Authority

Prepared by:

Trussell Technologies, Inc.
Brian Pecson, Ph.D., P.E.
David Hokanson, Ph.D., P.E.
Shane Trussell, Ph.D., P.E., BCEE
Brie Webber

RMC Water and Environment
Scott Goldman, P.E. (Review)

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1 Introduction

California has a long history of creating innovative solutions to deal with its water resource challenges. Water scarcity throughout the state has promoted advancements in the way we distribute, reuse, and conserve water. For the last five decades, California has been a leader for both the country and the world in the field of potable water reuse. This leadership is seen not only in the diversity and number of existing potable reuse projects, but also in the development of regulations created to protect public and environmental health (CDPH 2014).

Potable reuse projects are frequently categorized into two options, *indirect* and *direct* potable reuse (IPR or DPR). IPR projects by definition must include an environmental buffer—such as an aquifer or reservoir—in between the advanced treatment of wastewater and distribution to consumers. IPR projects have provided a source of potable water in California since the first groundwater recharge (GWR) project began in 1962. Draft regulations governing GWR were first developed in 1986, and underwent various revisions as the industry gained more experience and understanding of the risks and requirements for public health protection. Twenty-eight years after the first draft was completed, a final GWR regulation was promulgated in 2014 (CDPH 2014). One of the main factors driving the finalization of the GWR regulation was California Senate Bill 918 (SB 918), which set a deadline for these regulations by the year 2014.

SB 918 not only formalized the groundwater regulations, but will advance two other forms of potable reuse: IPR through surface water augmentation (SWA) and DPR. Draft regulations for SWA are currently being developed with a deadline of 2016 for a final proposed regulation. While building off of the GWR regulations, the SWA regulations will need to address the unique aspects of using a reservoir instead of an aquifer as an environmental buffer. DPR has recently been gaining consideration as a third potable reuse alternative, with significant research investigating the feasibility of such an option.

The major components of these various forms of IPR and DPR are provided in Figure 1.1 to highlight the relevant similarities and differences. Many of the forms of potable reuse shown in Figure 1.1 will require a high degree of advanced treatment. The most salient difference between IPR and DPR is the use of the environmental buffer (aquifer or reservoir). One of the most important benefits of the buffer is *response retention time*, i.e., the time to detect and respond to compromises or failures in treatment. As systems move from aquifers to reservoirs to DPR, the response retention times become progressively shorter.

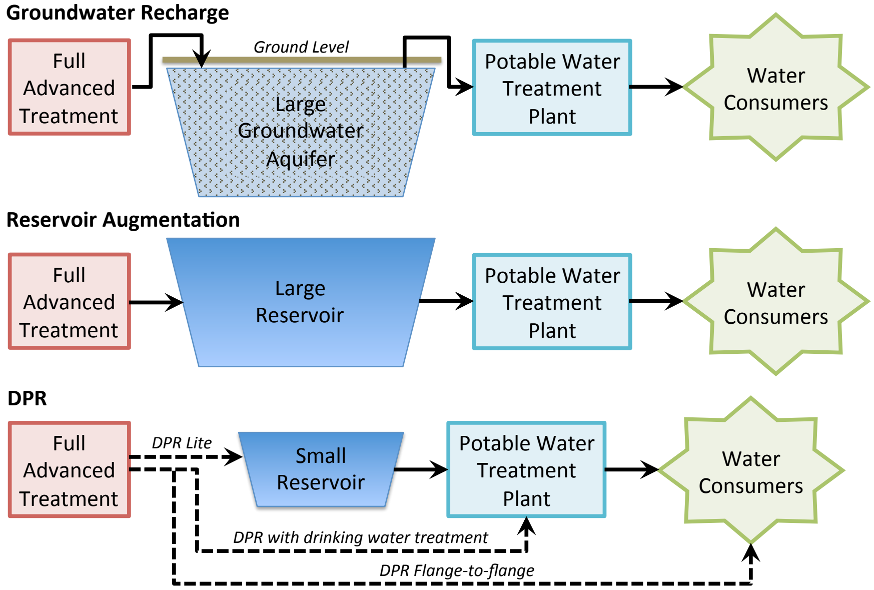

Figure 1.1 - Forms of current and potential potable reuse projects

Regardless of the form of potable reuse pursued, the top priority of all projects is reliability, or the consistent protection of public health (Pecson et al. 2015). The two main groups of contaminants of concern for public health are the pathogens and the toxic chemicals. Potable reuse systems are built upon the use of multiple barriers that can reduce the concentrations of these contaminants down to levels that are protective of public health. Failures in these barriers may expose the public to such contaminants, and are therefore the main threat to reliability. Reliability can be achieved through two main strategies: preventing failures from occurring and responding to failures that do occur. Safe potable reuse systems can therefore be built upon four "R": reliability, redundancy, robustness, and resilience. The overarching goal of reliability is supported by failure prevention in the form of redundancy and robustness, while resilience provides failure response (Figure 1.2).

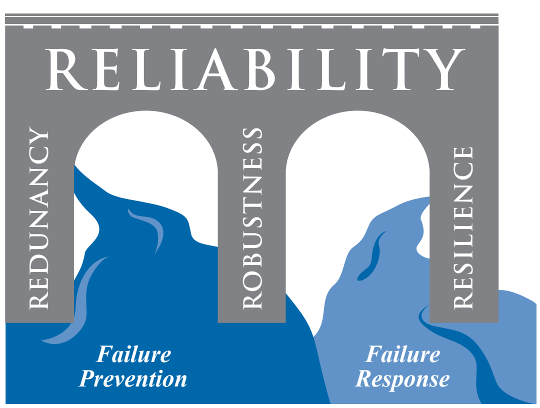

Figure 1.2 The Four Rs of potable reuse safety (adapted from Pecson et al. 2015)

The purpose of this document is to provide an overview of potable reuse experience in California, plotting an arc from the initial groundwater recharge projects and how they helped shape the current regulatory status today. This historical view provides important perspectives to understand how regulations currently under development may open the door to a greater diversity of potable reuse options. The following chapters focus on the more than 50 years of experience we have had with IPR through groundwater recharge (Chapter 2), before turning to the surface water augmentation regulations currently under development (Chapter 3), as well as providing perspectives on the feasibility of moving from IPR to DPR (Chapter 4).

2 Groundwater Recharge

Regulations for Groundwater Replenishment using Recycled Water were promulgated in June 2014 by the DDW within the SWRCB (formerly DDWEM within CDPH and California DHS)[1]. The regulatory requirements built on several past draft regulations that were modified from the original 1986 draft. The two current groundwater recharge options—surface spreading and subsurface injection—were both included by the 1994 draft. The principles of the draft regulations included creating a good water source, protective of public health, with a focus on pathogens and acute contaminants including a multi-barrier approach that avoided degradation of existing sources.

2.1 Groundwater Recharge Regulations

The Groundwater Replenishment Using Recycled Water regulations promulgated in June 2014 have two sections: (1) Surface Applications and (2) Subsurface Applications. A surface application is defined as "application of recharge water[2] to a spreading area," while subsurface application means "application of recharge water to a groundwater basin(s) by a means other than surface application." These latter projects are also commonly referred to as groundwater "injection" projects.

Many of the regulatory requirements for surface application and subsurface application are equivalent. A summary of the major requirements is provided in Table 2.1. The regulations assure that water used for recharge is of a high quality that protects public health.

[1] DDW = Division of Drinking Water under the State Water Resources Control Board (SWRCB)
DDWEM = Division of Drinking Water and Environmental Management
CDPH = California Department of Public Health
California DHS = California Department of Health Services

[2] Recharge water refers to recycled municipal wastewater or a combination of recycled municipal wastewater and credited diluent water used for groundwater replenishment.

Table 2.1 – Overview of 2014 DDW Groundwater Recharge Regulations

Requirement	Description
Public hearing	Required for the initial permit and whenever there is a proposal to increase the maximum recycled municipal wastewater contribution
Laboratory analysis	Must be performed by certified labs approved by the DDW using DDW-approved drinking water methods
Regulated chemicals	For the applied recycled municipal wastewater, quarterly monitoring of constituents with maximum contaminant levels (MCLs) and annual monitoring of constituents with secondary MCLs is required
Diluent water	Diluent water quality must not exceed a primary MCL, a secondary MCL or an unregulated constituent notification level (NL), with additional requirements for diluent waters that are not DDW-approved source waters
Additional monitoring	Additional chemical and contaminant monitoring requirements for recycled municipal wastewater and downgradient groundwater monitoring wells including quarterly monitoring of priority pollutants and other chemicals the DDW specifies based on review of the engineering report, as well as unregulated constituents with notification levels (NLs)
Operations plan	Operation Optimization Plan must be submitted to DDW prior to startup, which identifies and describes operations & maintenance, monitoring, and analytical methods for the groundwater replenishment reuse project (GRRP) to meet the requirements of the groundwater replenishment regulations
Reporting	Annual report must be submitted to DDW within six months of the end of each calendar year
Retention time	Retention time in the aquifer appears with regard to two aspects of the regulations. The first relates to pathogen removal (or treatment), while the second relates to the time to identify treatment failures and take actions to assure protection of public health. The response retention time can be established initially through modeling or with an intrinsic tracer, but a tracer study must be initiated within three months of operation. The retention time will be no less than two months for groundwater injection, and no less than six months for spreading.

2.1.1 Treatment Requirements

The treatment requirements differ for surface application and subsurface application. For surface application, Title 22 treatment is applied (oxidation, filtration, and disinfection) followed by soil aquifer treatment (SAT). Subsurface application requires full advanced treatment (FAT), i.e., treatment of the full flow through reverse osmosis and an advanced oxidation process (AOP).

In both cases, pathogen control is a critical goal. The regulations require 12-log enteric virus reduction, 10-log *Giardia* cyst reduction, and 10-log *Cryptosporidium* oocyst reduction. The treatment train must have at least three treatment processes. For each pathogen, a separate treatment process can be credited with no more than 6-log reduction and no less than 1.0-log reduction. Processes demonstrating less than 1.0-log pathogen removal receive no credit. For viruses, a 1.0-log credit is given for each month the water spends in the aquifer, regardless of whether it is a spreading or injection project. Important differences exist between these options, however, for *Giardia* and *Cryptosporidium*. For spreading projects that provide at least six months of retention time underground, the full 10-log credit is given for both *Giardia* and *Cryptosporidium*. Subsurface application projects receive no protozoa removal credit for time in the aquifer, regardless of the retention time provided.

A number of water quality requirements are also specified for chemicals, both those causing acute and chronic effects. For example, nitrogen compounds are required to be sampled twice weekly in the recycled municipal wastewater or recharge water. If there are any exceedances of 10 mg/L as N, actions will be required. This requirement assures the treated water will be low in nutrients.

Surface Application

For surface application, there are requirements for soil aquifer treatment to complement the Title 22 treatment. The maximum contribution of recycled water to the groundwater is limited based on the TOC present in the recycled water. The formula for the maximum recycled water contribution (RWC) is the following:

$$Recycled\ water\ contribution\ (RWC) = \frac{0.5\ mg/L}{TOC\ in\ recycled\ water\ (in\ \frac{mg}{L})}$$

For example, if a recycled water were to have a TOC of 2 mg/L, the maximum recycled water contribution would be 0.5 divided by 2, or 25%. Such a project would need to provide a suitable diluent water to constitute 75% of the total water, with the recycled water contributing the remaining 25%.

The initial allowable RWC for SAT is less than or equal to 0.2 (20%). The project sponsor must calculate the running monthly average RWC based on the total volume of recycled municipal wastewater and credited diluent water for the past 120 months. There are provisions in the regulation for increasing RWC from this initial 20%. For levels exceeding 0.5, special provisions are required including an updated Engineering Report and Operation Optimization Plan, a value of TOC/(new RWC) less than or equal to 0.5 mg/L over the past 52 weeks, and monitoring compliance. There are also provisions for SAT to increase TOC above 0.5 mg/L.

Subsurface Application

Subsurface application projects do not benefit from SAT, and so need to provide a higher degree of treatment above ground at the facility itself. There are specific requirements for both RO and AOP in the full advanced treatment train. The RO membranes 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 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.

Initially, RO was considered to be an absolute barrier to all pathogens and chemicals. Additional treatment downstream of the RO was therefore considered unnecessary. As analytical methods continued to improve, however, it was discovered that trace organics were present at quantifiable levels in RO permeates. Two constituents that were found to be poorly removed were N-nitrosodimethylamine (NDMA) and 1,4-dioxane. Accordingly, additional AOP treatment downstream of the RO became mandatory.

There are two options for demonstrating the performance of the AOP. The first option is to conduct an occurrence study to look at one constituent from each of nine classes of chemicals and demonstrate between 0.3- and 0.5-log reduction of the various classes. The second, simpler option is to demonstrate 0.5-log removal of 1,4-dioxane. 1,4-dioxane was selected as an indicator because it represents the class of low molecular weight, uncharged chemicals that are difficult to remove through RO, and it is one of the more difficult chemicals to remove by advanced oxidation. Processes that can control 1,4-dioxane are assumed to remove numerous additional CECs, and thereby protect public health.

The regulations used to also specify treatment requirements for NDMA, namely, requiring 1.2-log reduction. These requirements were based on the levels needed to reduce NDMA to acceptable concentrations at Orange County, but were extrapolated to other facilities employing RO as well. Over time, these requirements were modified given that some facilities consistently reduced influent concentrations below levels of health concern. The current requirements for NDMA necessitate that the treated effluents meet the notification level (NL) of 10 ng/L, either through treatment, source control, or some combination.

UV/hydrogen peroxide is the most common AOP in place for groundwater replenishment reuse projects. UV/free chlorine offers some unique advantages, and is being implemented as an alternative AOP at the City of L.A. Bureau of Sanitation Terminal Island WRP. There are also situations where ozone/hydrogen peroxide may be an effective AOP for a GRRP though its inability to remove NDMA is often a limiting factor.

2.2 Existing groundwater recharge projects

There are currently seven IPR projects throughout the state of California utilizing both spreading and injection. Potable reuse first began with surface spreading at Los Angeles County Sanitation District's (LACSD) Montebello Forebay, and the first injection project followed shortly thereafter at the Orange County Water District. The combined capacity of all of these projects is approximately 200 mgd, as shown in Table 2.2. The next sections provide a brief discussion of the two pioneering projects as exemplars of the two modes of groundwater recharge, and show how they helped to shape the existing GWR regulations.

Table 2.2 - Existing groundwater recharge projects in California

Potable Reuse Project	Facility Start-Up	Potable Reuse Type	Current Treatment	Capacity (mgd)
Montebello Forebay (LACSD)	1962	Spreading	• Biological • Granular media filtration • Disinfection	50
Groundwater Replenishment System (OCWD)	1978*	Spreading Injection	• Biological • MF • RO • UV/H_2O_2	100
West Coast Basin Barrier (West Basin)	1992	Injection	• Biological • MF • RO • UV/ H_2O_2	18
Chino Basin (IEUA)	2005	Spreading	• Biological • Granular media filtration • Disinfection	19
Alamitos Barrier (WRD AWTF)	2005	Injection	• Biological • MF • RO • UV/ H_2O_2	8
Dominguez Gap (Terminal Island)	2006	Injection	• Biological • MF • RO • Disinfection	5
TOTAL				**~200**

2.3 Montebello Forebay

On August 20, 1962, the Los Angeles County Sanitation Districts (LACSD) implemented the first project to recharge groundwater with recycled water in southern Los Angeles County. The Montebello Forebay Groundwater Recharge Project (MFGRP) utilizes surface-spreading as a means of introducing recycled water into the aquifer, and is a joint project between the LACSD, the Water Replenishment District of Southern California (WRD), and the Los Angeles County Department of Public Works (LACDPW). This multi-agency project stems from the fact that WRD manages replenishment of groundwater basins, LACSD supplies the recycled water and oversees compliance, and LACDPW operates and maintains the recharge facilities.

The MFGRP began replenishing the Central Groundwater Basin (Central Basin) using water from the Whittier Narrows Water Reclamation Plant (WRP), and subsequently added supplementary recycled water supply from the San Jose Creek and Pomona WRPs. Water from the MFGRP percolates into the groundwater via two sets of spreading grounds. The Rio Hondo Coastal Spreading Grounds represents 570 acres, including 20 individual basins. The San Gabriel Coastal Spreading Grounds represents 128 acres, including three individual basins within parts of the San Gabriel River (308 acres). At the time of the

MFGRP's 50th anniversary in 2012, over 1.6 million AF of recycled water had been recharged into the Central Basin.

Figure 2.1 Spreading basins at the Montebello Forebay Groundwater Recharge Project

Because this was the first project of its kind, the experiences at MFGRP provided important information in the development of the GWR regulations. The first large improvement of the WRPs occurred in the late 1970s. As regulations became stricter regarding total organic carbon (TOC) removal, and knowledge improved of the risks associated with pathogens such as *Giardia* and *Cryptosporidium,* the WRPs were upgraded with tertiary filtration. In the early 2000s, nitrification/denitrification (NDN) was implemented at the WRPs to improve nutrient removal, and sequential chlorination was implemented in the late 2000s in response to more stringent disinfection regulations and disinfection by-product (DBP) minimization (Whittier Narrows WRP converted to UV disinfection as the primary disinfection in 2011). All the changes improved the water quality of the recycled water. The regulations that were developed throughout this project helped form the Title 22 Code of Regulations, and now govern all recycled water used for non-potable sources, and potable sources when combined with groundwater recharge through spreading grounds.

The Division of Drinking Water (DDW) and the L.A. Regional Water Quality Control Board (RWQCB) heavily regulate the spreading of recycled water in the Montebello Forebay, which is now based on the recycled water contribution (RWC) calculation, a regulation that was developed in response to this project. The water receives a high level of treatment to make sure rigorous water quality standards are achieved. The amount of recycled water permitted to be recharged was originally limited to 32,700 acre-feet/yr (AFY). In 1987, it was increased to 50,000 AFY. In 1991, it was again increased to 60,000 AFY. The RWQCB, with concurrence of the California Department of Public Health (CDPH, now DDW), removed the quantity limits in 2009 and replaced them with a dilution-based limitation, allowing no more than 35% in any five-year period. The WRD estimates this could allow for an additional 5,000-7,000 AFY with a long-term goal of increasing replenishment to 75,000 AFY.

2.4 Orange County Groundwater Replenishment System

Orange County is prone to drought with only 13-15 inches of rainfall per year, and so has historically relied on imported water supplies from the State Water Project and the Colorado River. Challenges associated with these imported supplies led Orange County to pursue new water sources through potable reuse. In 1976, the Orange County Water District (OCWD) began recycling wastewater from the Orange County Sanitation District at a facility referred to as Water Factory 21. The water was initially produced to help mitigate seawater intrusion into Orange County's groundwater basin.

Water Factory 21 was the first GWR project to pursue aquifer injection, the second form of groundwater recharge. Because injection bypasses the spreading grounds (and the treatment benefits they provide), changes to the regulations were necessary to maintain the same level of public health protection. The outcome was to require more advanced treatment at the water recycling facility to make up for the lack of treatment occurring through the soil aquifer treatment. Experience at this project led to stricter treatment requirements for injection projects, namely the need to pass the full flow through both reverse osmosis and an advanced oxidation process. This set of treatment requirements is referred to as full advanced treatment, or FAT, though this acronym is being purposefully phased out. One benefit of providing a higher degree of treatment is that the regulations allow shorter retention times for injection projects (minimum of two months) than spreading projects (minimum of six months).

The OCWD completed a replacement facility that complied with the new regulations called the Groundwater Replenishment System (GWRS) in 2008, which included a 70 mgd advanced water treatment facility applying membrane filtration (MF), RO and ultraviolet irradiation (UV)-hydrogen peroxide to treat secondary effluent. The GWRS was recently expanded to 100 mgd with a goal to expand further to 130 mgd in the future.

3 Surface Water Augmentation

Senate Bill 918 set deadlines for a final set of groundwater recharge regulations, which were finalized and became effective on June 18, 2014. These regulations were based on over 50 years of successful IPR history, but were modified over that time period to adapt to the experiences of the existing projects. Senate Bill 918 also requires DDW to develop regulations for surface water augmentation (SWA). SWA projects are similar to groundwater recharge in that they also use an environmental buffer—in this case, a reservoir—in between treatment and distribution. SB 918 requires that SWA regulations be completed by the end of 2016. To aid DDW in this task, SB 918 also called for the creation of an Expert Panel whose goal is to provide DDW with expert input on numerous topics including treatment, public health, and other scientific and technical matters. Currently, DDW and the Expert Panel are actively evaluating the appropriate requirements for SWA, using the latest DDW draft regulations as a starting place.

3.1 Components of DDW draft regulations

In the most recent draft of the Surface Water Augmentation regulations, the treatment requirements look very similar to the groundwater recharge requirements, particularly with regard to pathogens. Four treatment options are currently available, with the most stringent requiring the same 12/10/10 requirement for virus, *Giardia*, and *Cryptosporidium* (V/G/C), along with an additional 1-log of treatment in excess of these requirements. Thus, the most stringent pathogen reduction requirement is 13/11/11 for V/G/C.

Where treatment credits are concerned, the principal difference between groundwater recharge projects and reservoir augmentation projects is the availability of treatment credit in the conventional drinking water treatment plant. The original surface water treatment rule, promulgated by EPA (EPA 1989), required the water treatment plant to provide treatment to remove 4-log virus and 3-log *Giardia.* Due to this difference, projects can combine the treatment credit achieved at the AWT facility and the conventional drinking water treatment plant to achieve the required pathogen reductions.

The draft surface water augmentation regulations continue to incorporate the concept of response retention time, albeit adjusted for the much shorter durations achieved in a reservoir relative to an aquifer. This requirement is most clearly seen in their dilution requirements, which require that advanced treated water discharged into the reservoir be blended with water that has been within the aquifer for more than 24 hours. This 24-h stipulation is based on the assumption that a facility would be able to detect and correct any treatment failures within a 24-h period. If no failures are detected, the water produced over that time period meets specifications, and is therefore suitable to use for dilution. The practical consequence of this is that facilities must have a high degree of monitoring that justifies the assumption of a 24-h response period.

The draft regulations set a number of system requirements including reservoir suitability, public hearings, alternative supply sources, and retention and mixing (Table 3.1). The requirements that are undergoing the most intensive revisions through discussions with the DDW Expert Panel are those related to retention time and mixing.

Table 3.1: Draft surface water augmentation requirements and revisions from DDW Expert Panel (excluding retention time and mixing requirements)

Requirement	Draft DDW Regulations	Expert Panel Revisions
Reservoir Suitability	- Operating as approved surface water source - In operation for > 5 years - Sufficient control over reservoir operation	None
Recycled Water Discharge Siting	- Requires that the location of the recycled water discharge point be sited such that the project can comply with retention time requirements	Eliminate as overly prescriptive
Reservoir LRVs	- Virus reduction based on modeled time in the aquifer	Too difficult to accurately assess reservoir LRVs; utilize any reservoir log removals as an additional but uncredited safety factor
Public hearings	- Public hearings - Information dissemination	None
Alternative supply source	- Requires alternative source of domestic supply	None

3.2 Reservoir Retention Time and Mixing Requirements

As discussed, the most active debate is currently focused on the requirements for retention time and mixing in the reservoir. An overview of the draft regulations and the modifications suggested by the DDW Expert Panel is presented in Table 3.2. For the purposes of this discussion, it is assumed that future draft regulations will incorporate the modifications proposed by the DDW Expert Panel. This assumption has been supported by recent comments from DDW.

Table 3.2: Retention time and mixing requirements in draft surface water augmentation regulation and suggested revisions from DDW Expert Panel

Requirement	Draft DDW Regulations	Expert Panel Revisions
Mixing and dilution	4 options for retention time and mixing: • Minimum 100:1 dilution of one week production of recycled water • Minimum 60-d retention time of recycled water in the reservoir • Minimum 10:1 dilution of a one-week production of recycled water and 30-d retention time in reservoir • Minimum 10:1 dilution of a one-week production of recycled water and 1-log reduction of each organism in addition to minimum requirements	Eliminate the 4 options and replace with the following new requirements: Demonstrate a 24-h input pulse results in: • A concentration in the reservoir withdrawal that is no greater than 1% of recycled water effluent concentration, *or* • A concentration in the reservoir withdrawal that is no greater than 10% of recycled water effluent concentration, *and* treatment to provide additional 1-log pathogen reduction beyond minimum requirements
Diluent water	Requirements on suitable water for diluent credit	None
Off-specification water	Requirements on maximum amount of off-spec water in reservoir	None
Retention time definition	Use of t_2 to define reservoir retention time	Eliminate use of t_2 and base requirements on theoretical retention time alone
Thermocline	Specifications on use of thermocline in reservoir management	Eliminate use of thermocline
Theoretical retention time	Requires $\geq$ 12-month theoretical retention time prior to withdrawal	Reduce theoretical retention time to $\geq$ 6 months
Tracer test	Tracer test requirements	No significant changes

Regarding the diluent water, the draft regulations specify that water suitable for dilution includes (1) reservoir watershed runoff, (2) improved imported water, and (3) recycled water meeting requirements for AWT and LRVs but none that does not meet the 24-hour retention time requirement. It is also required that no more than 1% of water in the reservoir may be off spec recycled water.

The three areas of focus for this discussion are the requirements that present the biggest potential obstacles: retention time, mixing and dilution, and tracer testing. As the latter two topics are intimately joined, they will be discussed together.

3.2.1 Retention Time

The DDW Expert Panel suggested a great simplification of the retention time requirement by eliminating the use of t_2 and relying solely on the theoretical hydraulic retention time (HRT). The HRT must be determined monthly by dividing the water volume in the reservoir (V) by the total outflow (Q) including both overflow and withdrawals for water use, that is:

$$\frac{V}{Q} \geq 6\ months$$

Where:

V = volume in the reservoir at the end of the month
Q = total outflow (withdrawals + overflow)

3.2.2 Mixing and Dilution Requirements

The DDW Expert Panel provided two pathways to meet the mixing and dilution requirements based upon the degree of treatment provided: maintain a recycled water concentration in the reservoir of no more than 1% at the point of withdrawal, or provide an additional 1-log pathogen reduction and maintain a recycled water concentration in the reservoir of no more than 10%. The main obstacle of proposed SWA projects will be to demonstrate the water withdrawn from the reservoir complies with the specified dilution of recycled water from the last 24-h period. For projects to demonstrate compliance with this part of the regulation, reservoir modeling and tracer testing will be required to quantify the hydraulics of the reservoir. Therefore, not relying on a reservoir for treatment credit may eliminate these regulatory hurdles and simplify the permitting process for new projects.

4 Direct Potable Reuse

Direct potable reuse is so-called because it bypasses the environmental buffer, moving advanced treated water directly to a drinking water treatment plant or to distribution. Perhaps the main hurdle for DPR is ensuring the reliability of public health protection given the short time periods between the advanced water treatment facility and consumers. Nevertheless, it is important to emphasize that there is a spectrum of DPR options with significant differences in the "directness" they seek. At one extreme, the flange-to-flange scenario envisions an advanced water treatment facility piped directly to a distribution system with no intervening barriers, storage, or retention time provided. This is the most direct form of DPR. At the other end of the DPR spectrum, advanced treated water could be piped to an equalization basin or a reservoir that is too small to comply with the surface water augmentation criteria. This water could be blended with an existing source water, treated through a drinking water treatment plant, and then sent on to distribution. As seen in Figure 4.1, there may be only very subtle differences between a surface water augmentation project and one undertaking this least direct "DPR lite" scenario.

SB 918 has as its final requirement that DDW assess the feasibility of developing regulations for DPR. It is important to note that SB 918 does not require the development of regulations, but only an assessment of whether or not is feasible to do so. As with the SWA regulations, DDW is also assisted in this endeavor by the DDW Expert Panel. One of the main obstacles in this task is the fact DPR as a concept is very new and untested.

Therefore, there are very little data that have been collected on DPR design, performance, and safety. Such information is critical to assess DPR feasibility.

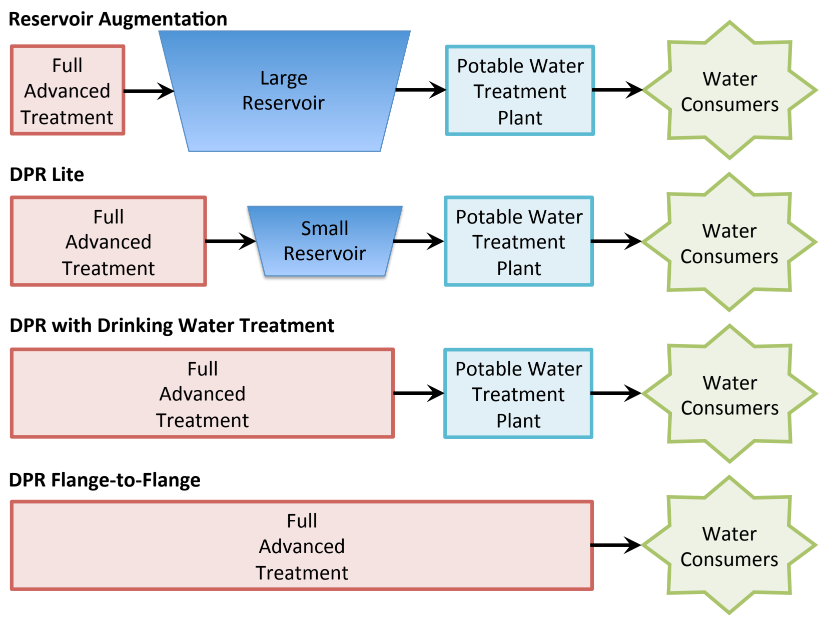

Figure 4.1 – Potential configurations of DPR options and comparison with surface water augmentation

To help address this knowledge gap, significant efforts have been ongoing, particularly in California, to provide the needed research findings for this task. Figure 4.2 provides an overview of the various research themes that are being pursued. The primary entities carrying out the research include the WateReuse Research Foundation (WRRF), WateReuse California, Water Research Foundation (WRF) and other international partners.

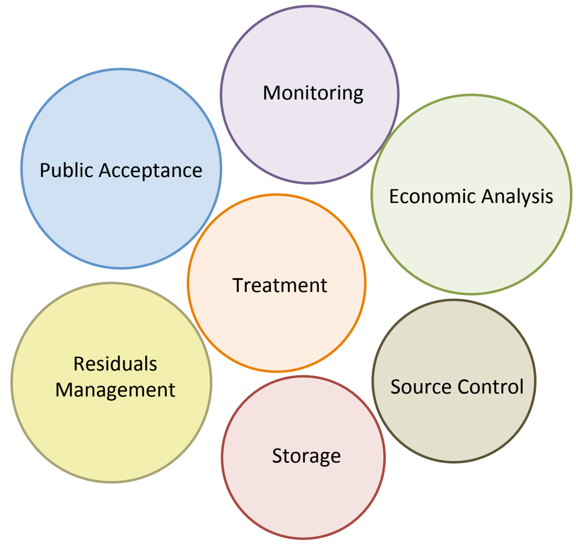

Figure 4.2 - Ongoing areas of DPR research

4.1 Demonstration Project on DPR Reliability

SB 918 set a December 2016 deadline for DDW's assessment of DPR feasibility. As this date approaches, WRRF has created a keystone project that seeks to tie together many of the findings from the last few years of research. This project is WRRF 14-12, entitled "Demonstrating Redundancy and Monitoring to Achieve Reliable Potable Reuse," a 1.6-MGD demonstration project at the City of San Diego's North City Water Reclamation Plant. This project ties together multiple aspects of DPR research on treatment, monitoring, and storage to address the fundamental issue of reliability in public health protection.

One of the lessons learned from both IPR and recent DPR research experience is that the elements of public health protection—treatment, monitoring, and storage—can be balanced in different ways while still providing equal public health protection. As retention time is reduced—in either an aquifer or reservoir or a DPR setting—augmentations in treatment and monitoring must be provided to compensate. This has been borne out in our experience with groundwater recharge, which requires minimum 6-month retention times for less-treated Title 22 water, while only 2-month minimum retention times for full advanced treated waters. This trajectory is also being pursued in surface water augmentation, which requires 13/11/11 logs of pathogen removal (instead of 12/10/10) if the reservoir provides less contaminant attenuation through dilution.

Project 14-12 has developed a DPR concept train that further augments both the treatment protection and the monitoring to provide continuous and demonstrable performance of a DPR train (Figure 4.3). The treatment train provides redundancy in both treatment and monitoring to reduce the probability that the system will fail to treat the water to the required levels. It also provides new and different barriers in the form of ozone and BAC pre-treatment, offering two new and different mechanisms to control the wide diversity of potential chemical and microbiological threats. Finally, the system has a high degree of monitoring to detect system compromises and failures, and respond accordingly. In this way, the system will seek to demonstrate reliability built on the 4Rs concept (Section 1).

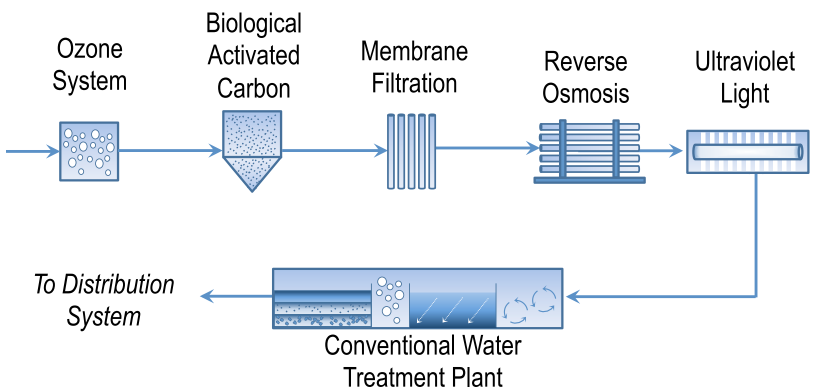

Figure 4.3. DPR treatment train currently undergoing testing for WRRF 14-12.

4.2 Institutional constraints with DPR

A number of institutional constraints will need to be overcome to make DPR a reality in California, starting with modifications of current management strategies. In California, water is separated such that drinking water and wastewater are managed and permitted separately. The two entities are rarely required to communicate, or to work together to manage a district's water. This separation may pose challenges as we move to more direct forms of DPR. For example, in a flange-to-flange scenario, an AWT facility operating under the recycled water code would become a producer of drinking water. As such, the AWT would likely be considered a drinking water treatment facility, and would therefore need to comply with drinking water code.

The DPR concept may also require the approval of the "sewershed" as a new water supply, much in the same way that conventional source waters are approved for drinking water. This would constitute a major change in the current permitting process, and may take time for the state of California to modify their existing management practices.

Another institutional constraint with DPR is the differences in operator and management certification between drinking water and wastewater treatment facilities. Specialized skills are required at both facilities, with multiple roles being significantly different at the two facilities. Combining the drinking water and wastewater treatment facilities, as some types of DPR will necessitate, would require operators and managers to receive training for both types of facilities. This change will take time and resources to both organize and implement.

The concerns associated with DPR are not limited to permitting and operation of the treatment facilities; the response of the public receiving the recycled water will be an important key to the success of future DPR projects. The WRRF recently conducted a survey in San Diego County to gauge the perception of DPR from potential recycled water consumers (Millan et al. 2015). The results of the survey indicated that more communication is needed between consumers and municipalities on the facts about DPR and the potential benefits it could have on water-scarce communities. WRRF's public outreach project is working towards developing a detailed communication plan at the state and community level in an effort to bolster public acceptance of DPR. With support from the local community, future DPR projects are more likely to come to fruition.

The constraints discussed in this section will be most difficult to overcome for the most direct form of DPR, flange-to-flange; however, many of these constraints are less problematic with less direct forms of DPR, such as DPR "lite." The current permitting system will still be applicable in this case, and operation and management techniques will remain the same as for IPR projects, with the addition of employees with specialized skills to operate the AWT facility. Public perception will still be an important aspect of any DPR project, but with timely, understandable and transparent communication it is likely that public acceptance can be achieved.

5 Conclusions

In summary, new and expanded forms of potable reuse are imminent in California's near future. By December 2016, regulations for surface water augmentation should be completed or well underway, along with a DDW decision on the future of DPR regulations. The history of recycled water has shown us time and again the importance of actual projects on regulatory development. It is much easier for DDW to develop regulations with concrete examples in hand.

Given the slow and progressive nature of these regulations—from surface spreading to aquifer injection and now to reservoir augmentation—it seems likely that the most viable near-term option for DPR will be the DPR "lite" scenario presented in Figure 4.1. This least-direct DPR scenario is closely related to surface water augmentation, a potable reuse option that DDW is gaining increasing confidence regulating. Many of the factors needed for safe surface water augmentation—dilution, blending, treatment (Section 3)—are used in similar, if not identical, ways in DPR "lite." One option for bridging this gap from SWA to DPR Lite is to follow the strategies that have previously been used to safely shorten retention times, namely, increasing the minimum amount of treatment and monitoring. As more reliance is placed on these elements, more independence can be gained from retention time requirements.

Even though there are no formal regulations for SWA, DDW has the authority to permit such projects. Agencies interested in SWA therefore have two clear paths forward. The first option is to wait and see how the regulatory process unfolds, allowing DDW and the Expert Panel to develop a final regulatory framework before commencing. The benefit of this wait-and-see approach is that the planning can be more streamlined, since the design and operation of the project will follow defined regulatory criteria.

The other option is to engage DDW prior to the completion of the regulation. The downside of this approach is that the requirements are less defined at this stage, and may shift through the revision process. It will likely entail more effort up front in the planning phases, but will likely not have a significant impact on the final cost of water. The benefit of this second approach is that it provides the agency an opportunity to help shape the regulations. As discussed, DDW has made multiple modifications of their draft groundwater regulations based on the on-the-ground experience of operational facilities, such as the Montebello Forebay and Groundwater Replenishment Systems. Just as they shaped the groundwater recharge regulations, new reservoir augmentation projects may help drive decisions about required treatment processes, or help define the role the reservoir will have regarding log removal credit. From this experience, an agency can show DDW the data needed to make decisions and thereby have a stronger influence on how those regulations are ultimately shaped.

Over the course of the last year, significant progress has been made on the SWA regulations, and the larger structure of those regulations has taken shape. While details will continue to change, it seems likely that the major elements outlined in Section 3 will continue to hold through to the final proposed regulation. In short, the draft regulations are undergoing revisions, but the general structure should remain largely in place.

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Potable Reuse Feasibility Study

Technical Memo #2: Ultimate Potable Reuse Project

October 2015

Prepared for:

Santa Fe Irrigation District
San Dieguito Water District
San Elijo Joint Powers Authority

Prepared by:

Trussell Technologies, Inc.
Brian Pecson, Ph.D., P.E.
Brett Faulkner
Shane Trussell, Ph.D., P.E., BCEE
Rhodes Trussell, Ph.D., P.E., BCEE (Review)

RMC Water and Environment
Rich Bichette, P.E.
Glenn Hermanson, P.E.
Alexis Brand
Scott Goldman, P.E. (Review)

Executive Summary

The purpose of this technical memorandum is to develop a long-term vision for the regional potable reuse project for SFID, SEJPA, and SDWD. The ultimate project will utilize an advanced water purification facility (AWPF) to provide 4 MGD of potable reuse flows to augment the San Dieguito Reservoir (SDR). Water from the SDR would then be further treated at the Badger Water Filtration Plant (WFP) prior to distribution. While the project will not comply with the existing draft of the surface water augmentation regulation, the Division of Drinking Water (DDW) has the authority to permit a reservoir augmentation project of this type. The City of San Diego is currently undertaking an effort to permit a similar reservoir augmentation project at Miramar Lake, providing an important precedent for the future SFID-SEJPA-SDWD project. The key to the regulatory effort is to demonstrate that additional treatment and monitoring can compensate for lower dilution in a small reservoir (Figure ES. 1).

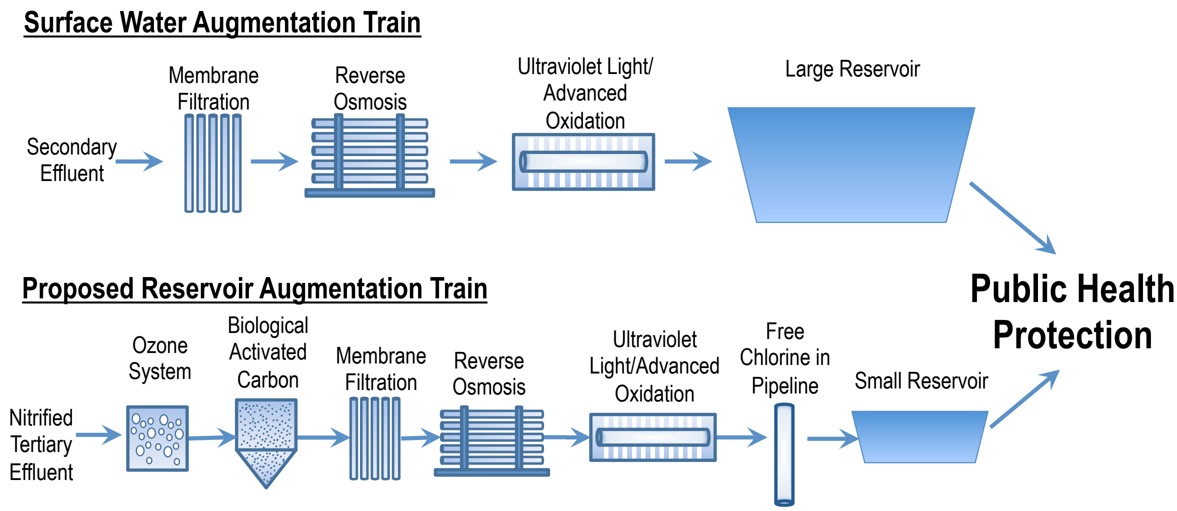


Figure ES. 1. Multiple potable reuse strategies can be used to protect public health. The proposed reservoir augmentation train uses enhanced treatment and monitoring to achieve public health goals using a small reservoir.

The project requires three major components in the form of treatment, conveyance, and reservoir needs. The AWPF treatment train builds on the full advanced treatment train through the addition of ozone and biological activated carbon (BAC) Figure ES. 1. The pre-treatment allows the system to deal with the three major water quality issues—pathogens, toxic chemicals, and aesthetics—without the need for dilution. The added treatment makes the system more resistant to failures while providing broader protection against contaminants—both known and unknown.

To accommodate the potable reuse goals, the AWPF would require 5.25 MGD of feedwater, which represents all of the existing flows into the San Elijo Water Recycling Facility (SEWRF) in addition to supplementary flows. The SEWRF would also need modifications to improve the quality of the AWPF source water. Major modifications include altering the existing secondary process configuration, and providing tertiary filters (Table ES. 1).

Table ES. 1: Current versus proposed process parameters for SEWRF

Parameters	Units	Values		
		Current	Proposed	Typical Design Values
Flow	*MGD*	*2.80*	*5.25*	-
Primary Clarifiers				
# of Primary Tank in Operation	***No.***	***2 of 6***	***4 of 6***	**-**
Primary Overflow Rate	gpd/SF	1046	947	700-1400
Primary Detention Time	hours	1.7	1.7	1.5-2.5
Bioreactors				
# of Bioreactor Online	***No.***	***1 of 4***	***4 of 4***	**-**
Active Bioreactor Volume	MG	0.4	1.7	-
Bioreactor Detention Time	hours	3.4	7.6	3-5 Non-Nitrifying, 8 -12 NDN
SRT	days	2	10	-
F/M	lbs BOD/lbs VSS.day	-	0.29	-
MLSS	mg/L	1400	1950	1000-5000
OUR (1st Aerobic Zone)	$mgO_2/(L.h)$	-	47	<100
Total Airflow	scfm	800	2950	-
Secondary Clarifiers				
# of Secondary Tank in Service	***No.***	***2 of 5***	***5 of 5***	**-**
RAS Rate	MGD	1.62	5.25	-
WAS Rate	gpd	81,000	72,450	-
WAS Concentration	mg/L	2800	3830	<10,000
2^o Overflow Rate	gpd/sf	610	432	400-700
2^o Solids Loading Rate	lb/(sf.d)	22.0	14.2	<28
2^o BOD	mg/L	8.4	4.9	<30
2^o TSS	mg/L	15.0	9.4	<30
2^o Ammonia	mg/L	25.00	0.25	-
2^o Nitrite+Nitrate	mg/L	0.0	13.3	-
2^o TKN	mg/L	35.0	5.1	-

The modified WRF and AWPF can be located in the area that has been designated for potable reuse water purification in SEJPA's 2015 Facilities Plan (Figure ES. 2).

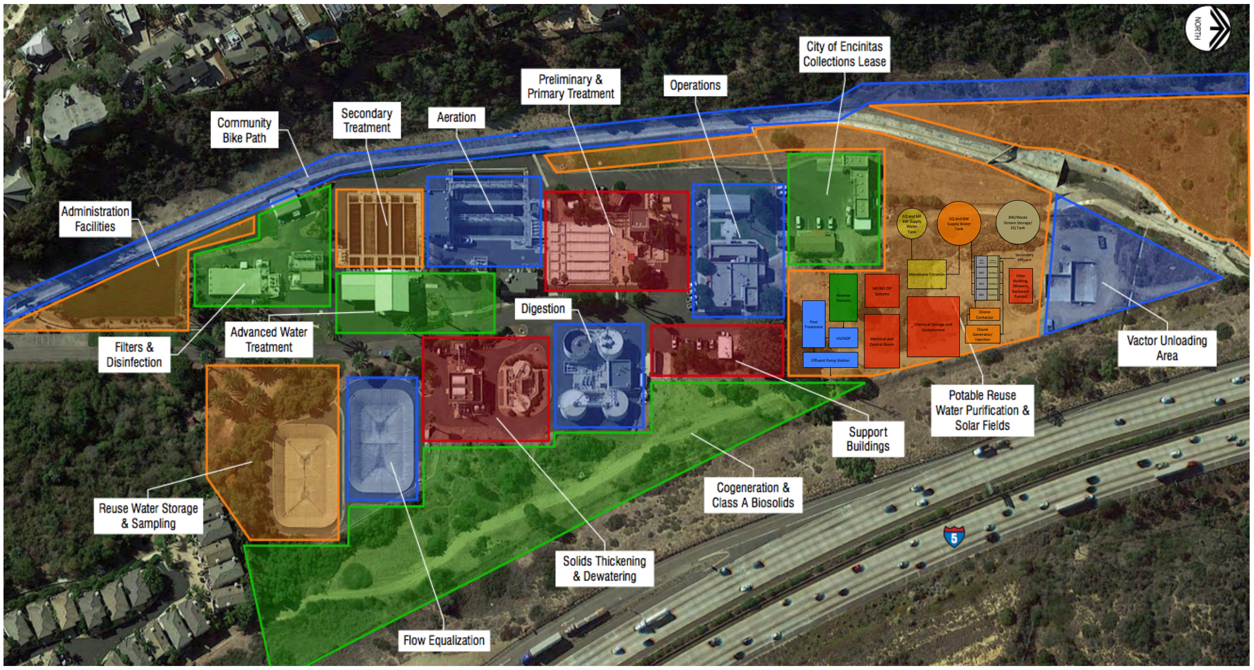


Figure ES. 2: Site layout for new facilities at SEWRF

The pipeline from the SEWRF to SDR would require approximately 27,000 lineal feet, including 2,200 lineal feet of new PVC pipeline, 23,250 lineal feet of PVC pipe slip-lined within the existing 30" low pressure pipeline, and 1,600 lineal feet of existing 16" PVC. The use of 24" PVC pipe is recommended for the slip-lining.

As there are no existing reservoir augmentation projects currently permitted, it is recommended that the SFID-SEJPA-SDWD project build off of the City of San Diego's permitting efforts for Miramar Lake, which should be largely completed by the end of 2018. The treatment train provided by the SFID-SEJPA-SDWD project is identical to the one proposed by the City of San Diego. Nevertheless, a number of project constraints exist:

- **Wastewater supply**: additional wastewater flows need to be identified to provide adequate source water to meet the 4 MGD potable reuse goals
- **Replacing recycled water commitments**: replacement sources for the existing non-potable recycled water customers need to be identified, given that all of the flow from SEWRF would be allocated for the AWPF
- **Source control**: expanding wastewater flows into SEWRF will require additional evaluation of source control and industrial pre-treatment programs
- **Utility size**: all projects must meet "technical, managerial, and financial" requirements, placing a potentially higher burden on small utilities. Demonstration testing may be useful to show the project team's ability to meet these requirements.

- **Improvements to SEWRF**: modifications to the SEWRF are needed prior to the implementation of the AWPF, and will likely be important drivers for schedule
- **Reservoir modeling**: modeling of the SDR are required to demonstrate the hydraulics and to quantify dilution and mixing within the reservoir
- **Modification of SDR operation**: To maximize the benefit of SDR for potable reuse, modifications of the current reservoir operation will be needed. The draft SWA regulations focus on two main functions of the reservoir: dilution and retention time. Providing adequate mixing of the AWPF water in the reservoir will be critical to achieve sufficient dilution within the reservoir and ensure the treatability of the water in Badger WFP. We can also maximize the retention time of purified water in the reservoir by (1) reducing other influent flow sources and (2) increasing the reservoir capacity. Currently, SDR is used for pre-treatment of Lake Hodges water prior to Badger WFP. Improvements at Lake Hodges that eliminate the need for pre-treatment at SDR would increase the available retention time for AWPF water and offer significant advantages for the reservoir augmentation project. Dredging would also increase SDR capacity and increase the retention time for potable reuse.

The construction cost estimate for the ultimate project is $73 million (Table ES. 2). This cost estimate is a Class 5 OPCC as defined by the AACE with an expected accuracy of +50% to -25% of the average bid price for construction.

Table ES. 2: Opinion of probable construction cost for ultimate reuse project

Description	OPCC, $M
SEWRF Improvements/Upgrades	$6.0
Tertiary Filtration	$5.3
Ozone Disinfection and Oxidation	$2.5
BAC Filtration	$5.3
Membrane Filtration	$3.5
Reverse Osmosis	$8.5
UV Advanced Oxidation	$3.0
Post-Treatment & Chemicals	$4.0
Yard Piping	$2.0
Tanks and Lift Stations	$6.0
Pipeline and Lift Station	$10.4
Dechlorination and Discharge Structure	$2.0
Subtotal	$59
Contingency (25%)	$15
Total	**$73**

The estimated cost per acre-foot of water is $1,518 Table ES. 3, assuming a production rate of 4 MGD (4,480 AF/year) and amortized capital cost assumes 3% interest over 30 years.

Table ES. 3: Unit cost of water for ultimate potable reuse project

Description	Cost ($/AF)
Amortized Capital Cost	$833
O&M - Labor	$199
O&M - Chemicals	$101
O&M - Power	$200
O&M – Equipment Replacement	$186
Total	**$1,518**

A proposed schedule for ultimate project is provided in Table ES. 4.

Table ES. 4: Proposed projects and timeline for ultimate project

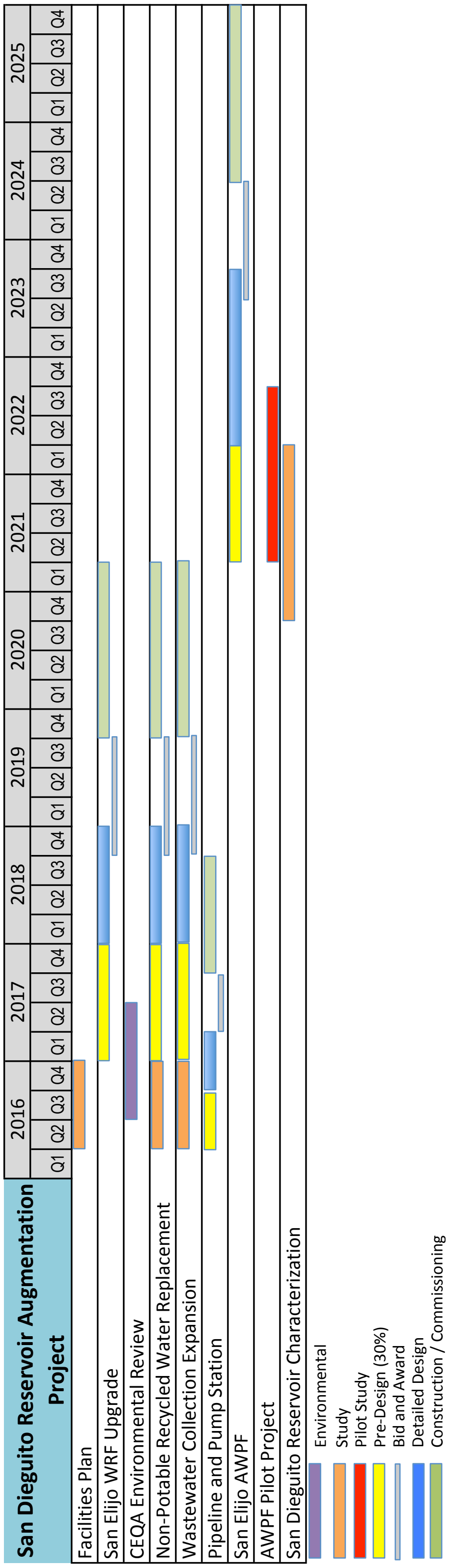


Table of Contents

1 Introduction

The purpose of this technical memorandum #2 (TM#2) is to develop a long-term vision for the regional potable reuse sought by SFID, SEJPA, and SDWD. This TM focuses on the components of a final or "ultimate" project and the major constraints that might inhibit or delay its realization. As this long-term plan is realized, a number of intermediate steps must be taken along the way. The third and final TM will focus on the phasing of these intermediate projects or a smaller potable reuse project that could be realized in the short-term.

TM#2 is organized to show the major components of the ultimate potable reuse project, important project constraints, schedule, and costs. The analysis includes an estimated cost per acre-foot of water of $1,518. The TM is structured with the following sections:

- Section 1: Introduction
- Section 2: Treatment Concept, including advanced water treatment facilities and water recycling facility upgrades
- Section 3: Conveyance Concept
- Section 4: Reservoir Concept
- Section 5: Project Constraints
- Section 6: Project Cost and Schedule

2 Treatment Concept

The potable reuse treatment requirements for groundwater recharge are explicitly described in existing regulations (CDPH 2014), and the State of California is currently developing regulations for the next form of potable reuse, namely surface water augmentation (refer to TM#1). While still in draft form, the treatment requirements for this new paradigm have been thoroughly discussed by both the regulators and their expert advisors, and appear unlikely to undergo significant change in the near term. The most distinguishing feature between groundwater recharge and surface water augmentation is the reduced time between the treatment of water and its consumption. To date, the draft surface water augmentation regulation is compensating for the shortened response time by requiring: (1) higher degrees of *treatment* at the advanced water purification facility (AWPF), (2) additional *dilution* of potable reuse supplies and (3) a minimum hydraulic retention time (HRT) in the surface water storage facility. Future potable reuse scenarios, including the augmentation of small reservoirs (hereafter called "reservoir augmentation") and direct potable reuse, will further reduce these response times. The challenges facing these future potable reuse scenarios can already be perceived in the requirements for the surface water augmentation regulations.

One of the hallmarks of groundwater recharge is the long aquifer retention times, which provide significant time to detect and respond to failures in treatment and monitoring. With the shorter response times of surface water augmentation, this strategy no longer provides the same benefit. Accordingly, DDW has begun to develop their strategy to replace retention time with additional treatment, monitoring and dilution. Adding additional treatment and monitoring impacts the cost and complexity of treatment, but are obstacles that can be overcome through the use of known and established processes for reuse. The key to achieving safe potable reuse at short retention times is therefore figuring out a way to replace the final requirement—the need for dilution.

Dilution is an effective strategy because it is the definition of a robust treatment – its effectiveness is independent of the type of contaminant, be it chemical or microbial, organic or inorganic, easily treatable or refractory. Looking at the history of the groundwater recharge regulations, it is interesting to note that DDW eliminated the need for dilution if a high degree of advanced treatment was provided (compare spreading requirements in Sections 60310.116 and .118 with injection requirements in Sections 60310.216 and .218, in CDPH (2014)). This raises the question: what is driving the reinstatement of dilution requirements for surface water augmentation? Pathogens have long been the focus of DDW's requirements, but existing regulations already place the highest emphasis on pathogen control, requiring high degrees of removal with large factors of safety. Dilution, therefore, does not serve primarily for pathogen control, but as an additional safeguard against toxic chemicals. If a failure were to occur, dilution would buffer out the consequences by reducing chemical concentrations down to acceptable levels (Figure 2.1). As potable reuse moves toward smaller reservoirs or more direct schemes, the amount of water available for dilution drops significantly, meaning that this barrier can no longer be counted on to provide such protection. An alternative strategy needs to replace it.

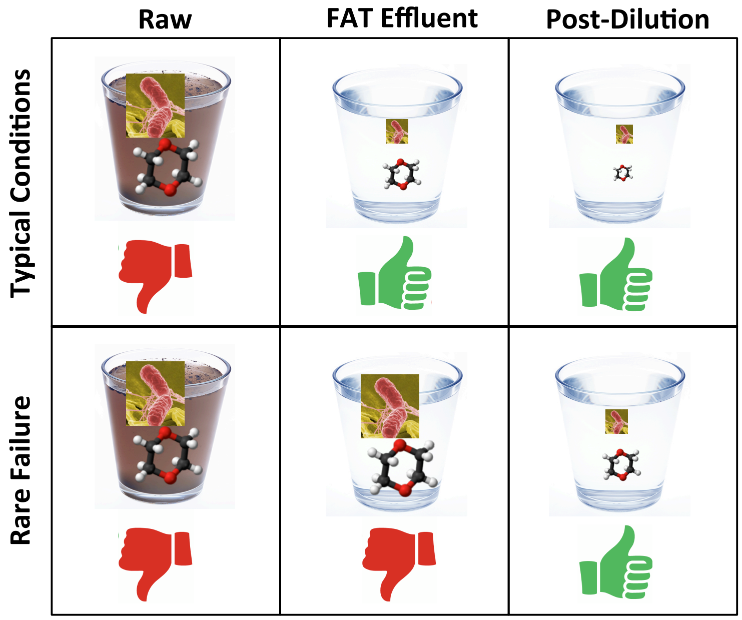


Figure 2.1 – Benefit of dilution in dealing with treatment failures. Dilution provides a safeguard against treatment failures that would leave unacceptably high concentrations of pathogens and chemicals in the treated effluent of the full advanced treatment (FAT) train.

2.1 Treatment Overview

The ultimate SFID-SEJPA-SDWD reservoir augmentation project is built on the assumption that the regional project will produce the maximum amount of potable reuse water to offset imported needs. The calculation of maximum flows (up to 4 MGD) is discussed in subsequent sections (including Sections 2.3 and 4). Given the preferred amount of product water flow and the small size of the San Dieguito Reservoir (SDR), the retention times and dilutions would not conform to the requirements of the draft surface water augmentation regulations. Importantly, it will fail to meet the 6-month hydraulic residence time requirement, and may fail to meet the minimum 10-to-1 dilution requirement. One option to offset these losses is the inclusion of additional treatment with on-line monitoring. The next three subsections discuss the three major issues facing systems with short response times and the ability of treatment and monitoring to address them.

2.1.1 Pathogen Control

The existing standard for high-level treatment, the full advanced treatment (FAT) train—MF, RO, UV/AOP—does not by itself provide all of the pathogen removal needed to comply with the existing requirements. In particular, the FAT train cannot meet the 12-log requirement for virus removal. In groundwater recharge systems, this deficit is typically addressed through the use of long aquifer retention times (6+ months), which provide an additional 1-log of credit for each month in the ground. Because these retention times are not feasible in reservoir augmentation systems, additional treatment at the AWPF is essential, just to meet the existing 12-log virus removal requirement. Dilution would also provide some protection against pathogens, but even a 10-fold dilution would only provide a 1-log reduction (of the 10- to 12-log requirement). Thus, dilution is not a feasible strategy for pathogen control.

2.1.2 Chemical Control

One of the motivations to reinstate the dilution requirement is the growing body of knowledge that RO is a great chemical barrier, but not alone sufficient to deal with all possible contaminants of concern. Over the years, a handful of chemicals have been shown to breach RO systems (e.g., NDMA and 1,4-dioxane), and recent episodes at Orange County Water District's Groundwater Replenishment System (OCWD GWRS) have further identified additional contaminant breakthroughs (including acetone). One of the fears expressed by stakeholders is the presence of other "unknown" contaminants that may be present but not yet identified. Dilution would be effective at chemical control, since chemical contaminants do not typically require the same log-reduction requirements as pathogens (NRC 2012). In the absence of dilution, an additional chemical barrier—beyond those present in the existing FAT train—would be a meaningful safeguard.

2.1.3 Aesthetics

As the industry moves closer to the implementation of new potable reuse paradigms, increasing attention is being placed on aesthetic issues and the importance of public acceptance. The appearance of taste and odor compounds in the water may spell disaster for projects, even if those compounds have no impact on public health. The recent discovery of acetone, a distinctly scented compound, and the potential for other "unknowns" provides further impetus to include additional treatment to protect against aesthetic issues.

2.2 Proposed AWT Treatment Train

The proposed reservoir augmentation project will not be able to provide significant dilution as a means to further ensure public health and acceptance. However, there are multiple paths to public health protection, each relying on different components. While dilution would reduce all of the contaminants of concern—pathogens, toxic chemicals, and taste and odor compounds—it is also possible to achieve the same levels of reduction through treatment. Two different options providing equivalent public health protection are presented in Figure 2.2. The top treatment train shows an alternative using a lower level of treatment (FAT) with higher levels of dilution in a large reservoir, corresponding to the surface water augmentation scheme. The bottom treatment train incorporates ozone / BAC pre-treatment and free chlorine post-treatment to provide a higher degree of treatment, which compensates for the lower degree of dilution in the smaller reservoir. Both provide equivalent degrees of public health protection. The second AWT treatment train is the one envisioned for the SFID-SEJPA-SDWD regional project.

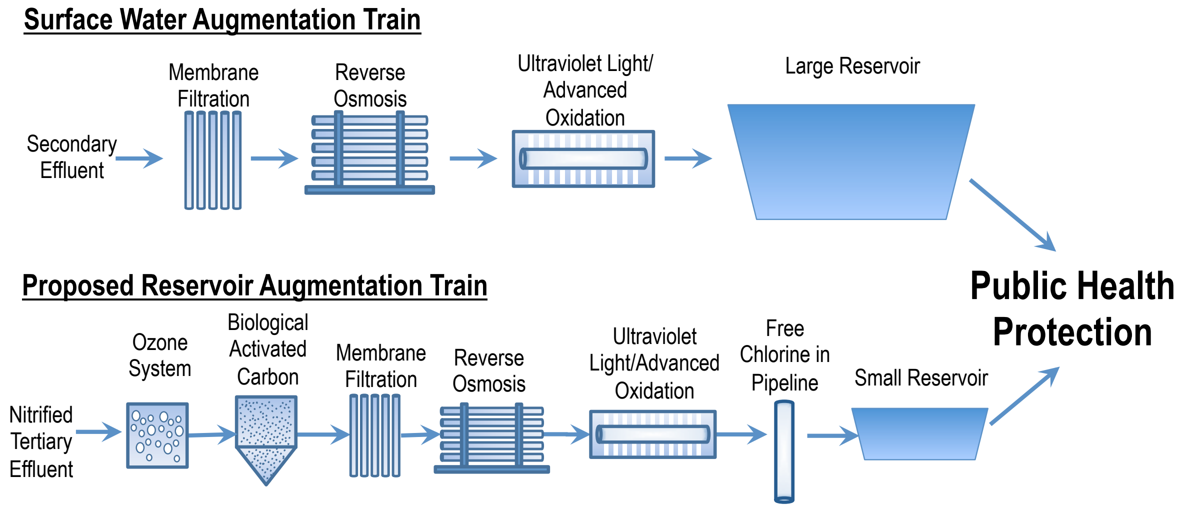
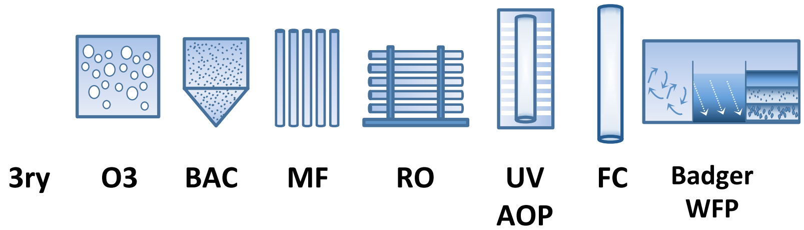


Figure 2.2 – Multiple potable reuse strategies can achieve reliability in public health protection. The surface water augmentation train uses a combination of treatment and dilution in a large reservoir to meet public health criteria. The alternative utilizes enhanced treatment and monitoring with lower levels of reservoir dilution to meet the same public health goals.

2.2.1 Achieving Reliability and the Four "Rs"

The proposed AWT train provides public health protection (reliability) through the use of both redundancy and robustness. Redundancy is the use of measures (such as treatment and monitoring) *beyond the minimum requirements* to ensure that treatment goals are more reliably met or demonstrated (Pecson et al. 2015). The benefits of this can be seen in the following figure, which represents typical log removal values achieved by the individual unit processes (Figure 2.3). Redundancy is evident in the fact that the sum of the log removals across the treatment train is greater than the minimum requirements (Figure 2.3, *upper half*). The benefit of redundancy is that the overall train can still meet the minimum requirements, even with a failure in one of these processes. For example, a UV failure that reduces performance from 6-log to 4-log would not drop the overall removals below the minimum requirements (Figure 2.3, *lower half*). Thus, failures can occur—both in treatment and monitoring—and redundancy will prevent those failures from impacting public health. Redundancy also allows for a more realistic operating scenario, where water production can proceed uninterrupted, even during issues with treatment or monitoring.

The other main strategy is the inclusion of robustness, or the ability of the system to address a broad variety of contaminants and resist catastrophic failures (Pecson et al. 2015). Contaminants of concern cover a wide range of physical, chemical, and biological properties. One consequence of this diversity is that no single process is capable of effectively controlling all contaminants. The use of a diversity of barriers (robustness) is therefore critical for adequate contaminant control.



Typical Conditions – Log Removal Credits

	3ry	O3	BAC	MF	RO	UV AOP	FC	Badger WFP	Total	Minimum
Virus	2	6	-	-	1-2	6	6	5	26-27	12
Crypto	1	2-4	-	4	1-2	6	-	2	16-19	10
Giardia	2	6	-	4	1-2	6	-	4	23-24	10

UV Failure Conditions – Log Removal Credits

	3ry	O3	BAC	MF	RO	UV AOP	FC	Badger WFP	Total	Minimum
Virus	2	6	-	-	1-2	4	6	5	24-25	12
Crypto	1	2-4	-	4	1-2	4	-	2	14-17	10
Giardia	2	6	-	4	1-2	4	-	4	21-22	10

Figure 2.3 – Benefit of redundancy in achieving reliability and addressing system failures.

The proposed AWT train builds off of the multiple-barrier FAT train (MF, RO, UV/AOP) and adds further robustness by introducing two new types of barriers—ozone and BAC (Figure 2.4). These added barriers allow us to target an even broader selection of contaminants, particularly those that may pass through the FAT train. It also gives us added protection against "unknown" contaminants and potential aesthetic issues.

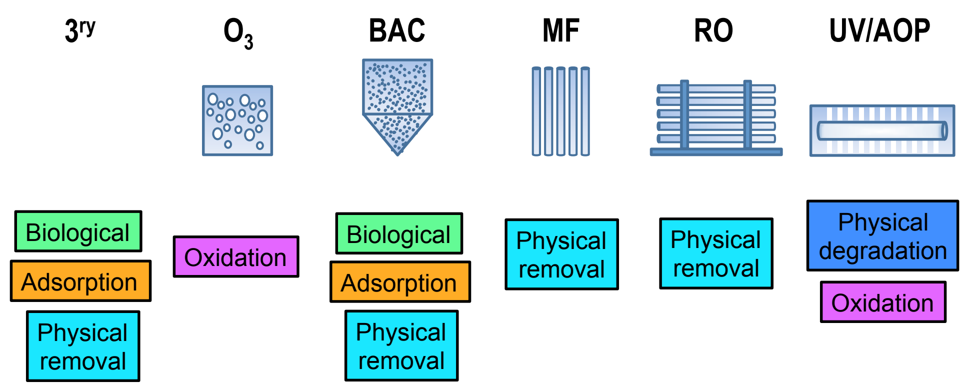


Figure 2.4 – Robust treatment trains utilize a number of contaminant removal mechanisms to protect against the large diversity of contaminants and prevent major failures.

The process also utilizes free chlorine disinfection during post-treatment, with contact time provided in the pipeline during conveyance to the reservoir. Based on initial estimates, the pipeline would provide more than sufficient contact times for disinfection (up to 2.5 hours, see Table 3.1). Spreading out treatment over a larger number of processes also helps protect against catastrophic, or complete system failures, and is the second component of robustness. Because less reliance is placed on any single unit process, even a complete failure of a given process would not cause the entire system to fail. The additional processes help to buffer out such impacts. As a final barrier, the Badger WFP provides an additional layer of protection after the AWPF and reservoir. The WFP can be operated to achieve 5-logs of virus and 4-logs of Giardia, providing additional protection beyond the minimum of 4- and 3-logs.

The final concept supporting the reliability framework is resilience, or the ability to respond and adapt rapidly to any failures that might occur. The first line of resilience is the high degree of continuous monitoring that the treatment system will provide. With such tight temporal control of performance, any failure events will be rapidly communicated to the operators. Providing AWPF performance monitoring data to operations staff at both SEWRF and Badger WFP would also bolster resilience, particularly if both parties were able to initiate resilience features, such as the diversion of off-spec water. Staff at Badger WFP are accustomed to using source waters of varying quality, a skill that will be of use with the introduction of advanced treated water into the source water options.

Future resiliency considerations will include evaluating whether monitoring is tied to automated responses, such as the diversion of off-spec water to the front of the treatment train. Other resiliency features may include options for draining the pipeline feeding the San Dieguito Reservoir.

2.2.2 Additional benefits of proposed AWT train

The primary driver for the additional ozone and BAC pre-treatment is public health protection (reliability), though these processes also provide a number of additional downstream benefits. For example, the pre-treatment creates a water that is not only lower in pathogens and toxic chemicals, but is of higher quality in terms of membrane fouling and more benevolent in terms of ocean discharge. Current testing at NCWRP has shown that significant increases in membrane flux are achievable for both the ultra- and microfiltration systems. By passing more water through a given membrane area, the number of membranes needed for treatment is reduced. At NCWRP, the ozone/BAC pre-treatment allows for equivalent performance using 50% less membrane modules (Figure 2.5). This benefit translates to a substantial savings in capital cost related to the reduced equipment needs and helps offset the additional costs of the ozone and BAC pre-treatment.

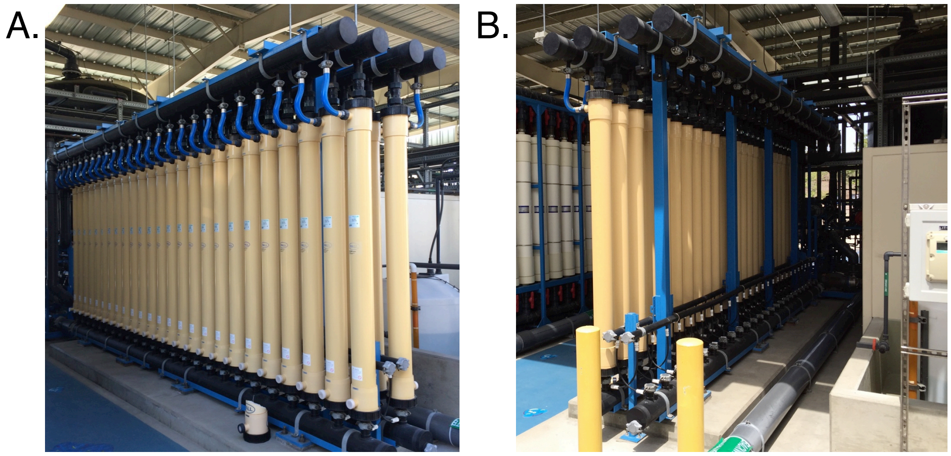


Figure 2.5 – Ozone / BAC pre-treatment allows for 50% reduction in membrane filter requirements at North City Water Reclamation Plant. Figure shows membrane filter requirements before pre-treatment (A), and after pre-treatment (B).

The pre-treatment also improves the bulk water quality as measured by total organic carbon (TOC). TOC is often used as a surrogate for the degree of residual organics, including potential contaminants of emerging concern and other "unknown" contaminants. DDW has specified that FAT water must contain less than 0.5 mg/L of TOC in order to protect against such potential concerns (CDPH 2014). The ozone and BAC pre-treatment reduce the TOC concentration in the feed water to the MF, and this benefit continues through the final effluent. The finished water quality is also therefore "improved" when compared to a typical FAT water in terms of organic content. Extensive studies in WRRF project 11-02 have also shown that preceding RO with ozone/BAC substantially reduces the load of CECs in the RO feed, substantially reducing their occurrence in RO permeate.

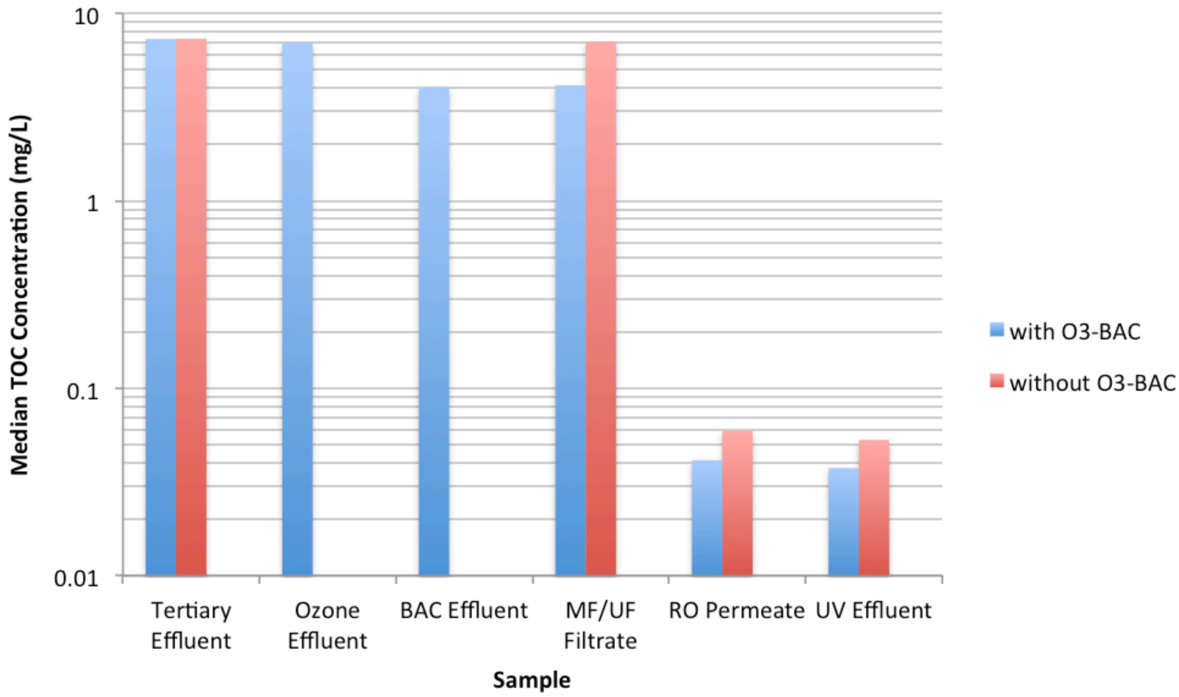


Figure 2.6 – Ozone / BAC pre-treatment produces a higher quality effluent in terms of bulk total organic carbon (TOC) content. Figure shows benefit of ozone / BAC pre-treatment for TOC removal, a benefit that is passed on in both the MF/UF filtrate and the final RO and UV product.

2.3 Water Reclamation Facility Requirements and Limitations

The San Elijo Water Reclamation Facility (SEWRF) will supply the source water for the proposed potable reuse project. The SEWRF is located in Cardiff by the Sea, California and is owned and operated by the SEJPA. The SEWRF is permitted to produce up to 3.0 million gallons per day (MGD) of tertiary treated wastewater in compliance with the California Department of Public Health Title 22 Code of Regulations for recycled water users and discharge up to 5.25 MGD of secondary treated wastewater in compliance with their Environmental Protection Agency's (EPA) National Pollutant Discharge Elimination System (NPDES) permit to the Pacific Ocean via an ocean outfall. The recycled water treatment train includes primary sedimentation, secondary aeration and clarification, filtration, and chlorine disinfection. Up to 2.48 MGD of recycled water is filtered with granular media filters (GMF), and as of 2013, an additional 0.5 MGD can be filtered with microfiltration (MF) and reverse osmosis (RO) to reduce the recycled water salinity. Currently SEWRF treats an average influent flow of 2.8 MGD, however recycled water demands vary throughout the year ranging from as high as 2.3 MGD in the summer to as low as 0.3 MGD in the winter. Secondary effluent flows in excess of the recycled water demands are discharged directly to the ocean via outfall. Figure 2.7 summarizes the average monthly flow rates at SEWRF for 2014.

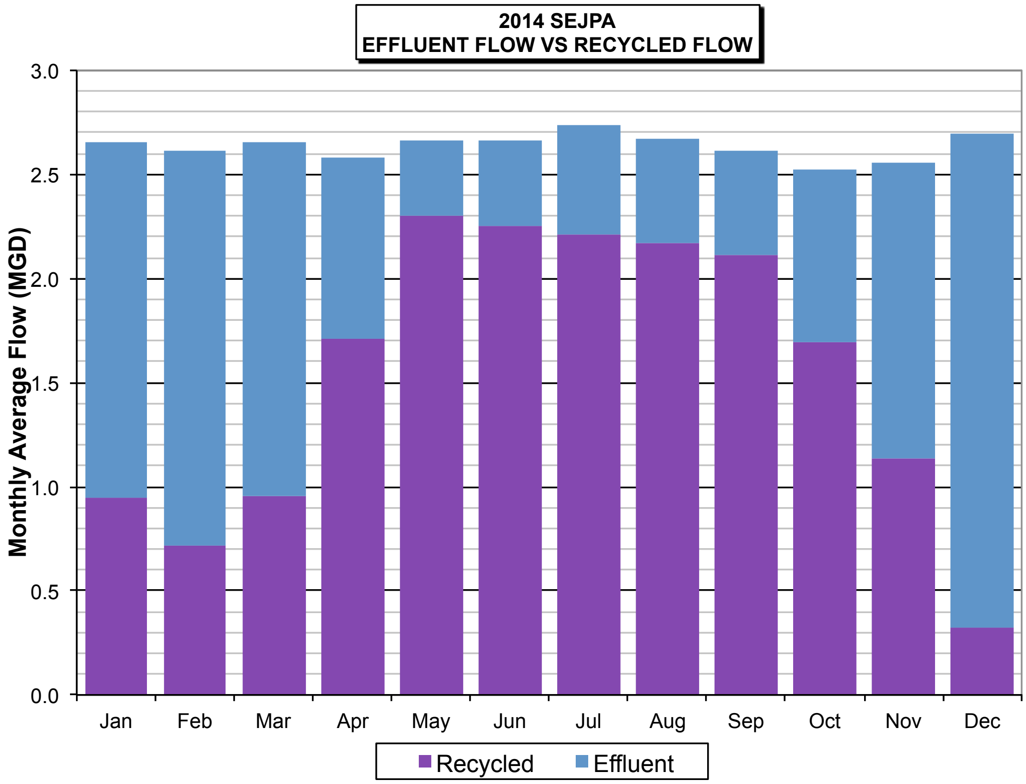


Figure 2.7: 2014 monthly flow rates and recycled water production at SEWRF

To maximize potable reuse production, all of the available flow will need to be utilized at the AWPF. This will require replacing the existing recycled water production and minimizing effluent discharge to the ocean.

2.3.1 Wastewater Treatment Requirements

The reliability and effectiveness of any water reuse project starts with the upstream wastewater treatment. There are several key treatment requirements that will help produce a stable and ideal feed water for the advanced treatment processes. These treatment requirements include:

- Flow equalization
- High solids retention time / biological nitrogen removal
- Proper management of dewatering recycle streams
- Filtration prior to disinfection

2.3.1.1 Flow Equalization

Flow equalization stabilizes the organic and nitrogen load to the biological process, making the biological and each subsequent treatment step easier to operate and manage. The constant flow allows the processes to become more stable and reliable. Currently SEWRF has primary flow equalization, which is ideal.

2.3.1.2 High solids retention time / biological nitrogen removal

A high solids retention time (SRT) in the biological process is important to break down, oxidize, and reduce the dissolved organic carbon in the secondary effluent (see Figure 2.8). Longer SRTs promote a more diverse biological population that is capable of not only enhancing the removal of dissolved organic carbon, but also effectively reducing the concentrations of important chemicals of emerging concern for potable reuse.

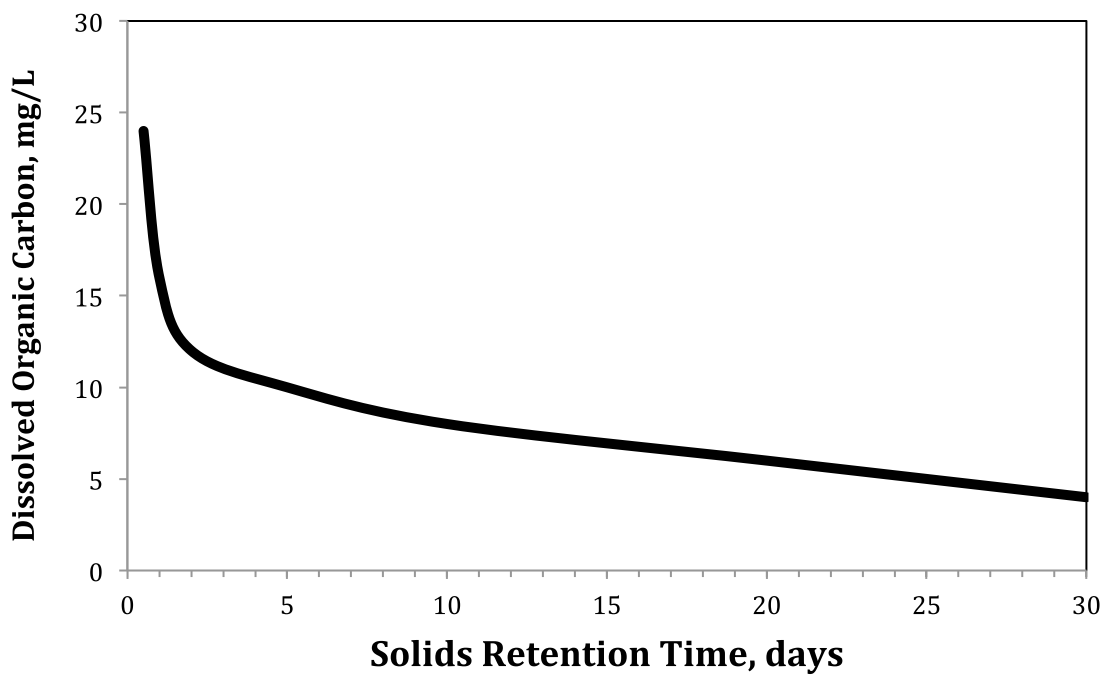


Figure 2.8: Dissolved organic carbon reduction with longer SRT

Longer SRTs (>10 days) will also produce a superior water quality more consistently in terms of BOD, TSS, turbidity, and TOC, and will reduce the total nitrogen concentration with proper nitrification and denitrification. Currently SEJPA operates the SEWRF at a low SRT of ~ 1 to 2 days to avoid nitrification; therefore, ammonia is always present at significant concentrations in the secondary effluent (25 to 45 mg/L). This is practiced because neither of the existing discharge permits regulates nitrogen compounds, and the additional oxygen demand associated with nitrification would result in a significant increase in power consumption.

The recommendation for the future secondary process is to seek the improved water quality provided by longer SRTS and biological nitrogen removal. The proposed process includes an anoxic selector and mixed liquor recycle in a Modified Ludzack-Ettinger (MLE) configuration (Figure 2.9). This set up provides biological nitrogen removal by converting the nitrate formed (in the aerobic zone) into nitrogen gas (in the anoxic zone) through denitrification. The bacteria responsible for denitrification also reduce the overall aeration requirements by consuming nitrate instead of oxygen.

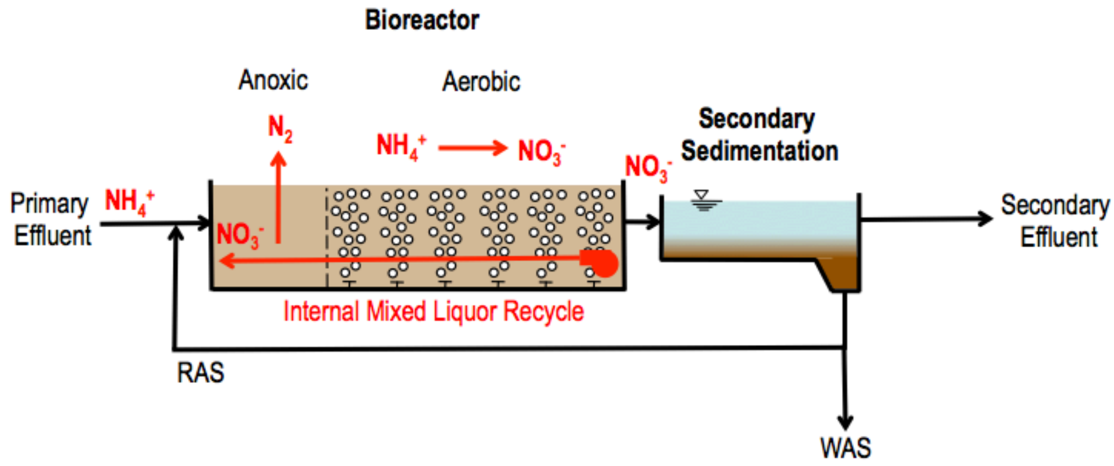


Figure 2.9: Modified Ludzack-Ettinger (MLE) process schematic for biological nitrogen removal

For potable reuse, both long SRTs (e.g., 10 days) and modification of the biological process to MLE are essential to produce a higher quality feed water for the AWT processes.

2.3.1.3 Proper management of sludge dewatering recycle streams

The dewatering of digested sludge results in liquid sidestreams that contain high concentrations of (1) nutrients (ammonia and phosphorus), (2) polymers and organic components that are known NDMA precursors, and (3) recalcitrant organics that behave as strong membrane foulants. It is critical to manage and dilute these sidestreams effectively to ensure reliable nitrification, minimize NDMA formation, provide consistent treatment, and protect the downstream membranes. The best location to discharge these streams is into the primary flow equalization basins, where they are diluted and slowly brought back into the biological treatment plant when the BOD and ammonia load are lowest. Ideally, solids handling would be performed at another facility and these liquid sidestreams would not be returned to the potable reuse facility.

2.3.1.4 Filtration prior to disinfection

Filtration is recommended to reduce the particulate matter in the secondary effluent prior to the disinfection process. Lower particulate levels will help improve the effectiveness of disinfection and reduce the maintenance requirements for the online meters. The filters will also provide a significant buffer to any process upsets in the upstream wastewater treatment plant, making disinfection and advanced treatment more effective.

2.3.2 Biological Modeling and Treatment Capacity

Biological wastewater modeling using GPS-X was utilized to determine if the existing infrastructure and tankage available at the SEWRF is capable of treating the average daily design flow of 5.25 MGD while operating at an SRT of 10 days. Table 2.1 compares the modeling results at the proposed flow of 5.25 MGD with the current operating values based on recent SEWRF process data.

Table 2.1: Current versus proposed potable reuse process parameters

Parameters	Units	Values		
		Current	Proposed	Typical Design Values
Flow	*MGD*	*2.80*	*5.25*	-
Primary Clarifiers				
# of Primary Tank in Operation	**No.**	***2 of 6***	***4 of 6***	**-**
Primary Overflow Rate	gpd/SF	1046	947	700-1400
Primary Detention Time	hours	1.7	1.7	1.5-2.5
Bioreactors				
# of Bioreactor Online	**No.**	***1 of 4***	***4 of 4***	**-**
Active Bioreactor Volume	MG	0.4	1.7	-
Bioreactor Detention Time	hours	3.4	7.6	3-5 Non-Nitrifying, 8 -12 NDN
SRT	days	2	10	-
F/M	lbs BOD/lbs VSS.day	-	0.29	-
MLSS	mg/L	1400	1950	1000-5000
OUR (1st Aerobic Zone)	$mgO_2/(L.h)$	-	47	<100
Total Airflow	scfm	800	2950	-
Secondary Clarifiers				
# of Secondary Tank in Service	**No.**	***2 of 5***	***5 of 5***	**-**
RAS Rate	MGD	1.62	5.25	-
WAS Rate	gpd	81,000	72,450	-
WAS Concentration	mg/L	2800	3830	<10,000
2^o Overflow Rate	gpd/sf	610	432	400-700
2^o Solids Loading Rate	lb/(sf.d)	22.0	14.2	<28
2^o BOD	mg/L	8.4	4.9	<30
2^o TSS	mg/L	15.0	9.4	<30
2^o Ammonia	mg/L	25.00	0.25	-
2^o Nitrite+Nitrate	mg/L	0.0	13.3	-
2^o TKN	mg/L	35.0	5.1	-

Table 2.1 shows that the primary clarifiers provide abundant capacity and redundancy at the average daily flow of 5.25 MGD, requiring only 4 of the 6 available basins to provide desirable operating hydraulic residence times (HRTs) and surface overflow rates. Table 2.1 also shows that the four available aeration basins provide sufficient volume to treat 5.25 MGD at an SRT of 10 days. The model results suggest stable performance, reasonable operating concentrations, and high quality nitrified effluent. Typically, an 8-hour HRT is required for reliable nitrification compared to only 3-4 hours for conventional carbon oxidation (low SRT). Since the aeration basins provide only 7.6 hours of detention time, it is not recommended to treat average flows much greater than 5.25 MGD. The secondary clarifiers also provide abundant capacity for 5.25 MGD as suggested by the lower surface overflow and solids loading rates compared to current operations.

Based on the biological modeling results the aeration basins are the limiting process component in terms of tankage and treatment volume. Since the existing aeration basins are capable of reliably treating 5.25 MGD at an SRT of >10 days, a flow of 5.25 MGD is assumed for the ultimate project without adding another aeration basin.

2.3.3 Summary of SEWRF Required Changes and Upgrades

SEWRF will require the following changes and upgrades in order to facilitate the proposed ultimate potable reuse project:

- All wastewater flow will be treated for the potable reuse project only
- Influent wastewater flows must increase from 2.8 to 5.25 MGD.
- Convert the aeration basins to the MLE process configuration. Upgrades include new blowers, fine bubble diffusers, internal mixed liquor recycle pumps and piping.
- Operate the upgraded MLE biological process at a high SRT (10+ days).
- Route the dewatering recycle streams to the primary flow equalization basins.
- New tertiary filters to be used prior to disinfection (i.e., ozone).

2.4 Ultimate Project Facility Flows and Preliminary Layout

This section presents the ultimate facility's production rates and preliminary layouts, assuming that the modifications to the SEWRF and AWPF presented in Sections 2.2 and 2.3 are employed. Figure 2.10 presents the flow diagram for the ultimate project. When assuming losses in flow due to backwashes and in-plant uses (e.g., for analyzers, maintenance, and other needs) the facility will produce 4.0 MGD based on an influent wastewater flow to SEWRF of 5.25 MGD. This is a conservative estimate since the waste streams, with the exception of the RO brine, will be recycled back to the SEWRF and can be treated again. Recycling these flows could result in up to 4.5 MGD of product water under ideal conditions.

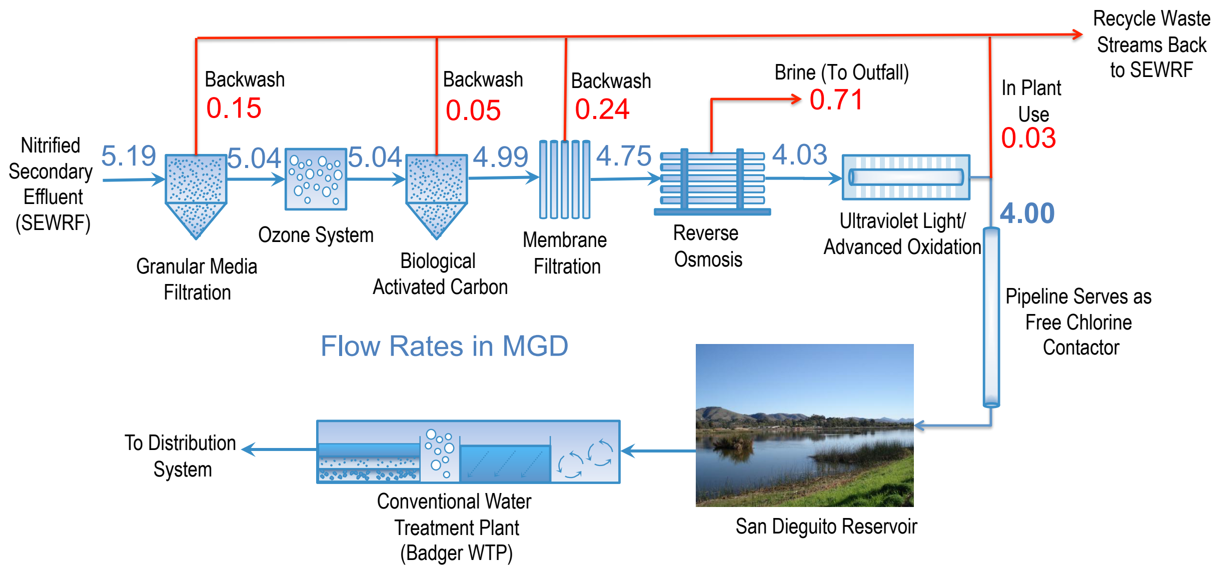


Figure 2.10: Ultimate project process flow diagram and flow rates

Each unit process and associated components were sized using comparable existing facilities, and scaled based on the flow rates shown in Figure 2.10. Figure 2.11 presents the preliminary layout for the new treatment facilities for the ultimate project.

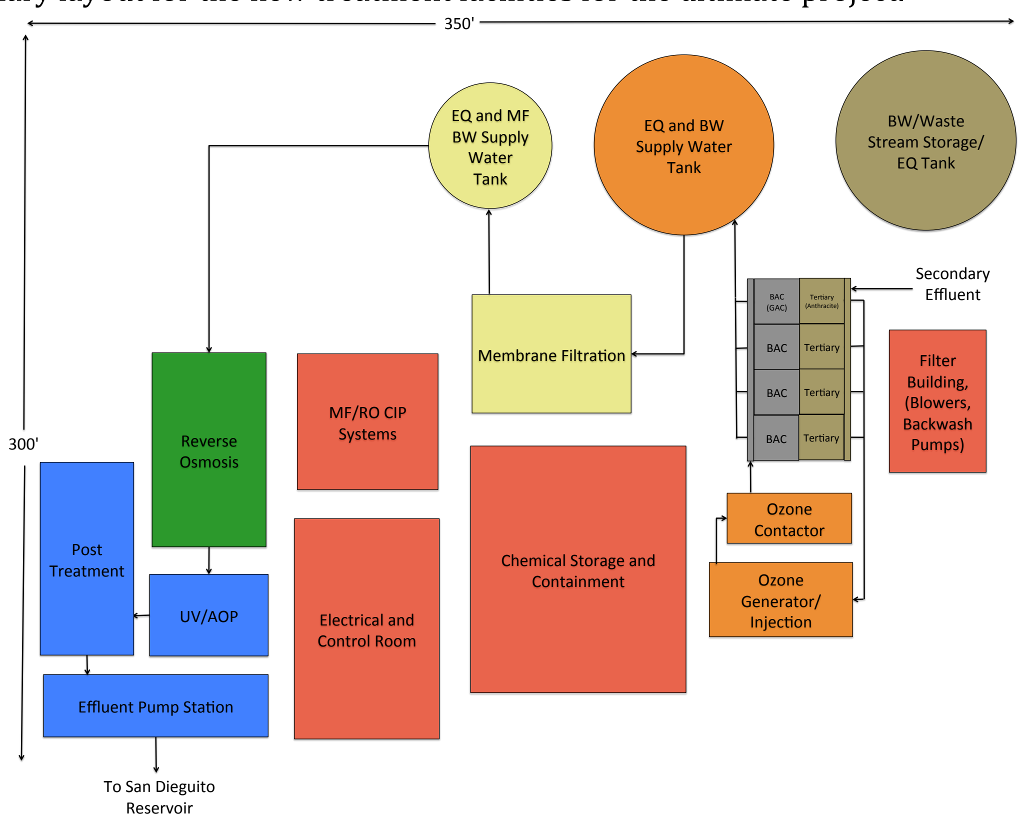


Figure 2.11: Preliminary layout of new facilities for ultimate potable reuse project

This preliminary layout can be located in the area that has been designated for potable reuse water purification in SEJPA's 2015 Facilities Plan. Figure 2.12 shows the scaled layout from Figure 2.11 superimposed on the site layout from the facilities plan.

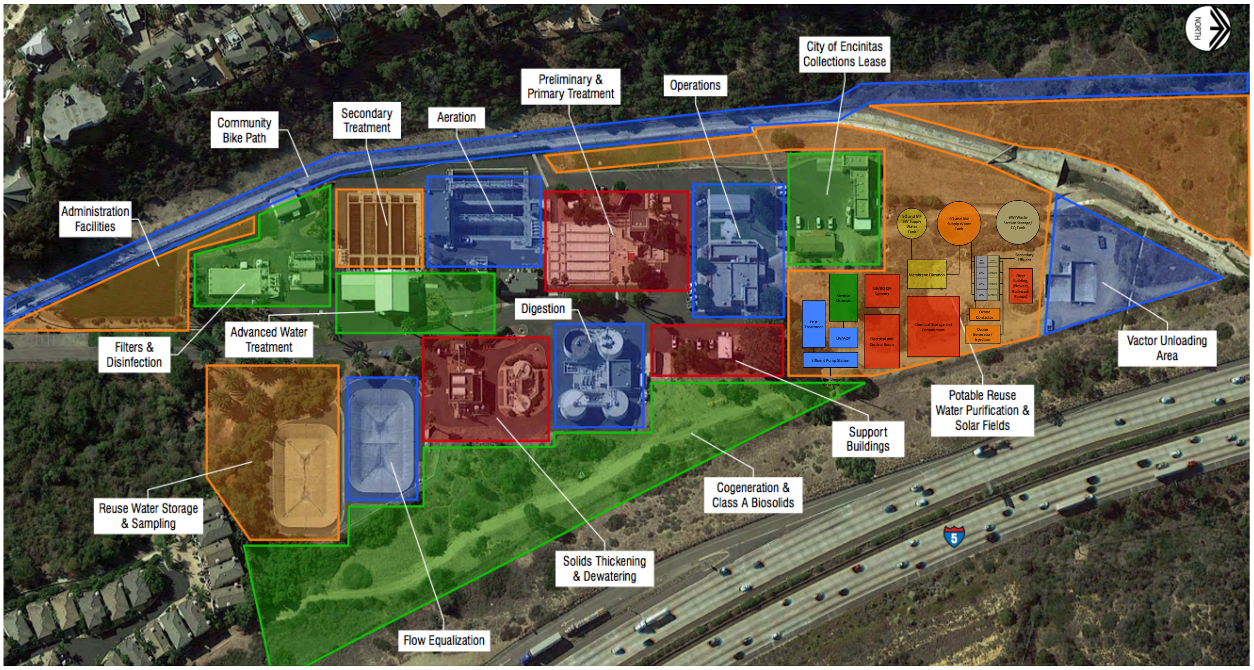


Figure 2.12: Site layout for new facilities at SEWRF

3 Conveyance Concept

3.1 Introduction

As part of the proposed potable reuse project, an existing 30-inch low-pressure San Dieguito Water District (SDWD) pipeline could be rehabilitated and used to convey advanced treated water from the SEWRF to San Dieguito Reservoir. This section provides preliminary recommendations for the conveyance facilities, including recommendations for the rehabilitation of this pipeline and pumping requirements. This section also includes an overview of construction requirements, CEQA screening of the pipeline facilities, and preliminary construction cost estimates.

The recommendations for the conveyance system are included in the following sections:

- **Section 3.1: Introduction**
- **Section 3.2: Pipe Materials –** Provides recommendations for pipeline materials.
- **Section 3.3: Hydraulic Evaluation –** Provides the results of hydraulic evaluation, including pipe diameter, pressure ratings and pumping requirements.
- **Section 3.4: Construction Requirements –** Provides construction requirements for slip lining requirements and an overview of construction by pipe segment.

- **Section 3.5: CEQA Screening –** Describes the potential environmental impacts associated with construction of the pipeline.
- **Section 3.6: Preliminary Construction Cost Estimate –** Provides a budgetary estimate of construction costs for the proposed conveyance facilities.

3.2 Pipe Materials

The two most viable pipe material options for slip lining in a pressure pipe application are high-density polyethylene (HDPE) and fusible PVC. Other materials are available for open cut piping, including steel and ductile iron; however, it is assumed that open cut segments would be installed with the same material as the slip line segments. HDPE and PVC are discussed further below.

3.2.1 HDPE

HDPE is available in ductile iron pipe sizes (DIPS) and iron pipe sizes (IPS) under AWWA Standard C906. DIPS HDPE pipe sizes match the outside diameter (OD) of ductile iron pipe and IPS HDPE pipe sizes match the OD of steel pipe. Either pipe size can be connected to any type of pipe with appropriate fittings.

HDPE can be supplied using resins that include PE 3408/3608 designation or a newer PE 4710 designation. An HDPE supplier (Isco) claims that most new HDPE products sold are of the PE 4710 designation. Isco indicates the 4710 resin has a higher stress crack resistance and higher pressure ratings (at the same DR) compared to PE 3408/3608 pipe and that the cost per pound for PE 4710 and PE 3408/3608 is virtually the same. According to Isco, the PE 4710 designation is an all-around better quality material; however, PE 4710 is currently not covered in AWWA C906-07. For HDPE, designing around PE3408/3608 pressure ratings is recommended, and either PE 4710 or PE3408/3608 pipe can be specified for the installation. In other words, the higher pressure rating identified by the suppliers of HDPE pipe for PE4710 would be ignored or considered a factor of safety since it is not currently accepted through AWWA standards. HDPE uses butt-welded joints.

Fittings for HDPE 12-inch diameter and smaller are typically molded and fittings larger than 12-inches are fabricated from straight pipe segments. Fabricated fittings are de-rated, therefore the pressure rating of fabricated fittings is lower than the pressure rating for straight pipe of the same DR. The result is that fabricated fittings must be a thicker wall (lower DR) than the adjacent pipe and the ends of the fitting are tapered to match the thickness of the connecting pipe. This situation often presents a design challenge in higher pressure applications, as fittings with the appropriate pressure rating may not be available. Using mechanical joints with steel or ductile iron fittings is an option, but mechanical joints in HDPE applications are a potential mode of failure that must be considered. This point is presented because IPS HDPE above 24-inch outside diameter may not be available lower than DR 9, and DR 9 is recommended for the lower elevation reaches of this pipeline.

There have been concerns raised in the industry regarding the potential for oxidative degradation of HDPE used for chlorinated water applications. Some studies have concluded that oxidative degradation could result in long term issues with crack propagation and failure of HDPE pipe. This concern is highly contested in the industry, and there have been numerous studies with conflicting results. Unfortunately, AWWA and the American Society for Testing and Materials (ASTM) have not addressed the issue of oxidative degradation in HDPE pipe to date. Many utility owners have stopped using HDPE for chlorinated water service until the issue is resolved. During final design of this project, this issue should be considered when selecting materials, considering chlorine residual in the pipeline.

3.2.2 PVC

PVC in 16-inch diameter and larger would be in accordance with AWWA C905 and is available with bell and spigot joints as well as fusible joints. Fusible PVC has the same pressure design properties as bell and spigot PVC, with special chemical formulations to allow for butt fusion welding. Fusible PVC would be recommended for slip lining since it does allow for installation of a larger nominal pipe diameter than belled pipe.

3.2.3 Material Recommendations

Both PVC and HDPE are potentially viable options; however, there are three main concerns with HDPE in this application that should be considered during final design:

- HDPE requires a thicker wall relative to PVC for the same pressure rating. Therefore, PVC will allow for installation of a pipe with a larger inside diameter than HDPE in this application, which will in turn reduce pumping costs. As an example, 24-inch DR 18 PVC has a standard pressure rating of 235 psi, an outside diameter of 25.80" and an inside diameter of 22.76". A hydraulically comparable HDPE pipe would be 30-inch DR 9 HDPE (IPS OD) with a standard pressure rating of 253 psi, 30" outside diameter, and 22.93" inside diameter. This pipe would not be an option for slip lining the 30-inch low pressure pipeline. A 26" DR 9 HDPE (IPS OD) pipe with a 26" outside diameter and 19.88" inside diameter would likely be the maximum HDPE size that could be slip lined, and it has a comparable inside diameter to 20-inch DR 18 PVC.
- Preliminary calculations and assumptions would require IPS HDPE DR 9 for the lower elevation reaches. Fabricated fittings with an equal pressure rating may be difficult to obtain.
- Until a consensus is reached by an industry organization such as AWWA, the potential concern of oxidative degeneration of HDPE in chlorinated applications should be considered.

For the purpose of this evaluation and costs presented below, PVC pipe sizes are assumed; however, the recommendations should be revisited during final design including pipe size, pressure rating, and associated costs (capital and pumping costs) to make an ultimate selection. Allowing both materials could also be a potential option, but the bidding/selection process must consider pumping cost increases when allowing a smaller ID pipe.

3.3 Hydraulic Evaluation

A hydraulic evaluation was conducted to recommend pipe diameter and pressure ratings for the proposed pipeline and to evaluate existing 16-inch DR 25 PVC pipe segments to determine if they can remain in service or must be replaced. The following assumptions were used in preparing preliminary hydraulic calculations.

- Maximum future flow through the pipeline will be 5 million gallons per day (MGD) or 3,472 gallons per minute (gpm) from SEWRF to San Dieguito Reservoir.
- Length of pipeline from SEWRF to San Dieguito reservoir is estimated to be 27,050 lineal feet (LF):
    - 2,200 LF of new pipeline from SEWRF to the slip line segment, including a segment to be relocated by Caltrans,
    - 23,250 LF of existing 30-inch low-pressure pipeline to be slip lined, and
    - 1,600 LF of pipeline of 16-inch DR 25 PVC (previously installed to replace the low-pressure line at two locations).
- Elevation of the proposed conveyance pump station at SEWRF is estimated to be 40 feet above mean sea level (MSL). Future location of this pump station is unknown.
- Elevation of the discharge at San Dieguito reservoir is approximately 240 feet above MSL.
- C-value used for hydraulic calculations is 120.
- Assumed hydraulic pumping efficiency is 80%.

An excel spreadsheet model was used to determine select pipe diameter, determine pumping requirements, and pressure requirements using an iterative process. The results are summarized below.

3.3.1 Pipe Diameter and Pumping Requirements

Flow velocity and pumping horsepower requirements were calculated for two options:

- **Option 1:** Using 20-inch DR 18 PVC for the new pipeline, except that the existing 16-inch DR 25 PVC segments would remain in place.
- **Option 2:** Using 24-inch DR 18 PVC for the new pipeline (slip line and open cut segments), except that existing 16-inch DR 25 PVC segments would remain in place.

Table 3.1 summarizes the length, inside diameter, flow velocity and headloss in the existing 16-inch pipe, and the two options for slip lining at a flow rate of 5 MGD.

Table 3.1: Summary of Pipeline Velocity and Headloss

Pipe Segment	Length	Inside Pipe Diameter	Flow Velocity	Retention Time	Headloss
Existing 16-inch DR 25 PVC	1,600 LF	15.92”	5.6 ft/s	4.8 min	13 ft
Option 1: 20-inch DR 18 PVC	25,450 LF	19.06”	3.9 ft/s	1.8 hours	79 ft
Option 2: 24-inch DR 18 PVC	25,450 LF	22.76”	2.7 ft/s	2.6 hours	33 ft

Static head from SEWRF to the San Dieguito Reservoir discharge is approximately 200 feet. Based on the head losses in Table 1 and static head, the pumping requirements for each option are presented in Table 3.2. Total station horsepower is total motor horsepower and will depend on the number of pumps installed. Assuming one standby pump at the pump station to provide firm capacity, a reasonable estimate of total station horsepower considering standard motor sizes and standby pumps is 1.5 x the hydraulic horsepower, rounded up to the nearest 50 HP.

Table 3.2: Summary of Pumping Requirements

Option	Pipeline Headloss	Static Head	TDH	Hydraulic Horsepower	Est. Total Station Horsepower
Option 1: 20-inch DR 18 PVC	95 ft	200 ft	295 ft	323 HP	500 HP
Option 2: 24-inch DR 18 PVC	48 ft	200 ft	248 ft	271 HP	450 HP

While the total station horsepower (and installed capital cost) for the pump station under Option 1 versus Option 2 will be similar, the additional 47 feet of pumping head and associated power costs will add up over time. When the final flow scenarios are developed for the project, the engineering team should conduct an analysis of capital cost versus pumping costs to select the final pipe size and size the pump station accordingly. For the purpose of this study and the cost estimates below, a 24” PVC pipe is assumed, since pumping costs will likely exceed the capital cost savings of a smaller pipe in a relatively short period of time.

3.3.2 Proposed Pipe Pressure Rating

Based on the hydraulic calculations, normal working pressure within the proposed pipeline near the SEWRF will be approximately 107 psi using 24-inch PVC. It is recommended to use a minimum design operating pressure and test pressure of 150 psi for the lower reaches with pressures exceeding 100 psi, which is consistent with many water agencies standards; however, the design team could consider designing around a lower pressure rating, particularly in the upper elevation reaches where operating pressure will be lower.

PVC in accordance with AWWA C905 uses a comparison of short term rating (STR) versus maximum pressure in the pipeline (operating pressure plus surge pressure) to calculate a safety factor against maximum surge. This analysis calculated the maximum surge pressure based on the change in velocity in the pipeline in accordance with the AWWA C905 methodology, but a surge analysis should be completed for final design and surges higher than those calculated using the AWWA method should be mitigated.

The pressure rating of PVC pipe is also limited by cyclic loading stresses resulting from the normal on/off cycling of pumps, but this limitation is more applicable to pipelines with large changes in pressure between normal operating pressure and the low pressure (pumps turned off condition), such as a sewer force main. Since this is a transmission main application pumping uphill and the pipeline will remain full at all times, cyclic loading stresses should not be a factor in the pipeline design. If cyclic loading is determined to be a factor during design, it can be mitigated by reducing pump cycles using variable frequency drives.

The preliminary recommendation for PVC pipe in the lower reaches where pressures will vary the most is AWWA C905 PVC, DR 18 based on a design pressure of 150 psi. DR 18 PVC has a standard pressure rating of 235 psi, but the pressure rating is de-rated based on temperature. The safety factor for surge based on preliminary calculations is 3.81. This safety factor for surge should be adequate; however, a surge analysis should be performed during final design and any surges above those estimated based on pipe velocity using AWWA procedure should be mitigated. This selection assumes a temperature de-rating factor of 0.75, which is applicable for water temperature up to 90 degrees.

The DR 18 PVC selection was evaluated against cyclic pressure surges based on the methodology in AWWA C900, Appendix B. Under this methodology the number of pump cycles during the life of the force main (C') is compared to the number of cycles to failure (C) based on the maximum pressure, minimum pressure and the dimension ratio (DR).

First, average hoop stress is calculated as follows:

$$\sigma_{avg} = \frac{(P_{max} + P_{min})(DR - 1)}{4}$$

Next, hoop stress amplitude is calculated as follows:

$$\sigma_{amp} = \frac{(P_{max} - P_{min})(DR - 1)}{4}$$

Where:

σ_{avg}=average hoop stress generated by recurring surges, psi

σ_{amp}=average hoop stress generated by recurring surges, psi

P_{max} = Maximum operating pressure for recurring surges, psi

P_{min}= Minimum operating pressure for recurring surges, psi (assumed to be 0)

DR = Pipe dimension ratio

P_{max} is based on the hydraulic grade line elevation, estimated to be 286 ft near the connection at SEWRF for an equivalent pressure of 107 psi. P_{min} is based on the static HGL, which is 240 ft for an equivalent pressure of 87 psi. Using DR 18, the average hoop stress is estimated to be 825 psi and hoop stress amplitude generated by recurring pressure surges would be 85 psi. Referring these values to Figure B.2 of AWWA C900, Appendix B, the predicted number of cycles to failure is near 100,000,000 cycles (1.E +08). Assuming a pipeline operation of 100 years with one on and off cycle every hour (which would be very conservative) and a factor of safety of 2 on the number of cycles, C' would be 1,752,000 cycles; therefore, based on these assumptions and criteria, cyclic loading is not a concern.

Although the pumping (horsepower) and pipe wall calculations above were developed for DR 18 based on the highest pressure reaches of the pipeline, the DR can be reduced as the pipeline heads uphill toward the reservoir. The existing 16-inch pipeline segments are DR 25; therefore, if those segments remain in place, it would not be sensible to install a pipe with a DR less than (higher pressure rating than) DR 25 up-gradient of those segments. Hydraulic calculations indicate the pressure at the lower gradient segment of 16-inch DR 25 PVC (Segment 3 in Figure 3.1) would be approximately 75 psi and the existing pipe would be adequate up to a working pressure of 100 psi. Therefore, DR 25 PVC should be adequate for all segments up-gradient of Segment 3.

3.4 Construction Requirements

This segment summarizes the construction requirements for the new pipeline. The conveyance pipeline has been divided into six segments described below and shown in Figure 3.1 and Figure 3.2.

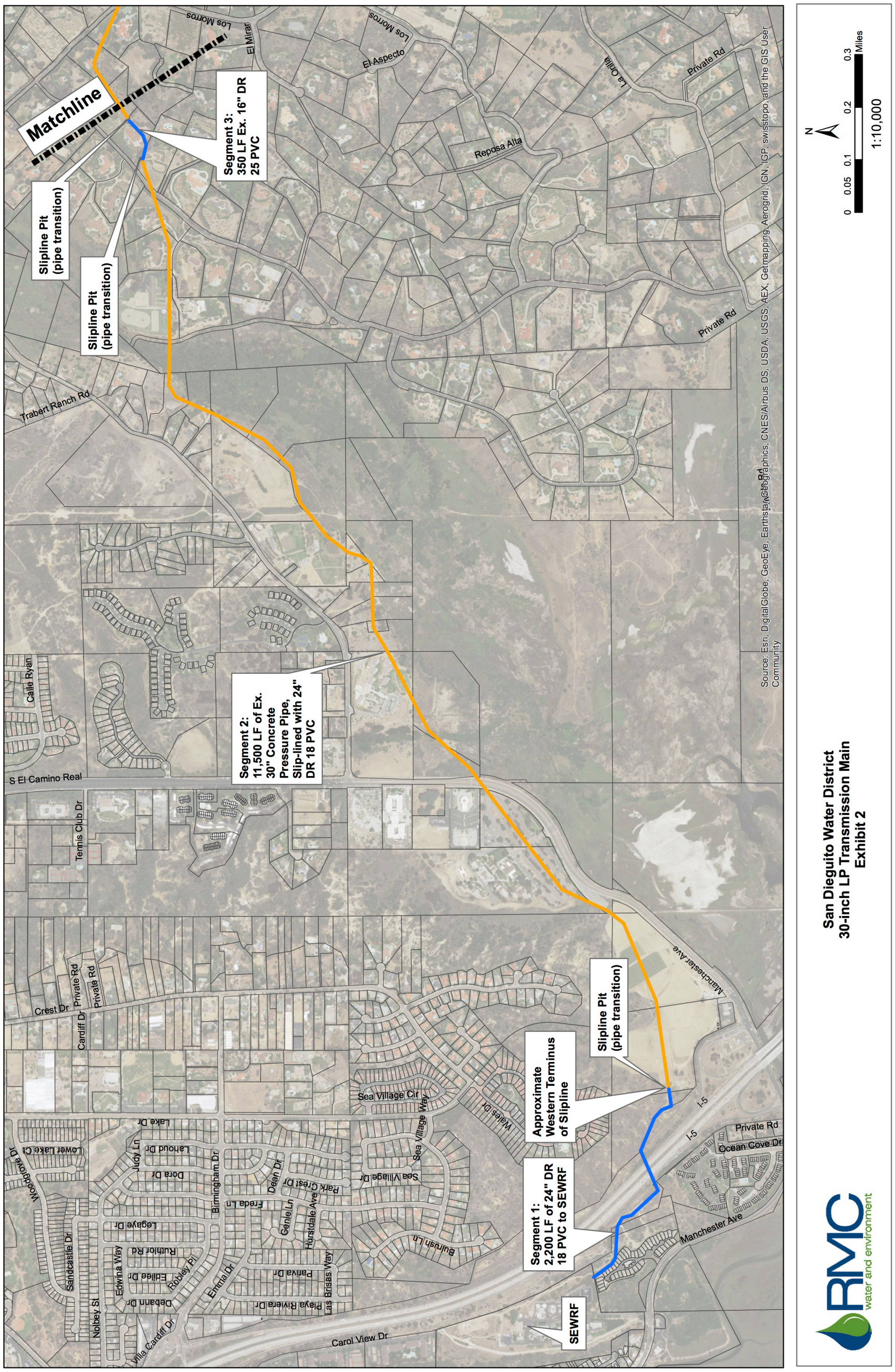


Figure 3.1: San Dieguito Water District 30-inch LP transmission main Sections 1-3

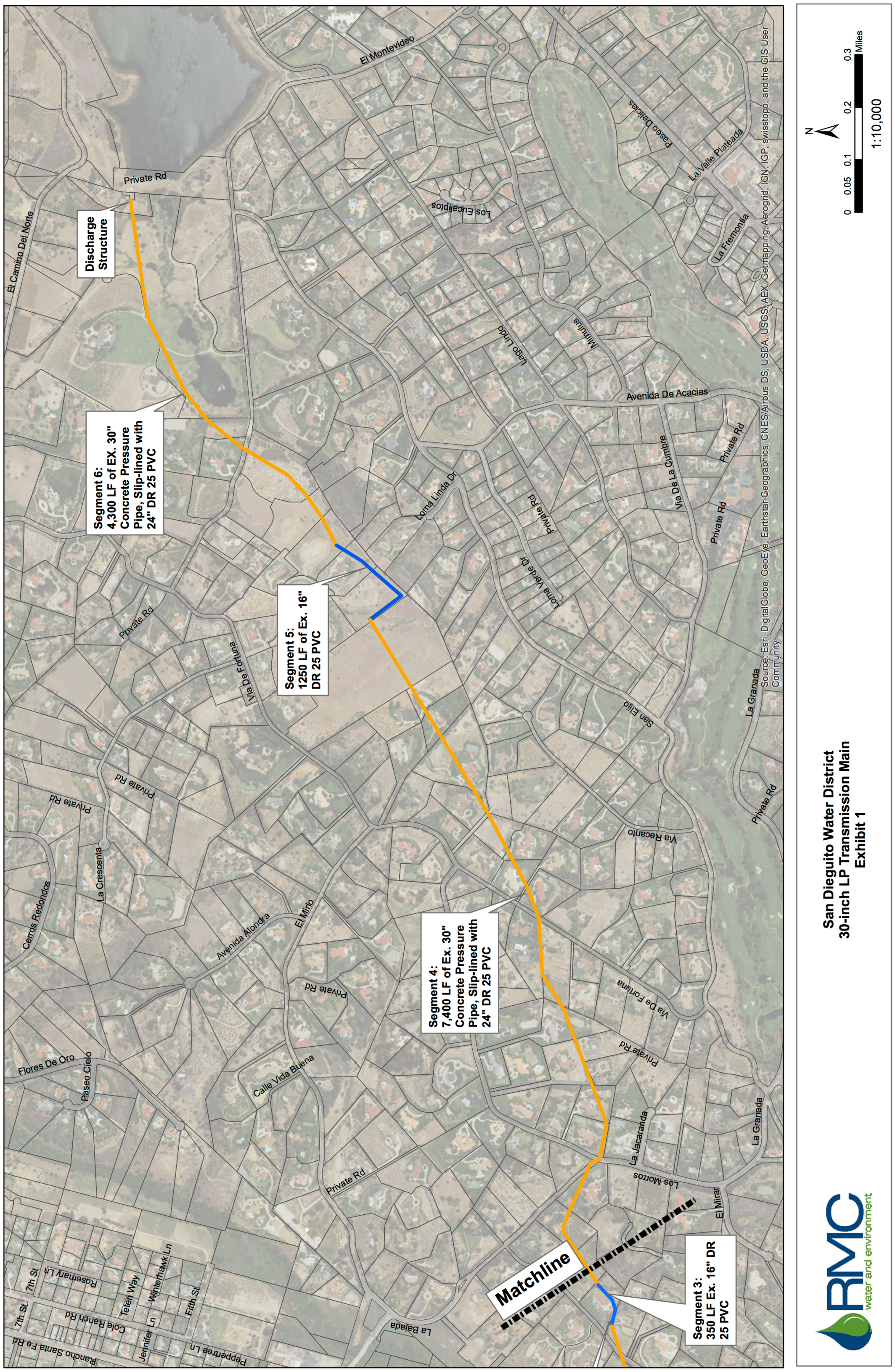


Figure 3.2: San Dieguito Water District 30-inch LP transmission main Sections 4-6

3.4.1 Slip lining – General Considerations

The existing SDWD 30-inch pipe is reinforced concrete and pre-stressed concrete cylinder pipe, both of which are inside diameter controlled and normally have 30-inch inside diameter. The as-built drawings for the pipeline indicate 30-inch inside diameter, which should be confirmed during final design. The inside diameter of the existing pipe will limit the maximum size of the slip line pipe to approximately 26-inches outside diameter using a rule of thumb to allow 2-inches between the slip line pipe and the host pipe for installation. A desktop evaluation of the as-built drawings and lay drawings was performed to evaluate bends and other pipeline features that could limit slip lining.

While the District owns an existing pipeline easement and it would be technically feasible to replace the existing pipeline with a new pipeline using open cut construction methods, it would be very disruptive to the various property owners along the alignment and would incur higher construction costs. To reduce impacts to property owners and to reduce construction costs, slip lining was evaluated.

Slip lining is the insertion of one long string of fused pipe into an existing, larger pipe through an access shaft. The annular space between the new pipe and the existing pipe is then usually grouted. Installation requires construction of access shafts and a layout area to string the pipe and fuse/test the joints prior to installation. Layout strings of up to 2,000 feet are typical. This would affect pedestrian and vehicle traffic in the vicinity of the insertion pit. Construction access typically requires a working area of 2,000 to 5,000 square feet to allow for equipment layout and work around the shaft. The shaft dimensions would be 6 to 8 feet wide and could be as long as 50 feet depending on the depth of the existing pipeline. Approximately 25-50% of the access shafts would not be used to insert pipe but instead would be used to pull two slip-lined segments together and connect the segments.

Based on a review of the record drawings and a preliminary review of the surface features along the pipeline alignment using Google Earth, it appears technically feasible to slip line the existing pipeline with 24-inch diameter fusible PVC or 26-inch IPS HDPE pipe.

The existing pipeline has several air release valves, blowoffs, isolation valves, and manholes/manways. In general, each of these items would be replaced during the slip lining operation and would require a small (10 feet by 8 feet) excavation. When slip lining access shafts locations are determined, it is advantageous to place the access shafts at the same location as appurtenances such as air release valves, blowoffs, or manholes/manways in order to reduce the number of excavations. There are approximately 34 of these appurtenances along the slip line segments that would require excavation. Slip lining length and location of entry shafts are determined during final design and construction by both length and number/severity of angle points. The number of slip lining access shafts is estimated by segment below.

3.4.2 Segment 1: New Pipeline from SEWRF Across Interstate 5

Segment 1 would be a new pipeline from SEWRF across Interstate 5. This would include a segment of pipeline that is proposed to be relocated by Caltrans as part of an I-5 improvement project. Recommendations for the Caltrans segment were provided in an earlier TM (*Interstate 5 Crossing Pipeline Sizing, Material and Pressure Rating TM*, dated May 21, 2015*).* The recommendations of that TM are still valid, although the hydraulic evaluation presented herein is based on new information obtained. Segment 1 would also include new pipeline to SEWRF from the Caltrans segment. If it is an option, the existing 30-inch SDWD pipe at this location could be slip lined, or the pipeline could be installed by traditional open cut methods. Slip lining construction issues are discussed further below.

3.4.3 Segment 2

Segment 2 is approximately 11,550 feet long and extends from a point 250 feet north of the Manchester Avenue interchange on Interstate 5 to a point 1,500 feet west of the intersection of La Bajada and Los Morros. Based on a preliminary evaluation, approximately 18 slip lining access shafts would be required to slip line this segment. This segment includes 5 air release valves, 7 blowoffs, 6 isolation valves, and 4 manholes/manways that would be replaced (although this number may decrease as additional evaluation is performed).

3.4.4 Segment 3

Segment 3 is approximately 350 feet long and extends from a point 1,500 feet west of the intersection of La Bajada and Los Morros to a point 1,200 feet west of the intersection of La Bajada and Los Morros. Segment 3 consists of 16-inch DR 25 PVC installed in approximately 2012. The slip lined pipe would connect to the existing PVC pipe and no additional work is needed on this segment.

3.4.5 Segment 4

Segment 4 is approximately 7,400 feet long and extends from a point 1,200 feet west of the intersection of La Bajada and Los Morros to 2,000 feet east of the intersection of Via De Fortuna and Los Mirlitos. Based on a preliminary evaluation, approximately 10 slip lining access shafts would be required to slip line this segment. This segment includes 4 air release valves, 2 blowoffs, 1 isolation valve, and 2 manholes/manways that would be replaced (although this number may decrease as additional evaluation is performed).

3.4.6 Segment 5

Segment 5 is approximately 1250 feet long and extends from a point 2,000 feet east of the intersection of Via De Fortuna and Los Mirlitos to 2,000 feet south of the intersection of Via De Fortuna and El Montevideo. This segment consists of 16-inch DR 25 PVC installed in approximately 2004. The slip lined pipe would connect to the existing PVC pipe and no additional work is needed on this segment.

3.4.7 Segment 6

Segment 6 is approximately 4,300 feet long and extends from a point 2,000 feet south of the intersection of Via De Fortuna and El Montevideo to San Dieguito Reservoir. Based on a preliminary evaluation, 4 slip lining access shafts would be required to slip line this segment. This segment includes 2 air release valves, 1 blowoff, and 1 manholes/manway that would be replaced (although this number may decrease as additional evaluation is performed).

3.5 CEQA Screening

This section describes the potential environmental impacts associated with construction of the proposed project, including pipe slip-lining, replacement of blow offs and valves, and connections to existing pipe. Slip lining has significantly less impact on the environment than open cut pipeline construction; however, open cut access will be required at several locations along the existing pipeline for slip lining pits and to replace air valves, isolation valves and blowoffs.

3.5.1 Biological Resources

The pipeline alignment runs cross-country (not within a public right-of-way) within the boundary of the County of San Diego's Multiple Species Conservation Program (MSCP), North County Plan (MSCP North County Plan Vegetation Communities Map, 2008). Much of the alignment and associated blow off and valve sites are located on undeveloped or orchard lands that are privately owned. The MSCP North County Plan designates marsh, coastal sage scrub, riparian scrub, grasslands, and urban, disturbed habitat and agriculture habitats within the project area (MSCP North County Plan Vegetation Communities Map, 2008). The project crosses Escondido Creek, just above the discharge point to San Elijo Lagoon, and has the potential to impact riparian and wetland habitat.

A biological survey will need to be conducted to identify sensitive biological resources and ensure impacts to biological resources will be avoided or mitigated. Focused surveys (presence/absence surveys) will need to be conducted to determine if excavation will have a significant impact on any threatened and endangered (T&E) species. Construction of access roads to the blow off and valve sites and excavation of pits may require tree removal, particularly within private undeveloped or orchard lands, which will need to be mitigated. Specifically for the riparian and wetland habitats, coordination with the regulatory agencies may be needed. Similarly, coordination with regulatory agencies may also be needed if any modifications at the San Dieguito Reservoir outfall occur. For any construction within the riparian extant of Escondido Creek or the reservoir outfall, the following permits may be needed:

1. U.S. Army Corps of Engineers, Clean Water Act Section 404 Permit (jurisdiction within high water mark)
2. Regional Water Quality Control Board, Clean Water Act Section 401 Water Quality Certification (triggered by Section 404)

3. California Department of Fish and Wildlife, California Fish and Game Code 1600 Streambed Alteration Agreement (jurisdiction within riparian extant)
4. Consultation with U.S. Fish and Wildlife Agency (impacts to T&E species)

3.5.2 Cultural Resources

The proposed pipeline alignment is located in an area historically occupied by Native Americans. A cultural resources survey will need to be conducted to determine if the project site has known archeological or cultural resources. The project has the potential to impact cultural or archeological resources due to the excavation activities necessary to replace the blow offs and valves. Although the excavation sites were previously excavated when the pipeline was originally installed, a cultural resources monitor may be required during excavation activities.

3.5.3 Transportation/Traffic

The proposed pipeline alignment runs from just west of Interstate-5 to the eastern shore of San Dieguito Reservoir. Hauling and equipment trucks will be likely routed along Interstate 5 to the project sites. The pipeline alignment runs cross-country, through private property, and excavation sites are located in areas with limited access. Sites will be accessed through local roadways and additional access roads through undeveloped or orchard lands may need to be constructed to deliver equipment to the excavation sites. The remote access of the sites and the need for additional access roads may trigger or contribute to agricultural, biological, or hydrologic issues.

3.5.4 Hydrology / Water Quality

The project area drains to Escondido Creek and San Elijo Lagoon. Both Escondido Creek and San Elijo Lagoon are on the Clean Water Act Section 303(d) list, a list of water bodies that do not meet water quality standards. Escondido Creek is listed for DDT, manganese, phosphate, selenium, sulfates, and TDS. San Elijo Lagoon is listed for eutrophic, indicator bacteria, and sedimentation/siltation. The proposed pipeline alignment crosses Escondido Creek, and if excavation is required within the vicinity of the creek, a hydrologic analysis may need to be conducted. Excavation within the riparian extent of Escondido Creek will be subject to the regulatory permits identified under Biological Resources above.

The project may temporarily impact water quality due to the use of heavy machinery for construction activities. Use of heavy equipment could cause accidental release of construction-related contaminants (e.g., fuels, oil, concrete, paint and trash), thereby potentially impacting downstream water quality and aquatic habitats. Development of a Stormwater Pollution Prevention Plan (SWPPP) and associated BMPs would be necessary to mitigate these impacts to the extent possible, particularly as they relate to the 303(d) listed constituents identified above.

3.5.5 Short-term Impacts Associated with Construction

There may be short-term environmental impacts associated with construction activities. Because these impacts are limited to the construction period, they will likely be less than significant or can be mitigated to less than significant.

3.5.5.1 Agricultural Resources

Temporary impacts may occur to agricultural resources due to this project. The pipeline alignment will extend through pockets of Prime Farmland, Farmland of Statewide Importance, or Unique Farmland as designated by the CA Department of Conservation (California Important Farmland Finder Map, 2014). A survey will need to be conducted to determine the extent to which these impacts would occur. If removal of trees or crops is required, mitigation measures may need to be implemented.

3.5.5.2 Hazards and Hazardous Materials

This project may have temporary hazards and hazardous materials impacts due to construction activities. As stated in Hydrology above, use of heavy equipment could cause accidental release of construction-related contaminants (e.g., fuels, oil, concrete, paint and trash), thereby potentially releasing these materials into the environment. However, BMPs can be implemented to mitigate impacts to the extent possible.

3.5.5.3 Air Quality and Greenhouse Gas Emissions

Air quality and greenhouse gas impacts may occur due to construction and excavation activities. Air quality modeling will be needed to determine the estimated quantity of emissions as compared to levels in the San Diego Air Basin. These impacts would be short-term and BMPs can be implemented to mitigate impacts to the extent possible.

3.5.5.4 Noise

Temporary noise impacts may occur due to construction related activities. Sensitive receptors, such as surrounding residents, may dictate implementation of sound dampening equipment or barriers. Constructions activities should comply with regulations regarding noise and impacts will need to be minimized to the extent possible.

3.6 Preliminary Construction Cost Estimate

An opinion of probable construction cost was developed based on the concept presented above. The cost is a Class 4 estimate and is expected to be within a +30% to -20% level of accuracy, as defined by the Association for the Advancement of Cost Engineering (AACE). The benchmark Engineering News Record Construction Cost Index (ENR CCI) for this estimate (June 2015) in the Los Angeles Area is 10981 and the 20-cities average is 10039. This cost estimate is intended to represent the average anticipated bid price for the construction work under a competitive bid process. Implementation costs are not included. Implementation costs may include but are not limited to planning, preliminary and final design, CEQA compliance, permitting, engineering services during construction,

construction management, inspection and testing, administration, legal, permitting, and property acquisition.

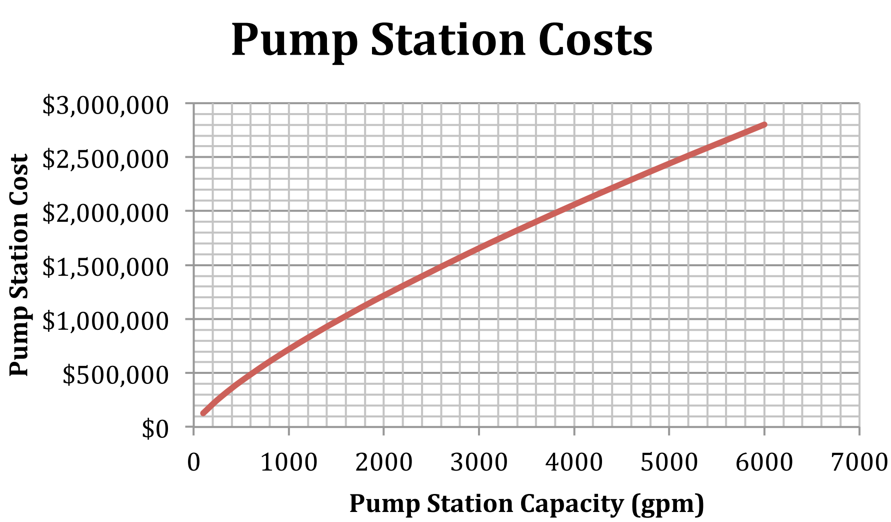
3.6.1 Pipeline Costs

A bid tabulation was obtained from Underground Solutions (a fusible PVC supplier) for a recent project in Folsom California to slip line an existing 30-inch concrete pipe with 24-inch fusible PVC. The unit prices for slip lining and grouting annual space between the carrier and host pipe are based on the average bid price from the project. Appurtenances (valves, blowoffs and air valves) are estimated at $5,000 each based on bid tabulation from similar projects.

3.6.2 Pump Station and Discharge Structure

Construction cost for the pump station is based on cost curves for water pump stations in *Pumping Station Design*, *Second Edition*, Robert L. Sanks, 1998 (Sanks 1998). Cost curves by flow rate shown in Figure 3.3 were estimated based on the pumping station costs in Sanks 1998 and adjusted from an ENR CCI of 4500 to the present ENR CCI.

Figure 3.3: Pump station cost curve



An allowance of $250,000 is provided for modification at the discharge to San Dieguito Reservoir. The required discharge structure or modifications are unknown at this time.

3.6.3 Cost Estimate

Table 3.3 is a preliminary construction cost estimate for the conveyance system.

Table 3.3: Construction cost estimate

Item	Quantity	Unit	Unit Cost	Total Cost
Slip line: 24-inch PVC	23,250	LF	$180	$4,185,000
Grout Annual Space	23,250	LF	$12	$279,000
Open Cut: 24-inch PVC	2,200	LF	$290	$638,000
Blowoffs/Valves/Manholes	34	EA	$8,000	$272,000
Pump Station	1	LS	$1,900,000	$1,900,000
Discharge Structure	1	Allow.	$250,000	$250,000
			Subtotal	$7,524,000
			Mobilization, Demobilization, Bonds, Insurance (8%)	$602,000
			NPDES Stormwater Compliance (3%)	$226,000
			Raw Construction Subtotal	$8,352,000
			Contingency (25%)	$2,088,000
			CONSTRUCTION COST ESTIMATE	**$10,440,000**
			ANTICIPATED COST RANGE (-20% to +30%)	**$8.4M - $13.6M**

4 Reservoir Concept

4.1 Regulatory Overview

As discussed in TM#1, two of the most stringent requirements in the draft surface water augmentation regulations relate to retention time and dilution/mixing. Since the completion of TM#1, DDW and their Expert Panel have come to further resolution on these criteria, and the expected requirements are presented in Table 4.1.

Table 4.1: Retention time and dilution requirements in draft surface water augmentation regulations

Requirement	Details
Theoretical retention time	Reservoir must provide a minimum of 6 months of theoretical retention time
Mixing and dilution	Demonstrate a 24-h input pulse results in: • A concentration in the reservoir withdrawal that is no greater than 1% of recycled water effluent concentration, *or* • A concentration in the reservoir withdrawal that is no greater than 10% of recycled water effluent concentration, *and* treatment to provide additional 1-log pathogen reduction beyond minimum requirements

4.1.1 Compliance with Retention Time Requirements

When originally constructed, the San Dieguito Reservoir provided approximately 1,130 acre-feet of storage. Over time, solids build-up has reduced the effective volume of the reservoir to approximately 750-800 acre-feet (Dudek 2012). For planning purposes, this analysis assumes that the maximum potable reuse capacity should not exceed the monthly minimum day flow. Using average monthly flow data from SFID, the maximum potable reuse flows should not exceed 4 MGD (Figure 4.1).

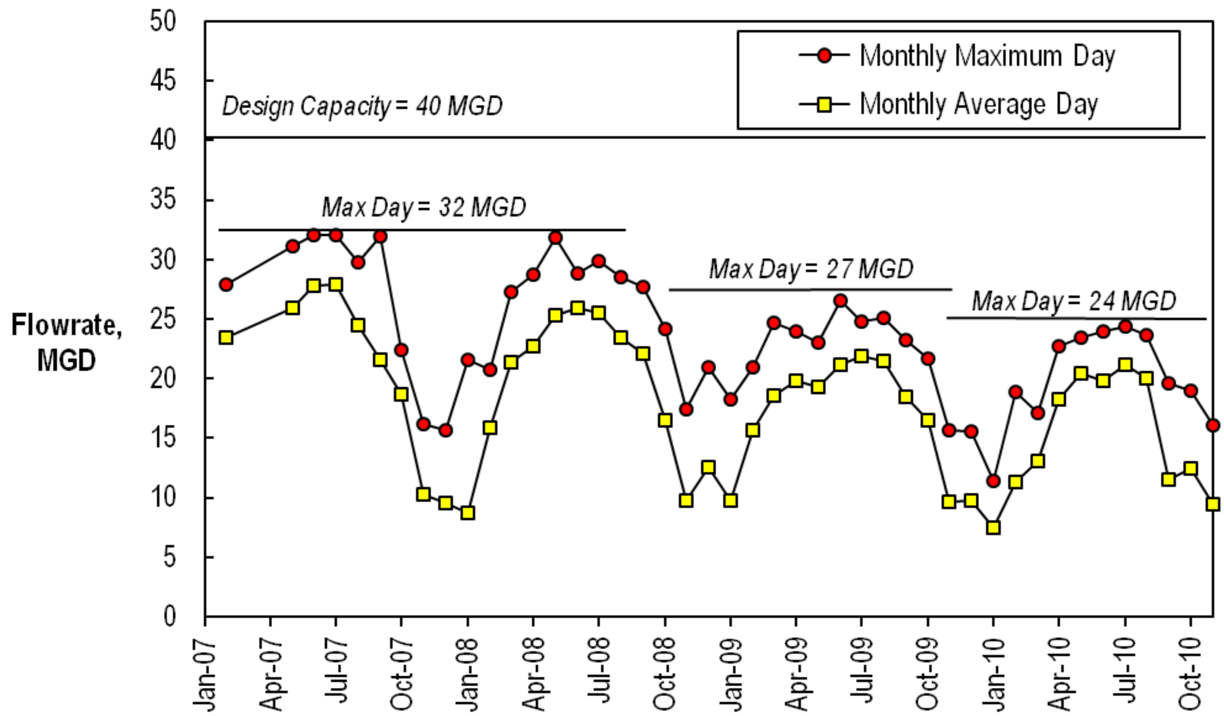


Figure 4.1 – Monthly Average and Maximum Daily Flow thru the Badger Water Filtration Plant, from 2007 – 2010 (courtesy of SFID)

Theoretical retention time is calculated as the reservoir volume divided by the total flowrate out of the reservoir:

$$Retention\ Time\ (T) = \frac{Reservoir\ Volume\ (V)}{Total\ Effluent\ Flowrate\ (Q)}$$

Based on the reservoir storage capacity and the proposed potable reuse flow rates, the 6-month minimum retention time would not be achieved (Table 4.2). Assuming only potable reuse flows enter SDR, the 65-day theoretical retention time is approximately one-third of the 6-month requirement. If flows from Lake Hodges were also routed through SDR, the theoretical retention time would further drop ($Q_{Total} = Q_{Reuse} + Q_{Hodges}$) and this option will be discussed further below.

Table 4.2 – Theoretical retention time in San Dieguito Reservoir. Assumes SDR would only receive potable reuse supplies, with Lake Hodges supplies bypassing the SDR and directly entering Badger WFP.

Parameter	Value	Units
Volume (V)	800	acre-feet
	261,000,000	gallons
Flow (Q)*	4	MGD
	4,000,000	gallons per day
Retention time (V/Q)	65	days

Based on this evaluation, the SFID-SEJPA-SDWD project would not meet the draft surface water augmentation requirements, and would need to seek an alternative regulatory permitting pathway. DDW has expressed that they are currently capable of permitting a number of potable reuse scenarios, even in the absence of formal regulations (Hultquist 2014). The existence of the groundwater recharge regulations greatly facilitates the permitting of new recharge projects, but both LACSD's Montebello Forebay and OCWD's GWRS were permitted decades before the formalization of the groundwater recharge regulations. More recently, the City of San Diego received conceptual approval for surface water augmentation at the San Vicente Reservoir prior to the creation of the draft regulations. DDW has stated that they currently have the authority to permit all forms of potable, including direct potable reuse (Hultquist 2014). Thus, the absence of formal regulations does not preclude the permitting of the proposed reservoir augmentation strategy. The City of San Diego is currently pursuing a potable reuse concept to Miramar Water Treatment Plant that has similar detention times and requirements. It is recommended that this project follow and build on the permitting work performed by the City of San Diego. By the end of 2018, it is anticipated that additional clarity will be available on the requirements for permitting a project of this nature.

4.1.2 Compliance with Dilution Requirements

One of the main goals of the enhanced AWT train is to be able to provide consistent public health protection without the need for dilution. Thus, the permitting strategy will emphasize that additional dilution is not *necessary* for public health. Nevertheless, there are significant benefits to the use of the SDR prior to Badger WFP (see Section 4.2). Thus, while not *necessary*, it will be advantageous to show the additional protection provided by the SDR in the form of dilution and additional retention time.

Reservoir characterization, modeling, and tracer tests will be essential to determine the extent of mixing and dilution in the SDR. Numerous data inputs will be necessary for the modeling team, including meteorological, water quality, and flow data. The most recent

Eliminating the need for dilution

Future Direct Potable Reuse (DPR) systems will by their nature not be able to benefit from the dilution provided by the aquifers and reservoirs that define Indirect Potable Reuse (IPR) projects. Through WateReuse Research Foundation project 14-02, Trussell Technologies is demonstrating the ability of an enhanced Advanced Wastewater Treatment (AWT) train to meet public health requirements without the need for dilution. Based on the performance of this facility, and positive feedback from various stakeholders, the City of San Diego is now also pursuing this AWT train for a reservoir augmentation strategy at Miramar Reservoir. The same train is proposed for the joint SFID-SEJPA-SDWD project. The regional project will benefit from the efforts made through both WRRF 14-02 and the City of San Diego in terms of demonstrating the safety of the system, and identifying the best permitting strategies. A regulatory precedent developed by the first reservoir augmentation project should greatly facilitate subsequent permitting efforts.

bathymetry evaluation was completed 5 years ago, and demonstrated the presence of significant solids build-up within the reservoir (Anderson 2010). Updated bathymetry may be necessary given the high solids deposition rate (0.5 inches per year). This would also be necessary following any future dredging and removal of solids from the reservoir. The modeling results will provide important information to understand the mixing and dilution with the reservoir, and the need for any engineered solutions to improve these characteristics. Tracer studies to validate the model will also be necessary, per the draft requirements. It is not anticipated that dilution will be a requirement, but this should be further studied as dilution does provide an important public health barrier.

4.2 Conceptual Operation of the San Dieguito Reservoir

One of the main goals of the high degree of treatment in the proposed AWPF is to eliminate dilution as a pre-requisite for public health protection. The ozone and BAC pre-treatment offers additional barriers that are meant to address any shortcomings of the current FAT train. Nevertheless, this project will seek to gain as much advantage as possible from the fact that the AWPF water passes through a significant engineered buffer in the form of the SDR. Importantly, the reservoir serves as a “wide spot in the road” where treated water is stored before being passed into the drinking water treatment plant. The time provided by the reservoir is a significant benefit that distinguishes reservoir augmentation from more direct forms of potable reuse (Figure 4.2). This analysis assumes that a reservoir component is necessary for planning purposes. Directly connecting the advanced treated water to Badger WFP may be a viable option in the future; however, such strategies will likely not occur before DDW has gained confidence in the ability of reservoir strategies to protect public health. The direct piping option would require a longer timeframe for completion, and was not included in this analysis.

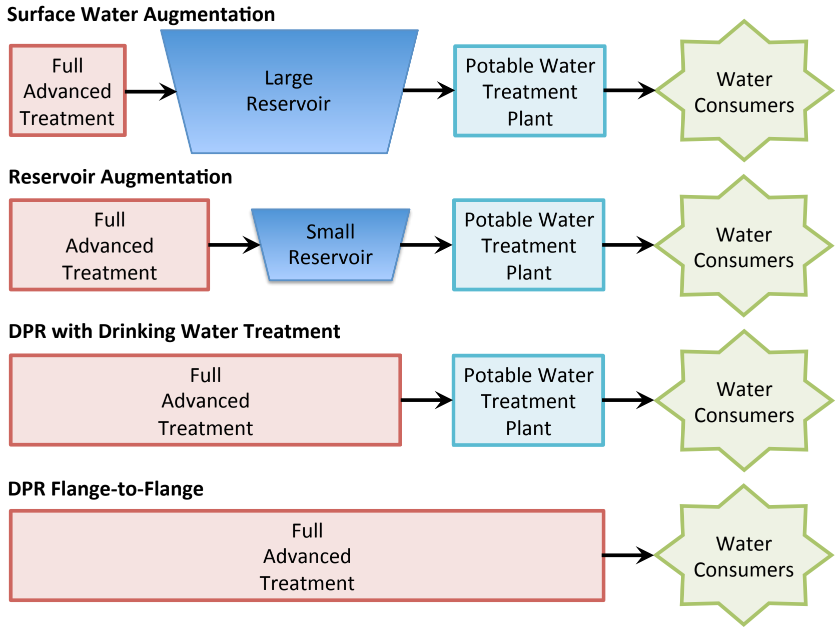


Figure 4.2 - Forms of new and future potable reuse projects

By using a reservoir, a chemical slug in the AWPF effluent would have its peak concentrations reduced through its passage and dilution in the reservoir. As this peak dilutes and makes its way through the reservoir, this configuration would also provide an ability to respond to the failure, allowing staff to determine the best path forward to deal with the treatment failure. Responses may include continued normal operation of the DWTP, the implementation of additional treatment for the contaminant in question, or even temporary suspension or draining of the reservoir. Furthermore, if the failure is detected before AWPF effluent reaches the reservoir, the DWTP could continue to treat water from the reservoir while the AWPF goes off-line to resolve any issues.

As discussed above, the passage of the water through the reservoir provides additional flexibility to manage failures more effectively. The reservoir will also provide some degree of dilution and retention. This important benefit of the SDR as an additional barrier will be emphasized throughout the permitting process. To maximize these benefits, it will be best to operate the reservoir in such a way to maximize the time that the potable reuse water spends in the reservoir.

Current operation of the SDR includes a number of uses, including use as a pre-treatment step for Lake Hodges water prior to the Badger WFP, and a receiving body for filter backwash streams from Badger, storm water, and urban water run-off (Figure 4.3). Both practices limit the retention time for potable reuse water by (1) increasing the effective influent flowrate, and (2) diminishing the reservoir capacity through the deposition of solids. Modifying these uses would represent significant changes in current SDR operation, but should be considered to maximize the retention time of potable reuse water in the reservoir.

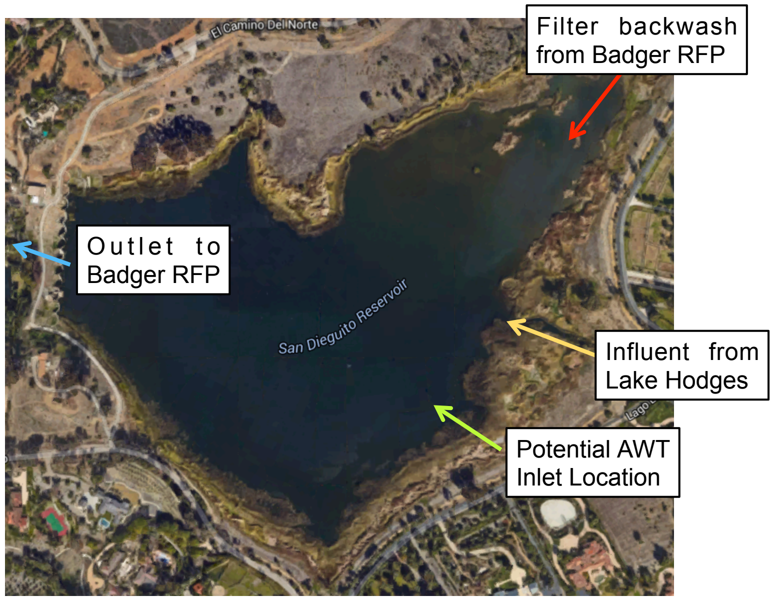


Figure 4.3 – Current and future potential flows into and out of San Dieguito Reservoir. Inlet location based on recommendation from SFID.

A number of upcoming and potential future projects could benefit this new operational paradigm. The first is dredging improvements, which have the potential to increase SDR capacity from its current 750-800 acre-foot capacity back toward the original 1,130 acre-foot design. Dredging of the SDR is included in the Master Plan, but has not yet been permitted.

Another future project is the improvement of water quality in Lake Hodges through the addition of a pure oxygen addition system. Pre-treatment is currently provided at SDR to deal with a number of water quality issues related to the local Lake Hodges source water, including high levels of TOC, manganese, geosmin, and MIB (SFID 2012). Currently, aeration within SDR is needed to ensure appropriate DO levels are present in the source water for Badger WFP. Improvements at Lake Hodges itself may reduce the need for pre-treatment at SDR, allowing for a larger percentage of Lake Hodges water to be fed directly to Badger. A 2010 study showed that the fraction of local water treated at Badger was increasing over the 2007-2010 timeframe, and that nearly all of this water was first passed through SDR (SFID 2012). Directly treating Lake Hodges water at Badger would decrease total flows into SDR (Q_{Total}) and thereby increase the retention time of potable reuse flows ($Q_{Potable}$) in the reservoir.

Unlike the retention time requirement (which is largely constrained by the physical limitations of the reservoir capacity and desired flowrates), there is greater engineering flexibility in achieving the 10-to-1 dilution requirement. A number of engineered solutions could be used to maximize the time between the entry and extraction of potable reuse water within the reservoir to meet this requirement. These solutions include optimizing the placement of the influent pipeline relative to the extraction site, and preventing short-circuiting through the use of various types of baffling. Adequate mixing will also ensure that advanced treated water is well blended with reservoir water, and provide a more consistent water quality as feed to Badger WFP. This consistency of water quality will improve the treatability and operational stability at Badger.

For example, current reservoir operation includes the use of a diffused aeration system, which has been effective at maintaining DO concentrations within the reservoir (Anderson 2009). This system maintains the reservoir in a well-mixed, oxic state that prevents the formation of stratification, and turns over the reservoir 2-3 times daily. This system should also serve to prevent short-circuiting since the air bubbles effectively create a barrier through which the bulk flow cannot pass. Additional engineering solutions include floating baffles, which could be employed to create more plug-flow hydraulics within the reservoir and maximize retention time.

Future studies should evaluate the use of such measures to maximize retention time and dilution within the reservoir.

5 Project Constraints

A number of constraints need to be addressed in order to realize the ultimate reservoir augmentation project. Eight major project constraints are discussed below.

5.1.1 Wastewater Supply

One of the main constraints facing this long term vision is the availability of wastewater flows to meet the reuse demands of both SEJPA's existing recycled water customers (non-potable) and the future potable reuse project. Based on the analysis provided in Section 2, a flow of 5.25 MGD would be required to meet the 4 MGD target of the potable reuse project. These flows would be in addition to the current demands for non-potable supplies, which currently go up to 2.3 MGD.

A number of options exist to meet these demands, including collecting and treating additional wastewater flows at SEWRF (as described in Section 2.3), or serving existing non-potable customers from other sources. Both a non-potable recycled water replacement study and a wastewater collection expansion study will be needed to evaluate the possibility of increasing supplies.

5.1.2 Source Control

Expanding wastewater flows into the future AWPF will necessarily involve expanding the wastewater service area. Consequently, additional source control studies will be required to identify and limit the inputs of potential toxic contaminants. Additionally, any existing industrial pretreatment programs will need to be revisited in the context of this potable reuse project.

SEJPA's current service area includes portions of Encinitas, Rancho Santa Fe, and Solana Beach. This service area is mainly residential and light commercial facilities that produce wastewater flows similar in quality to domestic waste flows. A recent 2014 study on the existing service area determined that there were no significant industrial users (SIUs) in the service area, and therefore, no need for a pretreatment program at that time (Hoch Consulting 2014). The previous 2009 study also concluded that there were on SIUs in the area.

Preliminary estimates suggest that the expansion of the service area will not yield a substantial amount of potential SIUs (PSIUs), as the surrounding areas are similar in character to the existing service area, but this should be reviewed again once the wastewater sources have been identified.

5.1.3 Utility Size

The question of utility size has arisen a number of times in recent discussions about the feasibility of potable reuse. Regulators have expressed concerns that smaller utilities may not have the ability to meet the "technical, managerial, and financial" requirements of potable reuse projects (CDPH 2014). These discussions can also be found in both the upcoming DPR Framework document (Tchobanoglous et al. *in print*) as well as in recent DDW Expert Panel meetings. As potable reuse moves away from the long retention times provided by groundwater aquifers, increasing reliance is placed on treatment and monitoring to ensure public health protection. Regulators need to feel comfortable that each project has sufficient staff, monitoring, maintenance, and control to ensure that failures are identified and resolved before public health is threatened. A review of the existing groundwater recharge projects shows that large utilities are the only ones with permitted projects.

Nevertheless, smaller agencies are also now pursuing potable reuse in a variety of forms. Padre Dam (Padre Dam) Municipal Water District, for example, is pursuing both a groundwater recharge and a surface water augmentation project. Padre Dam currently recycles approximately 2 MGD of wastewater for non-potable uses, but seeks to expand its service area to provide up to 13 MGD of potable reuse water for their regional East County project. To support this endeavor, Padre Dam has constructed a 100,000 gallon per day (gpd) Advanced Water Purification Demonstration Facility to test the performance of their future AWT treatment train. This demonstration provides a number of benefits to Padre Dam, including familiarizing staff with the operation and maintenance of the new treatment processes, and introducing the public to these new concepts. This testing also provides important exposure for DDW to become familiar with Padre Dam and gain confidence in their ability to meet the stringent requirements of potable reuse projects. Finally, DDW has an opportunity to observe the interactions between the regional partners—including Padre Dam, Helix Water District, and a number of cities served—to assess how well they communicate and share responsibilities, particularly where the water passes from one jurisdiction (e.g., wastewater and AWT treatment by Padre Dam) to another (e.g., reservoir storage and drinking water treatment by Helix). In the end, the project partners must demonstrate the technical, managerial, and financial capacity to DDW that will satisfy the needs of the project.

A similar demonstration-scale or pilot-scale project would be prudent for SFID-SEJPA-SDWD to engage DDW and demonstrate the willingness to invest in the project. This demo/pilot project could not be initiated until after the SEWRF is converted to an operational mode that includes nitrification.

5.1.4 Improvements of WRF

In order to demonstrate the successful operation and performance of an AWT treatment train, a number of intermediate steps will first need to be accomplished. Of highest priority are the modifications to the SEWRF described in Section 2.3, which would both expand the existing facility and provide a higher quality source water (secondary effluent) to serve as feed to the AWPF. For example, converting the secondary process to provide nitrification and partial denitrification will lead to significant improvements in the water quality that will benefit all of the downstream processes. The WRF upgrade is a significant initial investment that will require substantial resources and will likely set the timetable for the AWT testing.

Given the dependence of the AWT demonstration on the WRF upgrades, it will be important to consider the staging of the WRF construction in order to evaluate the water quality and treatment concepts at as early a stage as possible.

5.1.5 Reservoir hydraulics and modeling

A key component in the reservoir augmentation strategy is to demonstrate the benefits of the SDR, which provides a significant contribution to the project's ability to protect public safety. Unlike direct potable reuse projects that connect AWT effluent directly to a drinking water treatment plant or distribution system, the proposed reservoir augmentation project provides an added layer of protection. The benefits of the reservoir in terms of increased operation flexibility but also for retention time and dilution need to be quantified. Thus, modeling of the reservoir will be an important future study.

5.1.6 Modification of San Dieguito Reservoir operation

As outlined in Section 4.2, optimizing the use of the SDR for the potable reuse project would result in significant changes to current operations. For example, introducing a significant flow of AWT water into the reservoir will cause substantial changes in water quality given that the AWT water is a highly purified, low turbidity, low TOC water with low nutrient levels. These changes will alter the water's appearance and will likely modify the existing ecology of the SDR. The ability of the reservoir to support the existing fauna and flora will likely be altered (Anderson 2013). Such modifications should be studied and anticipated as a potential consequence of this project.

5.1.7 Public Perception

Public acceptance of the potable reuse project will be critical for its success. As the project moves forward, a demonstration facility (Section 5.1.3) would serve a number of goals, including providing the public with an opportunity to see the process and engage the project team on issues. Additional efforts for outreach and education will likely be important steps in developing public support for the project. Previous experience in the region has shown the critical importance of public outreach efforts, and should be emphasized as a part of this regional project as well.

5.1.8 Replacing Existing Recycled Water Commitments

Another significant project constraint is that all the recycled water produced at the SEWRF would be consumed by the potable reuse project. A study is necessary to determine if and how the existing recycled water deliveries and commitments of the SEJPA could be replaced, converted to potable water, or if any other approach can be developed by the interested parties.

6 Project Cost and Schedule

Table 6.1 presents the opinion of probable construction cost (OPCC) for the ultimate project. This cost estimate is a Class 5 OPCC as defined by the AACE with an expected accuracy of +50% to -25% of the average bid price for construction[1].

[1] The cost estimate for the pipeline and lift station were developed separately in Section 3.6, and represent a Class 4 OPCC (+30%/-20%).

Table 6.1: Ultimate project construction costs

Description	OPCC, $M
SEWRF Improvements/Upgrades	$6.0
Tertiary Filtration	$5.3
Ozone Disinfection and Oxidation	$2.5
BAC Filtration	$5.3
Membrane Filtration	$3.5
Reverse Osmosis	$8.5
UV Advanced Oxidation	$3.0
Post-Treatment & Chemicals	$4.0
Yard Piping	$2.0
Tanks and Lift Stations	$6.0
Pipeline and Lift Station	$10.4
Dechlorination and Discharge Structure	$2.0
Subtotal	$59
Contingency (25%)	$15
Total	**$73**

Table 6.2 presents the anticipated unit cost of water on a $ per acre-foot basis. The costs assume a production rate of 4 MGD (4,480 AF/year) and the amortized capital cost assumes 3% interest over 30 years.

Table 6.2: Ultimate project cost of water

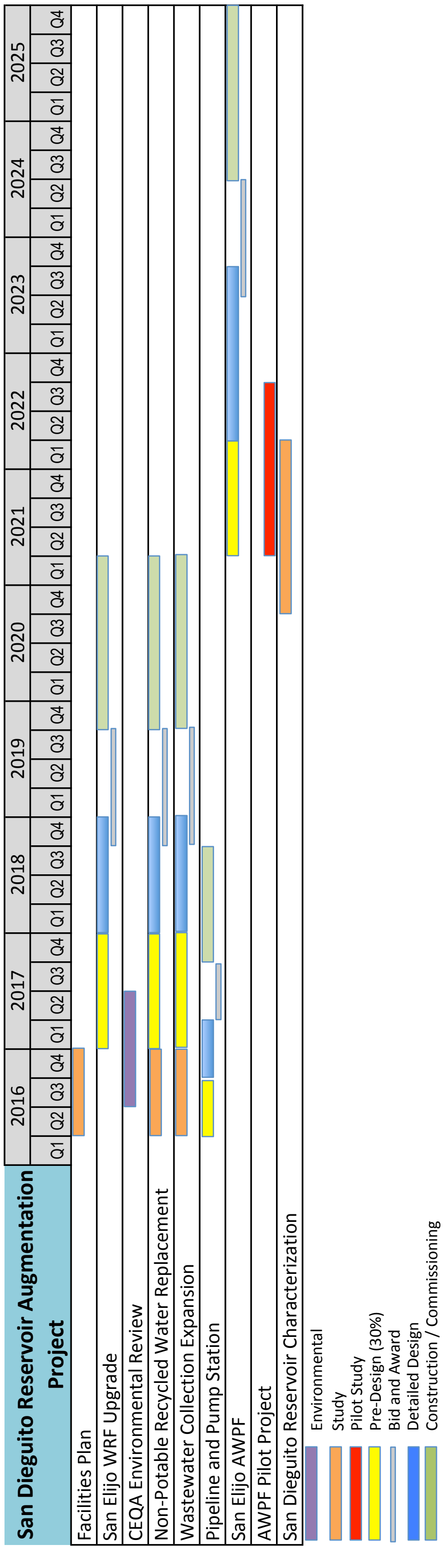
Description	Cost ($/AF)
Amortized Capital Cost	$833
O&M - Labor	$199
O&M - Chemicals	$101
O&M - Power	$200
O&M – Equipment Replacement	$186
Total	**$1,518**

A number of steps are needed to realize the final reservoir augmentation project. Table 6.3 describes the various tasks needed, as well as the duration and sequencing of these tasks. Major tasks include:

- **Facilities Plan**: Initial evaluation to determine if the future project is acceptable in terms of cost, layout, and other constraints.
- **San Elijo WRF Upgrade**: Necessary precursor to a potable reuse project, both to expand the facilities to accommodate the required flows and to modify treatment for improved AWPF source water quality.

- **CEQA**: Required for grant funding from State of California.
- **Non-Potable Recycled Water Replacement**: Proposed reservoir augmentation project would utilize wastewater flows currently used for non-potable recycled water needs. Replacement flows would be required at full build-out of the potable reuse system. A study should be undertaken to identify and evaluate alternatives.
- **Wastewater Collection Expansion**: Expansion of the wastewater collection system is needed to provide sufficient source water to meet the future 4 MGD product flows. A study should be undertaken to identify and evaluate alternatives for expanding the collection system.
- **AWPF Pilot Project**: Includes development, design, construction, and operation of a pilot-scale AWPF facility to test the proposed AWPF treatment train, and collect data over a yearlong period. Pilot project provides opportunities for staff to familiarize themselves with AWPF operation, and develop data to support both regulatory and public outreach efforts.
- **San Elijo AWPF**: Task includes the design, construction, and commissioning of the future AWPF facility.
- **San Dieguito Reservoir Characterization**: includes data collection to support modeling, development of reservoir model, and tracer tests to validate model.

Table 6.3 – Proposed projects and timeline for ultimate Reservoir Augmentation Project at San Dieguito Reservoir.



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Potable Reuse Feasibility Study

Technical Memo #3: Near-Term Potable Reuse Project

March 2016

Prepared for:

Santa Fe Irrigation District
San Dieguito Water District
San Elijo Joint Powers Authority

Prepared by:

Trussell Technologies, Inc.
Brian Pecson, Ph.D., P.E.
Brett Faulkner
Shane Trussell, Ph.D., P.E., BCEE
Rhodes Trussell, Ph.D., P.E., BCEE (Review)

RMC Water and Environment
Rich Bichette, P.E.
Scott Goldman, P.E. (Review)

Executive Summary

The purpose of this technical memorandum is to describe a near-term project for the regional potable reuse project for SFID, SEJPA, and SDWD. The near-term project is structured in order to comply with the requirements of the draft surface water augmentation (SWA) regulations currently under development by the California Division of Drinking Water (DDW). The project will utilize an advanced water purification facility (AWPF) to provide 1 MGD of potable reuse flows to augment the San Dieguito Reservoir (SDR). Water drawn from the SDR would then undergo surface water treatment at the Badger Water Filtration Plant (WFP) prior to distribution. The City of San Diego has received conceptual approval for a surface water augmentation project at San Vicente Reservoir, providing an important precedent for the near-term project. The proposed AWPF treatment train for the SWA project is presented in Figure ES. 1.

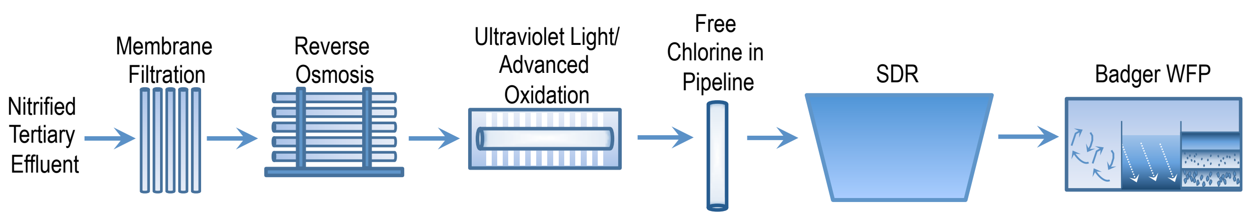


Figure ES. 1. The proposed surface water augmentation train utilizes full advanced treatment (MF, RO, UV/AOP), free chlorine disinfection, and the San Dieguito Reservoir (SDR) prior to treatment at Badger Water Filtration Plant.

The project requires three major components in the form of treatment, conveyance, and reservoir needs. The AWPF treatment train will be fed nitrified, tertiary feedwater from the San Elijo Water Recycling Facility (SEWRF) Figure ES. 1. The treatment train and reservoir operation will meet the requirements specified in the current draft of the SWA regulation.

To accommodate the near-term goals, the AWPF would require 1.2 MGD of feedwater, which would require the identification of additional flows for treatment at the SEWRF if the current non-potable reuse production is to be maintained. The SEWRF would also need modifications to improve the quality of the AWPF source water. Major modifications include altering the existing secondary process configuration, and providing tertiary filters. Analysis of the wastewater treatment processes in TM2 showed that upgrades to existing SEWRF would meet the feedwater needs for the proposed near-term project.

The new AWPF facilities can be located in the area that has been designated for potable reuse water purification in SEJPA's 2015 Facilities Plan (Figure ES. 2).

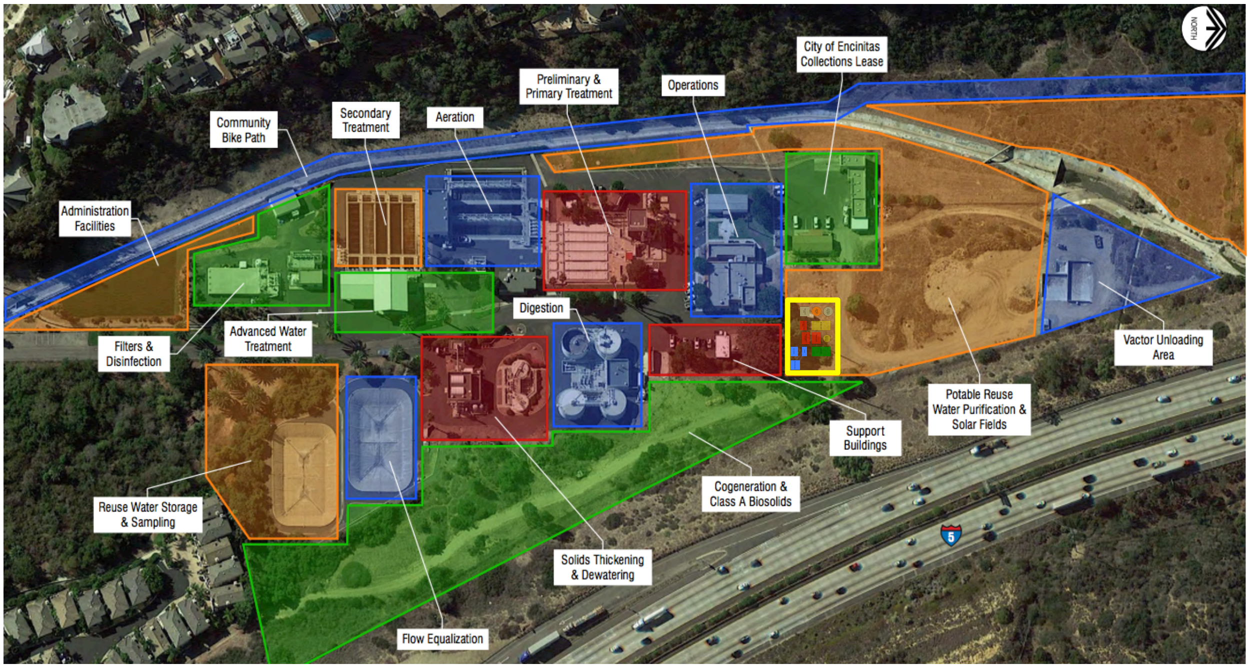


Figure ES. 2: Site layout for potable reuse system at SEWRF with new facilities located in the yellow box.

The pipeline from the SEWRF to SDR would require approximately 27,000 lineal feet, including 2,200 lineal feet of new PVC pipeline, 23,250 lineal feet of PVC pipe slip-lined within the existing 30" low pressure pipeline, and 1,600 lineal feet of existing 16" PVC. The use of 12" PVC pipe is recommended for the slip-lining.

Because there are no permitted SWA projects operating in California to date and the significant investments made by the City of San Diego to pursue SWA, it is recommended that the SFID-SEJPA-SDWD project build off of the City of San Diego's potable reuse efforts, which will have made significant progress by the end of 2018. While the treatment train and reservoir strategy meet the draft SWA requirements, there are a number of existing project constraints:

- **Wastewater supply**: additional wastewater flows need to be identified to provide adequate source water to meet the 1 MGD potable reuse goals while also maintaining recycled water commitments.
- **Source control**: expanding wastewater flows into SEWRF will require additional evaluation of source control and industrial pre-treatment programs
- **Utility size**: all projects must meet "technical, managerial, and financial" requirements, placing a potentially higher burden on small utilities. Strategies and agreements should be developed to show the project team's ability to meet these requirements.
- **Improvements to SEWRF**: modifications to the SEWRF are needed prior to the implementation of the AWPF, and will likely be an important schedule driver.

- **Reservoir modeling**: modeling of the SDR is required to characterize the hydraulics and quantify the dilution and mixing within the reservoir to ensure compliance with SWA requirements
- **Modification of SDR operation**: To maximize the dilution and retention time benefits of SDR for potable reuse, modifications of the current reservoir operation will be needed. To meet the retention time requirements in SDR, it will be necessary to eliminate existing influent flow sources, including filter wash water and Lake Hodges inputs. It may also be necessary to increase the capacity of the reservoir through dredging.

The construction cost estimate for the near-term project is $29 million (Table ES. 1). This cost estimate is a Class 5 OPCC as defined by the AACE with an expected accuracy of +50% to -25% of the average bid price for construction.

Table ES. 1: Opinion of probable construction cost for near-term IPR project

Description	OPCC, $M
Secondary Improvements	$1.5
Tertiary Filtration	$2.0
Membrane Filtration	$2.0
Reverse Osmosis	$3.0
UV Advanced Oxidation	$1.0
Post-Treatment & Chemicals	$1.0
Yard Piping	$2.0
Tanks and Lift Stations	$2.5
Pipeline	$6.6
Dechlorination and Discharge Structure	$1.5
Subtotal	$23
Contingency (25%)	$6
Total	**$29**

The estimated cost per acre-foot of water is $1,890 Table ES. 2, assuming a production rate of 1 MGD (1,200 AF/year) and amortized capital cost assumes 3% interest over 30 years.

Table ES. 2: Unit cost of water for near-term potable reuse project

Description	Cost ($/AF)
Amortized Capital Cost	$1,315
O&M - Labor	$186
O&M - Chemicals	$80
O&M - Power	$160
O&M – Equipment Replacement	$149
Total	$1,890
Anticipated Cost Range (±30%)	$1323 - $2457

A proposed schedule for the near-term project is provided in Table ES. 3.

Table ES. 3: Proposed projects and timeline for near-term project

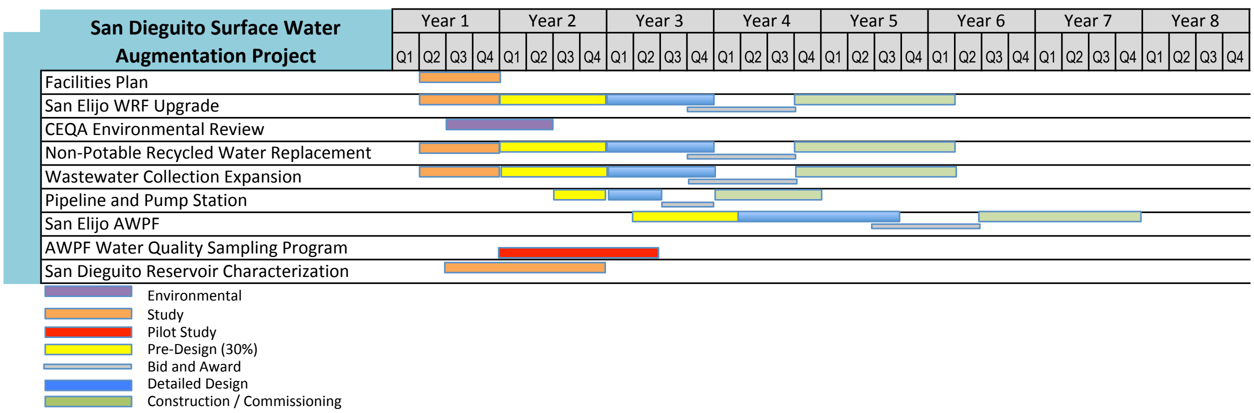


Table of Contents

1 Introduction

The purpose of this technical memorandum #3 (TM#3) is to develop a near-term project for the regional potable reuse sought by SFID, SEJPA, and SDWD. TM#3 focuses on the components of the near-term project and the major constraints that might inhibit or delay its realization. This project is meant to serve as either a stand-alone project, or as a project that could be integrated into the long-term vision proposed in TM#2.

TM#3 is organized to show the major components of the near-term potable reuse project, important project constraints, schedule, and costs. The analysis includes an estimated cost per acre-foot of water of $1,890. The TM is structured with the following sections:

- Section 1: Introduction
- Section 2: Treatment Concept, including advanced water treatment facilities and water recycling facility upgrades
- Section 3: Conveyance Concept
- Section 4: Reservoir Concept
- Section 5: Project Constraints
- Section 6: Project Cost and Schedule

2 Treatment Concept

The State's draft SWA regulation recognizes that one of the key differences between groundwater recharge and SWA is the shortened response times available in SWA projects. To compensate, the draft regulations specify reservoir requirements including:

1. **Retention time requirement**: minimum theoretical hydraulic retention time (HRT) of 6 months, *and*
2. **Dilution requirement**: achieving one of the two following options
    a. 100:1 dilution in the reservoir, *or*
    b. 10:1 dilution in the reservoir, plus 1-log additional control of pathogens at the AWPF to achieve 13/11/11 log control of virus, *Giardia*, and *Cryptosporidium*

The near-term project is built on the assumption that the regional project will maximize potable reuse water production while meeting the requirements of the draft SWA regulation. The calculation of maximum flows (up to 1 MGD) is discussed in subsequent sections (including Sections 2.2 and 4).

2.1 Proposed AWT Treatment Train

The proposed AWT treatment train for the SWA project is presented in Figure 2.1.

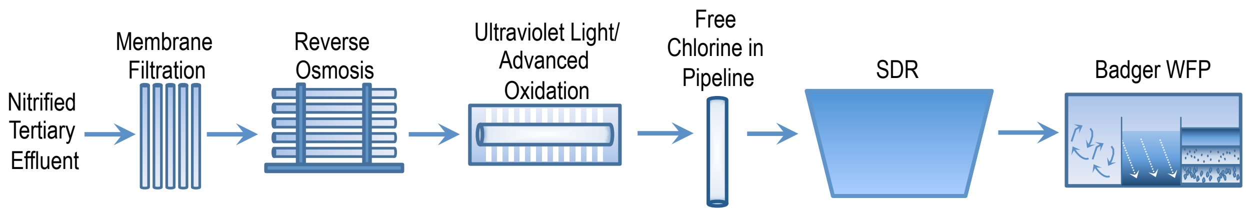


Figure 2.1 – Proposed treatment train for Surface Water Augmentation project.

The train utilizes the existing standard for high-level treatment—the full advanced treatment (FAT) train consisting of MF, RO, UV/AOP—along with free chlorine disinfection. Free chlorine disinfection is provided in the pipeline to achieve 6 additional logs of virus inactivation. The SWA train provides pathogen removal levels in excess of 13/11/11 log control (Table 2.1). This redundancy above 12/10/10 is necessary for projects that use lower levels of dilution (10:1 vs. 100:1). Achieving 13/11/11 therefore provides flexibility to seek lower dilution credits if needed.

Table 2.1: Pathogen log removal values (LRVs) provided by the proposed AWPF

	Nitrified Tertiary Effluent	Membrane Filtration	Reverse Osmosis	Ultraviolet Light/ Advanced Oxidation	Free Chlorine in Pipeline	**AWPF LRV Credits**	**Maximum SWA Requirements**
Virus	2	0	2	6	6	16	13
Giardia	2	4	2	6	0	14	11
Crypto	1	4	2	6	0	13	11

The effectiveness of the full advanced treatment train in controlling toxic chemicals has been demonstrated at numerous potable reuse facilities. DDW has also stated their belief that this treatment train provides sufficient control of toxic chemicals, including CECs. As an added safeguard, additional contaminant reduction occurs through the dilution of the advanced treated water in the reservoir. Dilution is effective at the control of chemicals, since these contaminants do not typically require the same log-reduction requirements as pathogens (NRC 2012).

The Badger WFP constitutes the final barrier, providing additional pathogen control of up to 5/4/2 for virus, *Giardia*, and *Cryptosporidium* downstream of the SDR. Design features that allow for rapid detection and response to treatment excursions should also be included (see TM#2). These resiliency features include extensive process monitoring, a high degree of interagency communication, and options for diverting off-spec water (see TM#2).

2.2 Water Reclamation Facility Requirements and Limitations

The San Elijo Water Reclamation Facility (SEWRF) will supply the source water for the proposed potable reuse project. The SEWRF is located in Cardiff by the Sea, California and is owned and operated by the SEJPA. The SEWRF is permitted to produce up to 3.0 million gallons per day (MGD) of tertiary treated wastewater in compliance with the California Department of Public Health Title 22 Code of Regulations for recycled water users and discharge up to 5.25 MGD of secondary treated wastewater in compliance with their Environmental Protection Agency's (EPA) National Pollutant Discharge Elimination System (NPDES) permit to the Pacific Ocean via an ocean outfall. The recycled water treatment train includes primary sedimentation, secondary aeration and clarification, filtration, and chlorine disinfection. Up to 2.48 MGD of recycled water is filtered with granular media filters (GMF), and as of 2013, an additional 0.5 MGD can be filtered with microfiltration (MF) and reverse osmosis (RO) to reduce the recycled water salinity. Currently SEWRF treats an average influent flow of 2.8 MGD, however recycled water demands vary throughout the year ranging from as high as 2.3 MGD in the summer to as low as 0.3 MGD in the winter. Secondary effluent flows in excess of the recycled water demands are discharged directly to the ocean via outfall. To facilitate potable reuse production, an additional 1.2 MGD of wastewater flow will be needed. A projected breakdown of SEWRF effluent flows is shown in Figure 2.2, showing that approximately 4.0 MGD of influent flow will be required to serve both potable and non-potable reuse needs for the proposed project.

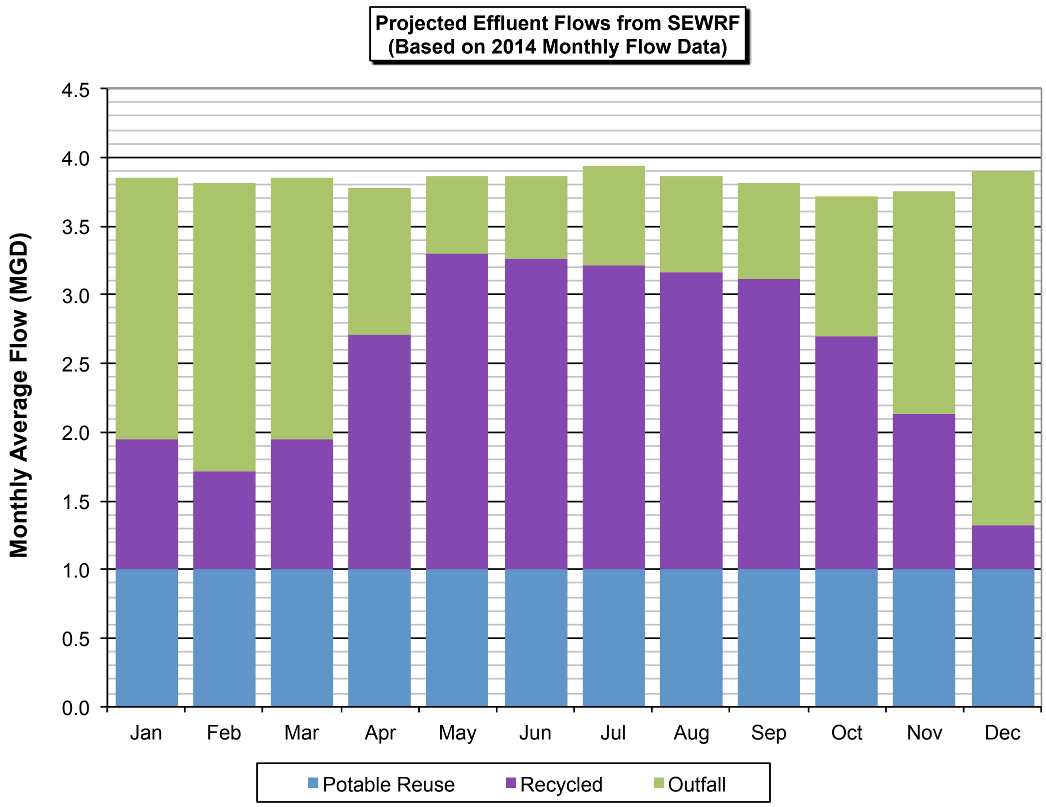


Figure 2.2 – Projected Monthly Average Flow Breakdown to Maintain Current Non-Potable Reuse Commitments and 1.0 MGD of Potable Reuse Production

2.2.1 Wastewater Treatment Requirements

The reliability and effectiveness of any water reuse project starts with the upstream wastewater treatment. There are several key treatment requirements that will help produce a stable and ideal feed water for the advanced treatment processes. These treatment requirements include:

- Flow equalization
- High solids retention time / biological nitrogen removal
- Proper management of dewatering recycle streams
- Filtration prior to advanced treatment

The importance of these requirements is elaborated in TM#2 and is necessary for both the near-term and ultimate potable reuse projects.

2.2.2 Biological Modeling and Treatment Capacity

Biological wastewater modeling using GPS-X was utilized to determine if the existing infrastructure and tankage available at the SEWRF is capable of treating the average daily design flow of 5.25 MGD while operating at an SRT of 10 days. This would result in a high quality nitrified feed water for the advanced treatment facilities. Based on the biological modeling results that were presented in TM#2, the aeration basins are the limiting process component in terms of tankage and treatment volume, but are capable of reliably nitrifying 5.25 MGD, so treating the required flow of 4.0 MGD for the near-term project will not be an issue with appropriate equipment upgrades to the existing infrastructure.

2.2.3 Summary of SEWRF Required Changes and Upgrades

SEWRF will require the following changes and upgrades in order to facilitate the proposed near-term potable reuse project:

- Influent wastewater flows must increase from 2.8 to 4.0 MGD.
- Convert the aeration basins to the MLE process configuration. Upgrades include new blowers, fine bubble diffusers, internal mixed liquor recycle pumps, surface wasting system and piping.
- Operate the upgraded MLE biological process at a high SRT (10+ days).
- Route the dewatering recycle streams to the primary flow equalization basins.
- New tertiary filters to be used prior to advanced treatment.

2.3 Near-Term Project Advanced Treatment Facility Flows and Preliminary Layout

This section presents the near-term project advanced treatment facility's production rates and preliminary layouts, assuming that the modifications to the SEWRF and AWPF presented in Sections 2.1 and 2.2 are undertaken. Figure 2.3 presents the flow diagram for the near-term project. When assuming losses in flow due to backwashes and in-plant uses (e.g., for analyzers, maintenance, and other needs) the facility will produce 1.0 MGD based on an influent wastewater flow to SEWRF of 1.3 MGD (1.2 MGD plus 0.1 MGD of recycle from AWPF). This is a conservative estimate since the waste streams, with the exception of the RO brine, will be recycled back to the SEWRF and can be treated again.

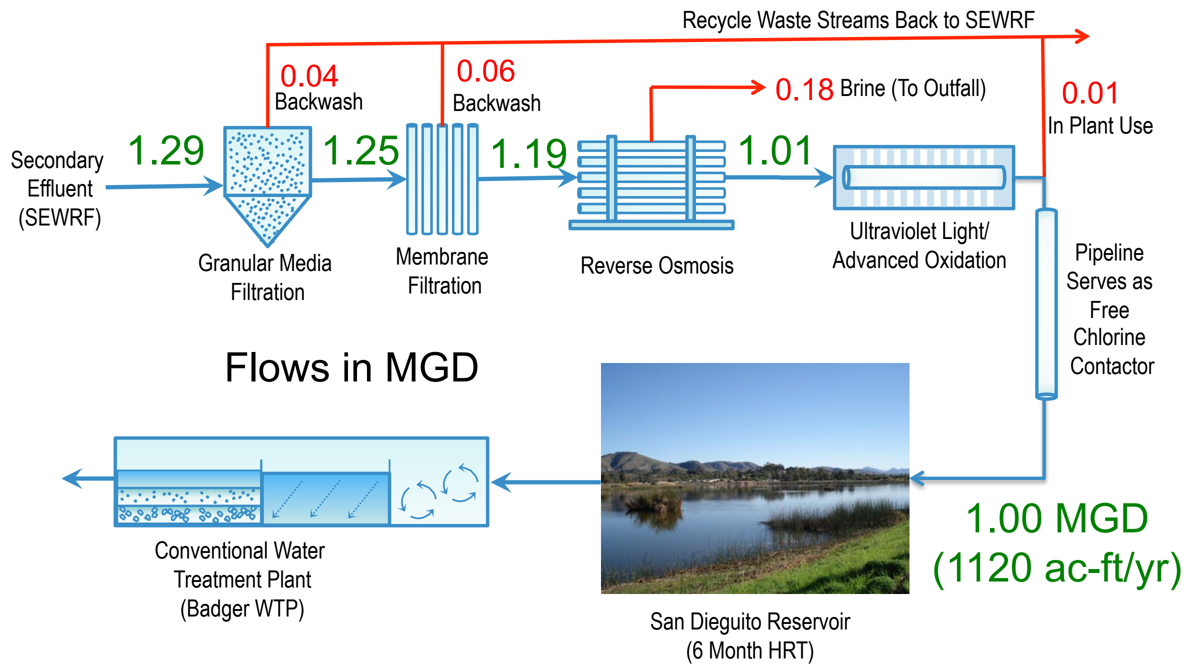


Figure 2.3 – Near-term project advanced treatment process flow diagram and flow rates

Each unit process and associated components were sized using comparable existing facilities, and scaled based on the flow rates shown in Figure 2.3. Figure 2.4 presents the preliminary layout for the new treatment facilities for the near-term project.

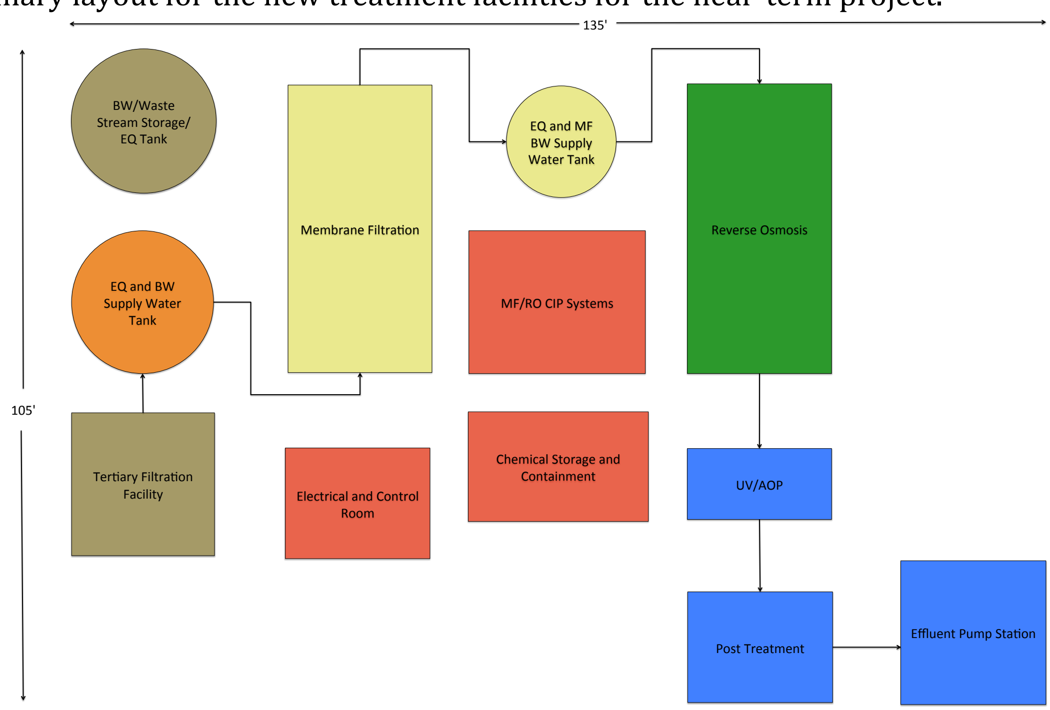


Figure 2.4 – Preliminary layout of facilities for near-term potable reuse project

This preliminary layout can be located in the area that has been designated for potable reuse water purification in SEJPA's 2015 Facilities Plan. Figure 2.5 shows the scaled layout from Figure 2.4 superimposed on the site layout from the facilities plan.

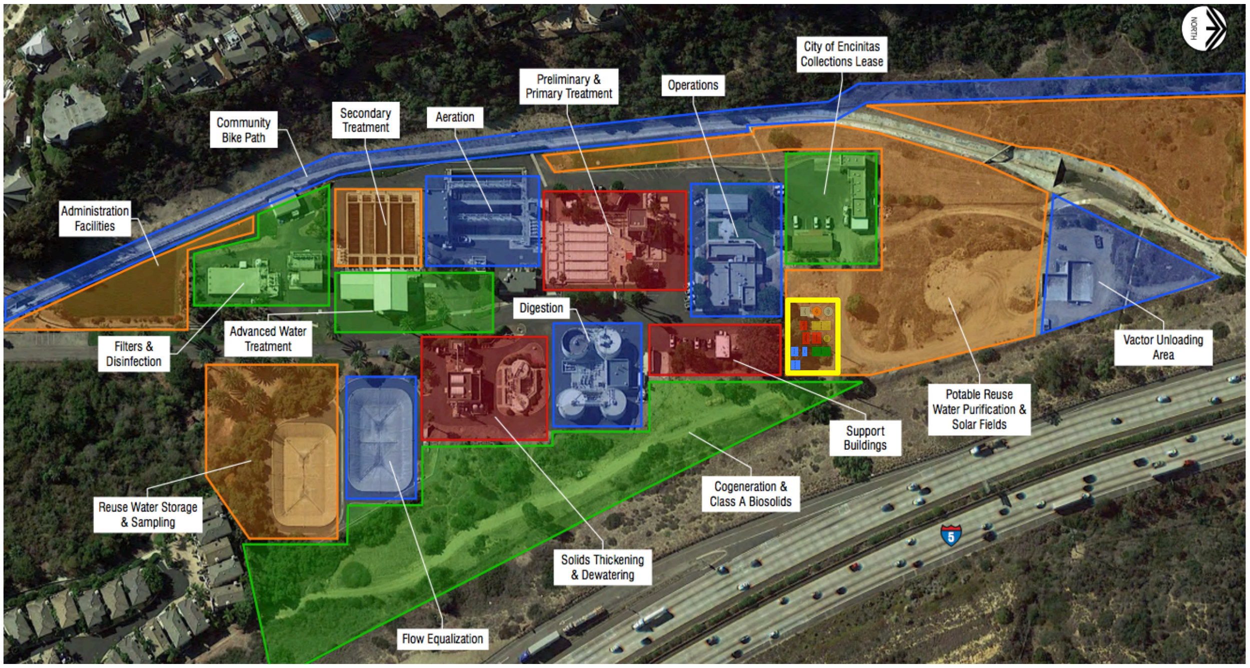


Figure 2.5 – Site layout for potable reuse system at SEWRF. Yellow box shows layout of new facilities described in Figure 2.4.

3 Conveyance Concept

3.1 Introduction

As part of the proposed potable reuse project, an existing 30-inch low-pressure San Dieguito Water District (SDWD) pipeline could be rehabilitated and used to convey advanced treated water from the SEWRF to San Dieguito Reservoir. This section provides preliminary recommendations for the conveyance system under a near-term project to deliver up to 1 MGD of advanced treated water to the reservoir. Recommendations include pipeline rehabilitation efforts and pumping requirements. For the purpose of this evaluation, the near-term project would be a stand-alone project that would only be sized to deliver 1 MGD and would not consider installing larger pipe for future flows. If the ultimate project were to occur after the near-term project, the pipeline and pump station would have to be replaced with larger facilities. Details on the conveyance system for the ultimate project are included in TM#2.

The recommendations for the conveyance system are included in the following sections:

- **Section 3.1: Introduction**

- **Section 3.2: Hydraulic Evaluation –** Provides the results of hydraulic evaluation, including pipe diameter, pressure ratings and pumping requirements.
- **Section 3.3: Preliminary Construction Cost Estimate –** Provides a budgetary estimate of construction costs for the proposed conveyance facilities.

Refer to TM#2 for information on pipe materials, construction requirements and CEQA screening, which remain applicable to the near-term project.

3.2 Hydraulic Evaluation

A hydraulic evaluation was conducted to recommend pipe diameter and pressure ratings for the proposed pipeline under the near-term project. The following assumptions were used in preparing preliminary hydraulic calculations.

- Maximum flow through the pipeline will be 1 MGD or approximately 700 gallons per minute (gpm) from SEWRF to San Dieguito Reservoir.
- Length of pipeline from SEWRF to San Dieguito reservoir is estimated to be 27,050 lineal feet (LF):
    - 2,200 LF of new pipeline from SEWRF to the slip line segment, including a segment to be relocated by Caltrans,
    - 23,250 LF of existing 30-inch low-pressure pipeline to be slip lined, and
    - 1,600 LF of pipeline of 16-inch DR 25 PVC (previously installed to replace the low-pressure line at two locations).
- Elevation of the proposed conveyance pump station at SEWRF is estimated to be 40 feet above mean sea level (MSL). Future location of this pump station is unknown.
- Elevation of the discharge at San Dieguito reservoir is approximately 240 feet above MSL.
- C-value used for hydraulic calculations is 120.
- Assumed hydraulic pumping efficiency is 80%.

An excel spreadsheet model was used to determine select pipe diameter, determine pumping requirements, and pressure requirements. The results are summarized below.

3.2.1 Pipe Diameter and Pumping Requirements

Flow velocity and pumping horsepower requirements were calculated for two options:

- **Option 1:** Using 12-inch DR 18 PVC for the new pipeline, except that existing 16-inch DR 25 PVC segments would remain in place.
- **Option 2:** Using 8-inch DR 18 PVC for the new pipeline (slip line and open cut segments), except that existing 16-inch DR 25 PVC segments would remain in place.

Table 3.1 summarizes the length, inside diameter, flow velocity and headloss in the existing 16-inch pipe, and the two options for slip lining at a flow rate of 1 MGD.

Table 3.1: Summary of Pipeline Velocity and Headloss

Pipe Segment	Length	Inside Pipe Diameter	Flow Velocity	Retention Time	Headloss
Existing 16-inch DR 25 PVC	1,600 LF	15.92”	1.1 ft/s	24 min	1 ft
Option 1: 12-inch DR 18 PVC	25,450 LF	11.65”	2.1 ft/s	3.4 hours	44 ft
Option 2: 8-inch DR 18 PVC	25,450 LF	7.98”	4.5 ft/s	1.6 hours	278 ft

Static head from SEWRF to the San Dieguito Reservoir discharge is approximately 200 feet. Based on the head losses in Table 3.1 and static head, the pumping requirements for each option are presented in Table 3.2. Total station horsepower is total motor horsepower and will depend on the number of pumps installed. Assuming one standby pump at the pump station to provide firm capacity, a reasonable estimate of total station horsepower considering standard motor sizes and standby pumps is 1.5 x the hydraulic horsepower, rounded up to the nearest 50 HP.

Table 3.2: Summary of Pumping Requirements

Option	Pipeline Headloss	Static Head	TDH	Hydraulic Horsepower	Est. Total Station Horsepower
Option 1: 12-inch DR 18 PVC	44 ft	200 ft	244 ft	54 HP	100 HP
Option 2: 8-inch DR 18 PVC	278 ft	200 ft	478 ft	105 HP	200 HP

The total station horsepower (and installed capital cost) for the pump station under Option 1 will be lower than Option 2, and the additional 234 feet of pumping head and associated power costs will add up over time. When the final flow scenarios are developed for the project, the engineering team should conduct an analysis of capital cost versus pumping costs to select the final pipe size and size the pump station accordingly. For the purpose of this study and the cost estimates below, a 12-inch PVC pipe is assumed, since pumping costs will likely exceed the capital cost savings of a smaller pipe in a relatively short period of time.

3.2.2 Proposed Pipe Pressure Rating

Pressures in the 12-inch PVC pipeline for the near-term project would be nearly identical to pressures estimated for the 24-inch PVC for the ultimate project. Therefore, the preliminary recommendation for pipe pressure class is DR 18 (235 psi rating) based on the analysis in TM#2.

3.3 Preliminary Construction Cost Estimate

An opinion of probable construction cost was developed based on the concept presented in this TM. The cost estimate is a Class 4 estimate and is expected to be within a +20% to -20% level of accuracy, as defined by the Association for the Advancement of Cost Engineering (AACE). The benchmark Engineering News Record Construction Cost Index (ENR CCI) for this estimate (June 2015) in the Los Angeles Area is 10981 and the 20-cities average is 10039. This cost estimate is intended to represent the average anticipated bid price for the construction work under a competitive bid process. Implementation costs are not included. Implementation costs may include but are not limited to planning, preliminary and final design, CEQA compliance, permitting, engineering services during construction, construction management, inspection and testing, administration, legal, permitting, and property acquisition.

3.3.1 Pipeline Costs

A bid tabulation was obtained from Underground Solutions, Inc. (a fusible PVC supplier in Poway) for a recent project in Folsom, California to slip line an existing 30-inch concrete pipe with 24-inch fusible PVC. The unit prices for slip lining and grouting annual space between the carrier and host pipe are based on the average bid price from the project. Costs were interpolated to estimate slip lining costs for the smaller, 12-inch diameter, pipeline for the near-term project.

Appurtenances (valves, blowoffs and air valves) are estimated at $5,000 each based on bid tabulations from similar projects.

3.3.2 Pump Station and Discharge Structure

Construction cost for the pump station is based on cost curves for water pump stations in *Pumping Station Design*, *Second Edition*, Robert L. Sanks, 1998 (Sanks 1998). Cost curves by flow rate shown in Figure 1 were estimated based on the pumping station costs in Sanks 1998 and adjusted from an ENR CCI of 4500 to the present ENR CCI.

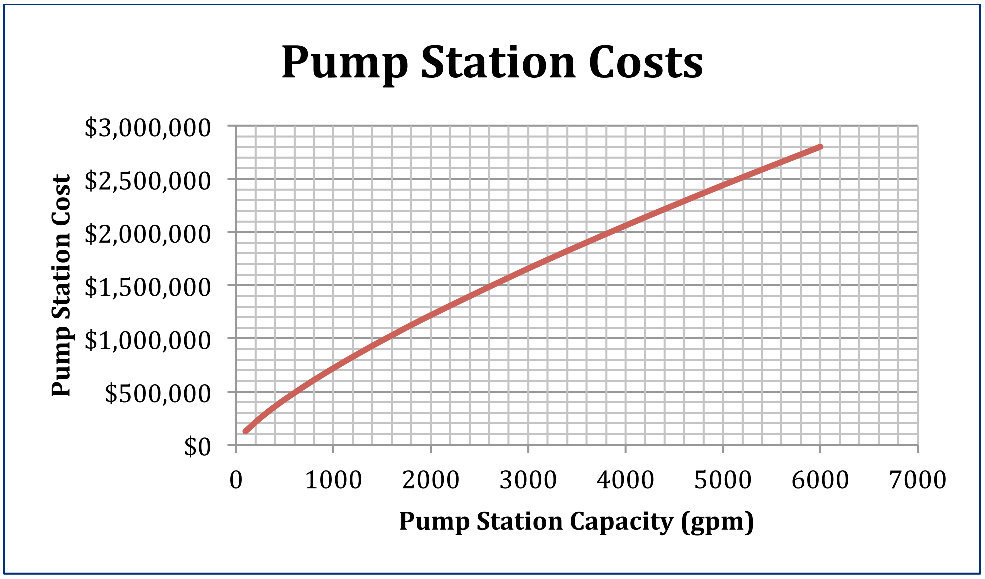


Figure 3.1: Pump station cost curve

An allowance of $250,000 is provided for modification at the discharge to San Dieguito Reservoir. The required discharge structure or modifications are unknown at this time.

3.3.3 Cost Estimate

Table 3.3 is a preliminary construction cost estimate for the conveyance system.

Table 3.3: Construction cost estimate

Item	Quantity	Unit	Unit Cost	Total Cost
Slip line: 12-inch PVC	23,250	LF	$120	$2,790,000
Grout Annual Space	23,250	LF	$24	$558,000
Open Cut: 12-inch PVC	2,200	LF	$180	$396,000
Blowoffs/Valves/Manholes	34	EA	$5,000	$170,000
Pump Station	1	LS	$600,000	$600,000
Discharge Structure	1	Allow.	$250,000	$250,000
			Subtotal	$4,764,000
Mobilization, Demobilization, Bonds, Insurance (8%)				$381,000
NPDES Stormwater Compliance (3%)				$143,000
Raw Construction Subtotal				$5,288,000
Contingency (25%)				$1,322,000
CONSTRUCTION COST ESTIMATE				**$6,610,000**
ANTICIPATED COST RANGE (-20% to +20%)				**$5.3 - $7.9M**

4 Reservoir Concept

4.1 Regulatory Overview

The current draft requirements for reservoir operation are presented in Table 4.1. Based on the current discussion between DDW and the State Expert Panel, these criteria are expected to remain unchanged in future drafts.

Table 4.1: Retention time and dilution requirements in draft surface water augmentation regulations

Requirement	Details
Theoretical retention time	Reservoir must provide a minimum of 6 months of theoretical retention time
Mixing and dilution	Demonstrate a 24-h input pulse results in: • A concentration in the reservoir withdrawal that is no greater than 1% of recycled water effluent concentration, *or* • A concentration in the reservoir withdrawal that is no greater than 10% of recycled water effluent concentration, *and* treatment to provide additional 1-log pathogen reduction beyond minimum requirements

4.1.1 Compliance with Retention Time Requirements

When originally constructed, the SDR provided approximately 1,130 acre-feet of storage. Over time, solids build-up has reduced the effective volume of the reservoir (Dudek 2012). For system sizing purposes, it is necessary to estimate the maximum capacity of the reservoir, since the volume (V) is essential for calculating the AWPF flow (Q) that meets the 6-month HRT requirement (T). The maximum storage volume value was estimated using the equation provided in the 2010 report on SDR bathymetry (Anderson 2010):

$$\text{Volume (acre-ft)} = -54.2 + 10.807*H - 0.7045*H^2 + 0.01498*H^3$$

Where *H* refers to the staff gage height at the reservoir. Under current operations, the reservoir must provide at least 6" of free board below the spill elevation (250 feet) for a maximum elevation of 249.5 feet (equivalent to a staff gage height of 49.5 feet). The maximum SWA project size is shown as a function of reservoir level in Figure 4.1. Assuming that the 249.5-foot level could be consistently maintained, the maximum project size that can comply with the SWA requirements is ~1 MGD.

SDR Elevation (*ft*)	Gage Height (*ft*)	SDR Storage Capacity Volume		AWPF flow [*in MGD*]*
		In *acre-feet*	In *MG*	
250	50	597	195	1.08
249.5	49.5	571	186	1.03
249	49	546	178	0.99
248	48	498	162	0.90
247	47	453	148	0.82
246	46	410	134	0.74
245	45	371	121	0.67
244	44	333	109	0.60

* Assumes 180-day HRT

Figure 4.1 – Maximum SWA project size based on storage volume in SDR. Analysis assumes compliance with the minimum theoretical HRT of 6 months.

4.1.2 Compliance with Dilution Requirements

The dilution requirements of the draft SWA regulations may be met by providing either 100:1 or 10:1 levels. With the high degree of pathogen control at the AWPF, it is expected that 10:1 dilution would be sufficient for this project, but modeling is needed to make the final determination (see Section 2.1). Reservoir characterization, modeling, and tracer tests will be essential to determine the extent of mixing and dilution in the SDR. Numerous data inputs will be necessary for the modeling team, including meteorological, water quality, and flow data. The most recent bathymetry evaluation was completed 5 years ago, and demonstrated the presence of significant solids build-up within the reservoir (Anderson 2010). Updated bathymetry may be necessary given the high solids deposition rate (0.5 inches per year). This would also be necessary following any future dredging and removal of solids from the reservoir. The modeling results will provide important information to understand the mixing and dilution with the reservoir, and the need for any engineered solutions to improve these characteristics. Tracer studies to validate the model will also be necessary, per the draft requirements.

4.2 Conceptual Operation of the San Dieguito Reservoir

Current reservoir operation will need to be modified in a number of ways to maximize potable reuse capacity and comply with the reservoir operation requirements. The required modifications are presented in the following sections.

4.2.1 Redirection of existing inflows to SDR

Current operation of SDR includes a number of uses, including as a pre-treatment step for Lake Hodges water prior to the Badger WFP, and a receiving body for filter backwash streams from Badger, storm water, and urban water run-off (Figure 4.2). Both practices decrease the available retention time for potable reuse water by (1) increasing the total influent flowrate, and (2) decreasing the reservoir volume through the deposition of solids. Eliminating these inflows would represent significant changes to the current operation of SDR, but would be necessary for a 1 MGD SWA project. Alternative management strategies for these two inputs are discussed below.

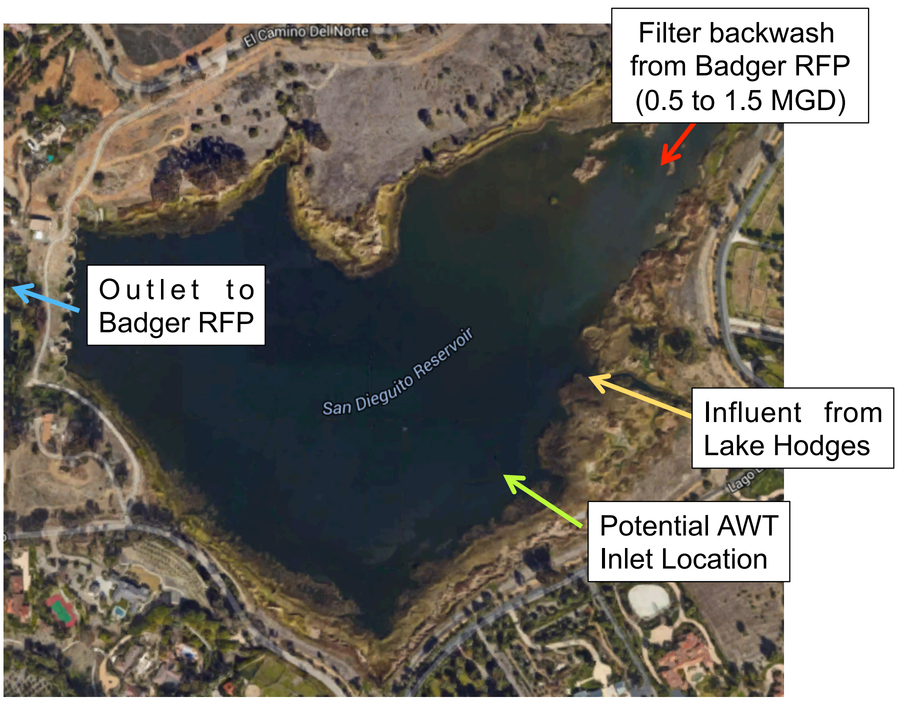


Figure 4.2 – Current and future potential flows into and out of San Dieguito Reservoir. Inlet location based on recommendation from SFID.

4.2.2 Water quality improvements at Lake Hodges

Currently, the passage of Lake Hodges water through SDR is used to provide pre-treatment prior to Badger WFP. SDR pre-treatment improves the water quality and treatability of the Lake Hodges source water; however, this practice also reduces the retention time of potable reuse water in SDR (Section 4.2.1). A number of on-going efforts by SFID seek to improve the quality of water within Lake Hodges itself and potentially reduce the benefit of pre-treatment at SDR. These projects would be necessary to divert flows from SDR and provide sufficient retention time for the potable reuse water.

The first water quality improvement project at Lake Hodges is the addition of a pure oxygen injection system. This system will address a number of water quality issues that are currently observed within the Lake Hodges source water, including high levels of sulfides, manganese, geosmin, and MIB (SFID 2012). This improvement project in Lake Hodges is anticipated to go on-line in 2016 and the effectiveness of the pre-treatment should be understood by 2017.

Two other improvement projects would further improve the water quality at Lake Hodges, though they are scheduled to take place after the implementation of the oxygenation system. These projects include (1) epilimnetic mixing of the central portion of Lake Hodges, and (2) wetland filters at the eastern end of the lake.

4.2.3 Rerouting of filter wash water flows

Currently, Badger WFP routes between 0.5 to 1.5 million gallons of filter wash water per day to SDR. To provide the 180-day theoretical HRT for the 1 MGD SWA flows, the filter wash water will need to be rerouted away from SDR. The current capital improvement plan (CIP) includes improvements for both mechanical dewatering and filter waste washwaters, with an estimated project cost in the CIP plan of $6.3M. The project would allow Badger to treat the residual streams on-site and then recycle them directly into the plant in lieu of discharge to SDR.

Another alternative would be to utilize the filter washwater flow as an additional input to the SEWRF. As discussed in Section 2.2, SEWRF requires additional wastewater source flows to achieve the goals of the SWA project. The feasibility and cost of this alternative strategy have not yet been developed to date.

4.2.4 Modification of SDR Elevation Requirements

Currently, SFID is required to maintain SDR below the 244' elevation from October 1 to April 30 each year, based on direction from the Division of Safety of Dams (DSOD), within the Department of Water Resources (DWR). This restricted water level is imposed by DSOD during the months representing the rainy season. At this lower elevation, however, SDR would only be able to accommodate a 0.6 MGD SWA project, or nearly half of the proposed

1 MGD project (Figure 4.1). Discussions with DWR and other relevant agencies will be needed in order to operate at the maximum 249.5' elevation year-round.

Modifications of the existing spillway may provide opportunities to modify the reservoir elevation requirements. An analysis of conceptual spillway alternatives was completed in 2013, and found that various alternative improvement projects would reduce the risk from future spillover events (Genterra Consultants 2013). Two supplemental spillway projects were identified to provide additional flood damage protection in the 2013 report. Further evaluation of these alternatives may provide a path forward for future reservoir operation.

4.2.5 Dredging of SDR

Dredging improvements have the potential to increase SDR capacity from its current 570 acre-foot capacity back toward the original 1,130 acre-foot design. Dredging projects were identified in the Master Plan, and are included in the 10-Year CIP Plan. The estimated cost of the project to reduce the mound of sediment in SDR is approximately $1.94M.

The increased capacity would facilitate the input of 1 MGD potable reuse flows year-round, including during the winter months when additional stormwater storage capacity is sought. The dredging project may offset the need for additional improvements to the spillway discussed above.

4.2.6 Maximizing dilution of AWPF flows at SDR

A number of engineered solutions could be used to maximize the time between the entry and extraction of potable reuse water within the reservoir. Solutions include optimizing the placement of the influent pipeline relative to the extraction site, and preventing short-circuiting through the use of various types of baffling. Adequate mixing will also ensure that advanced treated water is well blended with reservoir water, and provide a more consistent water quality as feed to Badger WFP. This consistency of water quality will improve the treatability and operational stability at Badger. Recommendations for improved dilution were discussed in TM#2.

5 Project Constraints

A number of constraints need to be addressed in order to realize the near-term reservoir augmentation project. Major project constraints were discussed in detail in TM#2, many of which carry over to the near-term project as well. These constraints are identified below, with additional discussion included for any constraints that differ between the near-term and ultimate projects.

1. **Wastewater supply needs**: Additional wastewater flows are needed to meet the reuse demands of both SEJPA's existing recycled water customers (non-potable) and the future potable reuse project. Based on the analysis provided in Section 2, a flow

of 4.0 MGD would be required to meet the 1 MGD target of the potable reuse project, while maintaining existing recycled water production.

2. **Source control**: source control studies will be needed for any additional wastewater sources, and revisited in the context of potable reuse.
3. **Utility size**: Regulators have expressed concerns that smaller utilities may not have the ability to meet the "technical, managerial, and financial" requirements of potable reuse projects (CDPH 2014). Demonstrating that the "TMF" requirements can be met will be critical for project success.
4. **Improvements at SEWRF**: modifications to SEWRF will be required to produce a high quality source water for the future AWPF, as described in Section 2.2
5. **Reservoir hydraulics and modeling**: modeling will be necessary to demonstrate that SDR can satisfy the requirements of the draft SWA requirements
6. **Modification of San Dieguito Reservoir operation**: Section 4.2 describes the modifications that would be required to optimize the use of the SDR for the potable reuse project
7. **Public perception**: Public acceptance of the potable reuse project will be critical for its success. Outreach and education efforts will likely be important steps in developing public support for the project.

6 Project Cost and Schedule

Table 6.1 presents the opinion of probable construction cost (OPCC) for the near-term project. This cost estimate is a Class 5 OPCC as defined by the AACE with an expected accuracy of +50% to -25% of the average bid price for construction[1].

[1] The cost estimate for the pipeline and lift station were developed separately in Section 3.3, and represent a Class 4 OPCC (+30%/-20%).

Table 6.1: Near-term project construction costs

Description	OPCC, $M
Secondary Improvements	$1.5
Tertiary Filtration	$2.0
Membrane Filtration	$2.0
Reverse Osmosis	$3.0
UV Advanced Oxidation	$1.0
Post-Treatment & Chemicals	$1.0
Yard Piping	$2.0
Tanks and Lift Stations	$2.5
Pipeline	$6.6
Dechlorination and Discharge Structure	$1.5
Subtotal	$23
Contingency (25%)	$6
Total	**$29**

Table 6.2 presents the anticipated unit cost of water on a $/AF basis. The costs assume a 1 MGD production rate and amortized capital costs with 3% interest over 30 years.

Table 6.2: Near-term project cost of water

Description	Cost ($/AF)
Amortized Capital Cost	$1,315
O&M - Labor	$186
O&M - Chemicals	$80
O&M - Power	$160
O&M – Equipment Replacement	$149
Total	$1,890
Anticipated Cost Range (±30%)	$1323 - $2457

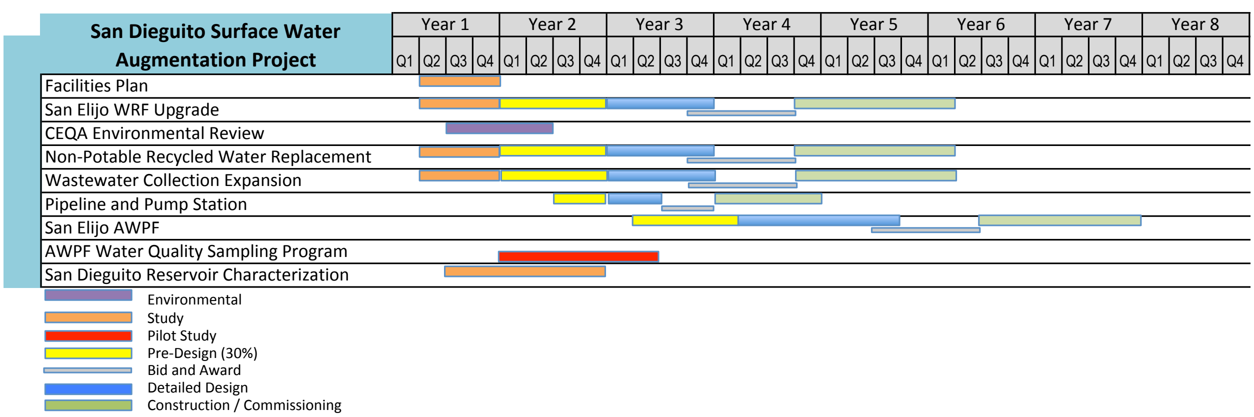
A number of steps are needed to realize the near-term reservoir augmentation project. Table 6.3 describes the various tasks needed, as well as the duration and sequencing of these tasks. Major tasks include:

- **Facilities Plan**: Initial evaluation to determine if the future project is acceptable in terms of cost, layout, and other constraints.
- **San Elijo WRF Upgrade**: A study will first occur to determine the feasibility of temporarily operating the facility in a nitrification mode without the necessary

capital improvements. The long-term upgrade to a nitrified facility is a necessary precursor to a potable reuse project, both to expand the facilities to accommodate the required flows and to modify treatment for improved AWPF source water quality.

- **CEQA**: Required for grant funding from State of California.
- **Wastewater Collection Expansion**: Expansion of the wastewater collection system is needed to provide sufficient source water to meet the future potable reuse product flows. A study should be undertaken to identify and evaluate alternatives for expanding the collection system.
- **AWPF Water Quality Sampling Program**: Includes development of sampling plan, engagement of DDW and IAP, and the continuous operation of one treatment train from the existing SEWRF AWT facility, which would ideally be fed nitrified water from the SEWRF. As mentioned earlier, an evaluation is needed to determine if a temporary operation in a nitrification mode is possible at the SEWRF prior to the necessary biological improvements. The AWPF sampling program would support both regulatory and public outreach efforts.
- **San Elijo AWPF**: Task includes the design, construction, and commissioning of the future AWPF facility.
- **San Dieguito Reservoir Characterization**: includes data collection to support modeling, development of reservoir model, and tracer tests to validate model.

Table 6.3 – Proposed projects and timeline for near-term Reservoir Augmentation Project at San Dieguito Reservoir.



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