White Paper

Current and Potential Future Opportunities for Indirect and Direct Potable Reuse of Recycled Water

City of Santa Cruz and Soquel Creek Water District
scwd^2 Desalination Program

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Section 1: Introduction and Background

1.1 Introduction

The City of Santa Cruz Water Department (SCWD,City) and the Soquel Creek Water District (SqCWD, District) are collaborating to conserve, protect, and create a reliable water supply portfolio. The City and District are evaluating developing a regional supplemental potable water supply that would benefit both agencies. The supplemental potable water supply would help the District offset some of its annual water needs as it reduces groundwater withdrawals of the over-drafted Soquel-Aptos area to prevent seawater intrusion. The supplemental potable water supply would also help the City meet the water needs of its service area during drought periods, as well as provide much needed operational flexibility should surface water reductions be required to protect endangered species.

The SCWD Integrated Water Plan (IWP, 2005) and the SqCWD Integrated Resources Plan (IRP, 2006, 2012) provide a flexible, phased approach for providing a reliable high-quality supply of water while ensuring protection of public health and safety. The integrated water plans for both agencies include the following primary components:

- **Conservation:** Permanently reduce customer demand for water and increase water use efficiency to obtain the greatest public benefit from available supplies.
- **Curtailment:** Further reduce water use by up to 15 percent through temporary water restrictions during times of drought.
- **Supplemental Supply:** Evaluate a small regional 2.5-million gallon per day (mgd) desalination plant to provide supplemental water during drought and to help protect our coastal aquifers.

The evaluation of recycled water has also played an important role in adding more diversification to the agencies' water portfolios. A recycled water white paper was previously prepared for the City and District, as part of the **scwd^2** Seawater Desalination Program, to describe recycled water, its benefits, and the potential to offset potable water needs for the City and District:

- *Opportunities and Limitations for Recycled Water Use* (Kennedy/Jenks 2010) investigates the use of recycled water for urban landscape irrigation, agricultural application, and indirect potable reuse through groundwater recharge based on the 2007/2008 California Department of Public Health (CDPH) draft regulations.

While the concept of indirect potable reuse was discussed in the above white paper, the concept of direct potable reuse was not explored. This white paper, *Opportunities for Indirect and Direct Potable Reuse:* 1) summarizes the current regulatory status and ongoing regulatory developments for indirect and direct potable reuse; 2) comments on the feasibility of various potable reuse options that could potentially provide a of supplemental potable water supply and; 3) describes a potential direct potable reuse (DPR) pilot study within the proposed **scwd^2** desalination project that could provide research and an opportunity to further develop uniform water recycling criteria for DPR.

1.2 Challenges for Current Water Supply Portfolios

The City and District rely upon a diversified portfolio of surface water and groundwater to meet water demands. The following sections describe these sources of water and challenges to meeting demands during droughts.

1.2.1 SCWD Water Supply Portfolio

The City relies primarily on surface water runoff that is captured in reservoirs or withdrawn through stream diversions. The City also has several groundwater wells that seasonally supply about 5 percent of its water supply. The City water supply facilities include:

- Surface water storage in Loch Lomond Reservoir (Newell Creek Dam and diversion from San Lorenzo River in Felton).
- Surface diversion on the San Lorenzo River in Santa Cruz.
- Surface diversions from three coastal streams and a natural spring (i.e., North Coast sources).
- Groundwater from the Live Oak Wells.

The City system relies on surface runoff from local rainfall and groundwater infiltration. No water is purchased from state or federal sources or otherwise imported to the region from outside the Santa Cruz area. The strong reliance on surface water to provide nearly all of its water supply is the primary threat to the City water system. Stream flows vary for a number of reasons including seasonal variations, drought, and potential long term impacts from climate change. If the City were faced with drought conditions similar to the 1977 drought, they would not have enough water to meet current demands; drought-related curtailment has historically been estimated to be as high as 45 percent. Even with ongoing conservation efforts and up to 15 percent additional water-use restrictions during drought periods, additional water supplies are needed to meet potable water needs for public health and safety, economic stability, and provide water for protection of endangered species.

1.2.2 SqCWD Water Supply Portfolio

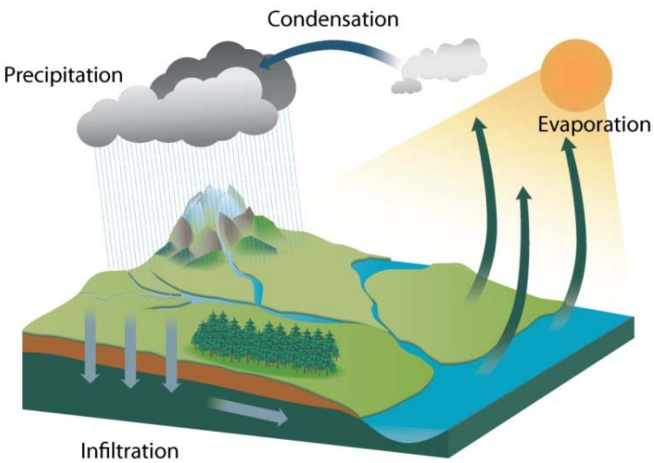
Similar to the City, no water supply for the District is purchased from state or federal sources or imported to the region from outside the Santa Cruz area. The District obtains 100 percent of its water supply from groundwater aquifers within the Soquel-Aptos Groundwater Management area via production wells. The groundwater aquifers are located within two geologic formations that underlie the District service area, the Purisima Formation and the Aromas Red Sands aquifer. The Purisima Formation provides the majority of the District's annual needs. These aquifers provide groundwater to the District as well as other municipal utilities (such as SCWD, Central Water District, and the City of Watsonville), small mutual water districts or companies, and private well owners. The primary threat to the District water supply is overdraft of the aquifers and the subsequent potential for seawater intrusion. The basin currently is in a state of overdraft, and the cumulative impact of pumping in excess of sustainable yields will likely lead to seawater intrusion and to potential contamination of the groundwater basin.

The District has practiced groundwater management for over 25 years and continually monitors for changes in water quality and groundwater levels. In addition, to conserve and protect its potable water supply, the District has joined the City to address common water supply issues. The District needs to find a supplemental water supply that will permit them to reduce pumping from the overdrafted groundwater aquifers and naturally allow the coastal groundwater levels to rise and thereby prevent seawater intrusion.

1.3 Reuse and the Water Cycle

The water cycle (Figure 1), or hydrologic cycle, describes the continuous movement of water above, below and on the surface of the earth in liquid, vapor and solid states. All water on Earth is reused again and again.

Figure 1: The Water Cycle



"The amount of water on Earth does not change. The water you drank this morning was once in the ocean. It may have once flowed through the sap of a maple tree, or been drunk by the builders of the pyramids. The water that flows down your drain may connect to the source of drinking water for another community. The water you drank this morning was used a week ago, a year ago, a century ago, and it will be used again tomorrow. We are all living downstream." (WRF 2012)

Recycled water is treated water from a wastewater treatment plant that has been re-treated to meet water quality levels appropriate for the intended use, such as irrigation, industrial use or potentially potable drinking water.

1.4 Exploring the Opportunity of Potable Reuse

Fresh water is required by our society for homes, businesses, and agricultural uses. As the population of California continues to grow, there is greater demand for the limited fresh water resources. According to WateReuse California's Potable Reuse Program Position Statement, "Conservation, efficient use of water resources, use of recycled water and alternative water sources, such as brackish and seawater desalination, are required to avert a potential water crisis and conservation alone will not meet California's future water demand." (WateReuse 2009).

Reuse of highly purified recycled water to augment potable supplies, referred to as potable reuse, presents the next frontier of developing new, local and sustainable water supplies to provide drought protection, reduce wastewater treatment plant effluent discharges and help meet the increasing demands for our most precious resource, water.

1.5 General Benefits of Potable Reuse

Implementation of a potable reuse project can benefit a local water supply portfolio and the environment, while reducing energy and minimizing new infrastructure (NWRI, 2012).

- **A New Locally Controlled Water Supply:** Potable reuse presents a new, reliable and locally controlled source of water to add to a water supply portfolio.

- **Environmental Preservation and Enhancement:** Potable reuse offers an opportunity to eliminate or minimize water importation to cities, through inter-basin transfers; thereby reducing environmental impacts resulting from construction of reservoirs and conveyance facilities as well as the repercussions of removing that source from its original beneficial use**.**

- **Energy Conservation:** Potable reuse provides the flexibility to produce the source of water near the demand, essentially creating decentralized water management systems that require less pumping and energy consumption that may also reduce greenhouse gas emissions.

- **Maximizes Existing Investments in Infrastructure:** Potable reuse provides an opportunity to satisfy a water demand with minimal infrastructure requirements. Augmentation of the potable water supply avoids the need for an independent system of recycled water “purple” pipes, pumps and storage facilities by utilizing the existing potable water distribution system. This saves significant costs while reducing the environmental impact of new facilities and community inconveniences due to new construction projects.

1.6 General Challenges to Potable Reuse

As the CDPH evaluates and develops potable reuse regulations as part of uniform water recycling criteria, there are some obstacles that must be addressed to determine when and if potable reuse projects can be implemented (WateReuse 2009).

- **Public Perception:** Helping the community to understand potable reuse is a safe and an acceptable source of water that may be used for drinking water purposes (WWR&D 2011). This includes educating the public about the water cycle and current practices where many cities already withdraw drinking water from rivers that contain varying amount of wastewater discharges from upstream cities and industries (sometimes referred to as de facto or unplanned potable reuse).

- **Health Risk Concerns:** Recent advances in laboratory techniques allow for the measurement of very small quantities of constituents, far below the regulatory limits for these constituents. Where a constituent was “not detected” in past water samples, that constituent may now be “detected” at very low levels due to more sensitive analysis methods. The water can still be safe, but the perception of the health risk can change because of the detection of the constituent. Additional research needs to be done to help confirm and communicate the safety of our water supplies now that extremely low levels of constituents are being detected and measured.

- **Technological Capabilities:** Confidence in and reliance on the safety of treatment technologies is key to ensuring the safe production of purified recycled water that is acceptable for consumption. Treatment process reliability, redundancy, disposal of treatment residuals, and monitoring are key elements of a potable reuse project to demonstrate that potable reuse produces purified water that exceeds current drinking water standards. Real time monitoring capabilities are also being carefully examined and considered to reassure regulators and the public of a safe delivery system.

- **Challenges for Satellite Recycling:** Withdrawal of wastewater directly from the sewer collection system (also referred to as satellite water recycling, sewer scalping, or sewer mining) requires sufficient flow in the sewer to satisfy recycled water demands while retaining enough bypass flow in the sewer to avoid clogging of pipes and odor issues resulting from too little in-pipe sewer flow. Discharging the waste stream from an advance treatment recycled water facility back into the sewer system may also have some implications to the downstream treatment facility processes.

- **Establishment of Regulations.** Development of a regulatory framework for all types of potable reuse is vital to the broader scale implementation of potable reuse projects. The current efforts, through California Senate Bill No. 918 (SB918) (discussed in Section 3.3), are focused on indirect potable reuse guidelines. Currently direct potable reuse is not permitted in California.

- **Development of a Clear Roadmap:** As more case studies are available, there will be greater guidance about when and how to develop a potable reuse project. Cities without access to imported water or whose alternative sources of water are either of poor quality or prohibitively expensive may find themselves among the first to explore direct potable reuse for lack of sufficient available water resources. Cities that have implemented seawater desalination projects may also find benefits from converting those systems to receive recycled water in lieu of seawater.

The following sections describe the two general categories of potable reuse, indirect potable reuse and direct potable reuse. The sections define the approach to potable reuse, describe current regulations and case studies, and discuss the opportunities and limitations of potable reuse as a supplemental potable water supply for the City and District.

Section 2: Indirect Potable Reuse

2.1 Indirect Potable Reuse – What is it?

Indirect potable reuse (IPR) is where highly purified recycled water is purposefully introduced into an untreated drinking water supply source, such as groundwater in an aquifer or surface water in a large reservoir. The recycled water is mixed with the untreated water source, and there is a specified blending ratio, travel time and distance between the point of addition and eventual extraction for treatment at a drinking water treatment plant. Although full treatment of the recycled water is provided to meet specific water quality objectives, the aquifer or reservoir also act as an additional "environmental buffer" that is viewed to provide several benefits including:

- improved water quality through various natural processes ("polishing")
- improved risk management – the buffer provides time to respond to any issue with upstream recycled water treatment processes
- improved public perception of the project (WateReuse 2011).

2.2 Approaches to IPR with Recycled Water

IPR can be accomplished using two general approaches, and each approach has particular regulatory requirements with respect to ensuring potable water quality and the protection of public health. The approaches include:

1. Groundwater Recharge using surface spreading ponds or injection wells.
2. Reservoir Augmentation of surface water supplies.

Figure 2, below, shows the general water cycle and approaches to IPR with recycled water.

After the blended recycled and untreated source water is removed from the environmental buffer, it receives additional water treatment and disinfection prior to potable reuse. In the case of Groundwater Recharge, additional treatment processes could be provided to address typical groundwater water quality issues, such as iron and manganese or Total Dissolved Solids (TDS), removal. For Reservoir Augmentation, additional treatment would be provided to meet the requirements of the Surface Water Treatment Rule that apply to all surface water sources. The concepts for indirect potable reuse via groundwater recharge are described in a previous white paper. (Kennedy/Jenks 2010)

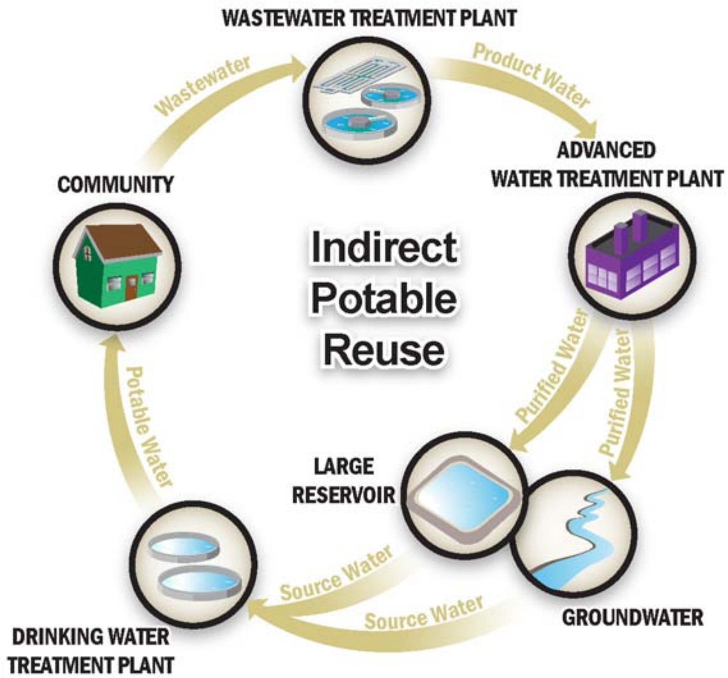


Figure 2: General Indirect Potable Reuse Approach

Typical projects that use IPR with recycled water include:

- **Groundwater Recharge:** Groundwater augmentation with recycled water can provide additional water for various beneficial uses, such as municipal water supply, agricultural irrigation and industrial water supply. An IPR groundwater recharge project can be accomplished by surface spreading, vadose zone injection wells or direct injection (EPA 2004, Asano 2007).

- **Seawater Intrusion Barrier:** Injecting recycled water into coastal groundwater aquifers adjacent to the ocean can serve to protect underground freshwater supplies by creating a barrier to seawater intrusion.

- **Reservoir Augmentation**: The addition of recycled water into or upstream of a large surface water storage reservoir can provide additional water for various beneficial uses, such as municipal water supply, agricultural irrigation and industrial water supply.

2.3 Current IPR Regulations

IPR is regulated jointly between the Regional Water Quality Control Boards (RWQCB's) and the California Department of Public Health (CDPH). The RWQCB's focus is protection of the environment and the CDPH has primacy over protection of public health. The IPR Regulations have been evolving in California for 30 years and are in the process of being finalized in accordance with the requirements of Senate Bill 918 (SB918) as described below.

2.3.1 IPR Groundwater Recharge Regulations

The most recent version of the groundwater recharge regulations for IPR are dated November 2011 (CDPH 2011). The CDPH and RWQCB's are currently responding to public comments on the 2011 Groundwater Replenishment Reuse Draft Regulations, and these regulations are expected to be finalized for adoption by December 31, 2013, per SB918.

Table 1 compares the following two key criteria included in the previous (2007/2008) draft regulations discussed in the Kennedy/Jenks 2010 white paper, and the current proposed (2011) draft regulations. These criteria for IPR projects have an influence on the feasibility of implementing an indirect potable reuse groundwater replenishment project for the City and District:

1. **Initial blending requirements:** The maximum recycled water percentage that is blended with a diluting water source (surface water or groundwater) prior to recharge.

2. **Minimum underground residence time:** Travel time of recycled water in the subsurface prior to extraction by any public or private potable drinking water well.

Table 1: Summary Requirements for Groundwater Recharge

	2007/2008 Draft Regulations		**2011 Draft Regulations**	
Application	**Initial Blending Requirements** *(Max. Recycled Water %)*[2]	**Minimum Underground Residence Time**[3]	**Initial Blending Requirements** *(Max. Recycled Water %)*[4]	**Minimum Underground Residence Time**[6]
Surface spreading (recharge ponds)	20%	6 months	20%	Must meet requirements of pathogen barrier and response time. Minimum of 2 months.
Surface spreading (recharge ponds) with full advanced treatment[1]	50%	6 months	Case-by-case basis[5]	
Subsurface injection (injection wells)	50%	6 months	Case-by-case basis[5]	

Notes:

(1) Assumes 100% reverse osmosis (RO) with advanced oxidation process (AOP).
(2) These percentages may be increased up to 100% over time based on the results of an extensive groundwater monitoring program to demonstrate that no degradation of groundwater quality is occurring.
(3) The 6-month minimum travel time requirement is only applicable after substantial testing has occurred. Initially, a 12 to 24-month separation between injection wells and production wells would be required.
(4) These percentages may be increased up to 100% over time based on water-quality driven monitoring of Total Organic Carbon and CDPH and RWQCB approval (per Section 60320.116(d)).
(5) An increase in the percentage of recycled water would require full advanced treatment and CDPH and RWQCB approval.
(6) Time may be reduced based on credits for pathogen removal through each treatment barrier and method used to estimate the retention time to the nearest down gradient well (per Table 60320.108). The project must demonstrate suitable retention times to provide an adequate pathogen barrier, react to a treatment failure, achieve effective soil-aquifer treatment, and comply with recycled water contribution requirements.

In general, the 2011 draft regulations provide greater flexibility to allow regulators and agencies to create projects that fit within communities that have widely varying and many site-specific conditions. The draft regulations provide more flexibility with blending requirements and underground residence time on a case-by-case basis, while ensuring the project can meet pathogen removal requirements, react to potential treatment failure, and provide protection of public health. It is anticipated that for a project to successfully achieve approval for less time in the subsurface or reduced blending requirements, the project would require full advanced treatment (100% reverse osmosis and advanced oxidation process) and a comprehensive understanding of the groundwater basin with field testing to demonstrate compliance with regulatory criteria.

2.3.2 IPR Reservoir Augmentation Regulations

A regulatory framework for augmenting potable reservoir supplies with purified recycled water is in the process of being established. SB918 directs the CDPH to develop and adopt water recycling criteria for surface water reservoir augmentation by December 31, 2016. A panel of academic and industry experts are assisting CDPH to assure the criteria are adequately protective of public health (Welch 2011).

Until the regulatory framework is completed, the CDPH is considering reservoir augmentation projects on a case-by-case basis. The City of San Diego has proposed a reservoir augmentation feasibility project (discussed in Section 2.4.5). In correspondence dated August 31, 1994, CDPH conditionally approved a proposed San Diego reservoir augmentation concept, subject to the following conditions (Welch 2011):

- reverse osmosis treatment would be provided for the entire reservoir augmentation discharge flow,
- purified recycled water should not comprise more than 50 percent of the reservoir water over a 3-year period,
- the reservoir must have a minimum one-year average hydraulic retention time, and
- the potential for short-circuiting between the discharge point and reservoir outline should be minimized.

It is anticipated the forthcoming CDPH regulations for IPR reservoir augmentation could be similar to the requirements for the proposed San Diego project, and could likely include requirements for recycled water treatment similar to those for groundwater recharge, reservoir size, mixing parameters and percentage of recycled water, a comprehensive monitoring program and appropriate potable water treatment of the blended surface water (Welch 2011).

2.4 IPR Project Case-Studies

The following IPR project case studies describe how several agencies are successfully using or planning to use recycled water to recharge groundwater aquifers, prevent seawater intrusion and augment surface water reservoirs.

2.4.1 County Sanitation District of Los Angeles County, CA - Montebello Forebay Groundwater Recharge Project

In 2012, the Sanitation Districts' Montebello Forebay Groundwater Recharge Project celebrated its 50 year anniversary, making it the oldest planned groundwater recharge project using purified recycled water in California. To date, over 525 billion gallons of tertiary treated recycled water have been recharged at the Montebello Forebay through surface spreading. The many in-depth research projects performed at the Montebello Forebay have been instrumental in demonstrating the long-term public health safety of groundwater recharge and contributing to the development of regulations for groundwater recharge of recycled water in California.

2.4.2 Orange County Water District, CA - Groundwater Replenishment System

The Orange County Water District (OCWD) in Southern California operates an indirect potable reuse program to recharge their large and relatively un-constrained groundwater basin. The OCWD and Orange County Sanitation District jointly-funded the Groundwater Replenishment System, a state-of-the-art water purification project that can currently produce up to 70 mgd of high-quality water. Operational since January 2008, this locally-controlled, drought-proof and reliable supply of high-quality water is used in an environmentally sensitive and economical manner to meet the needs of nearly 600,000 residents in north and central Orange County, California. The project uses a three-step advanced treatment process consisting of microfiltration, reverse osmosis and advanced oxidation (ultraviolet light with hydrogen peroxide) to produce a high-quality purified water that exceeds all state and federal drinking water standards. The purified water is injected into a seawater barrier and pumped to recharge basins where it naturally percolates into the groundwater basin. (OCWD 2013).

2.4.3 Upper Occoquan Sewage Authority, VA - Occoquan Reservoir Augmentation

Since 1978, the Upper Occoquan Sewage Authority (UOSA) has been discharging recycled water into a stream above Occoquan Reservoir, a potable water supply source for Fairfax County, Virginia (EPA 2004). This pioneering project was made possible by the creation of the Occoquan Watershed Policy to protect public health, specify the type of waste treatment practices that would have to be adopted on a basin-wide scale, and provide for an on-going program of water quality monitoring to measure the success (or failure) of the waste water treatment. This resulted in the construction of the UOSA advanced wastewater treatment plant with tertiary treatment (consisting of multimedia filtration, activated carbon) and disinfection (chlorination and dechlorination) with a current capacity of 13 million gallons per day (Ward 2012).

2.4.4 Singapore NEWater –Reservoir Augmentation

In just four decades, Singapore has overcome water shortages through a diversified and sustainable water supply from four different sources known as the Four National Taps (water from local catchment areas, imported water, recycled water known as NEWater and desalinated water). The NEWater treatment process includes membrane filtration (microfiltration), reverse osmosis and disinfection (UV irradiation) plus chlorination. The purified NEWater is primarily for non-potable industrial uses; however a small percentage is also blended with raw water in a surface water reservoir, which then goes through treatment at the potable waterworks before it is supplied to consumers as tap water. (Singapore, 2002)

2.4.5 San Diego County Water Authority – Planned Augmentation of San Vicente Reservoir

The City of San Diego's efforts to evaluate indirect potable reuse and augmenting the San Vicente Reservoir Water started in the 1990's. San Diego received conditional concept approval by CDPH in 1994 to study the concept and conduct pilot testing. After community debate and some delays in the project, the San Diego Purification Demonstration pilot project was initiated in 2007 to test the safety and cost of purifying recycled water for reservoir augmentation. After the pilot test data the CDPH provided conditional acceptance of the project (CDPH, 2012). The results from the 1-mgd demonstration project will also be reviewed by an independent advisory panel of experts. If approved by the San Diego City Council and Mayor, a full-scale, 10 mgd project could be implemented to augment the San Vicente Reservoir. The recycled water would be blended in the large 242,000 acre-foot capacity reservoir, and could typically be approximately 5-percent of the total capacity. The new advanced water treatment plant, would likely include membrane filtration, reverse osmosis and disinfection (UV and hydrogen peroxide), and disinfection. If constructed, this project would be the first IPR through reservoir augmentation project in California (City of San Diego, 2010).

2.5 IPR Opportunities and Limitations for the City and District

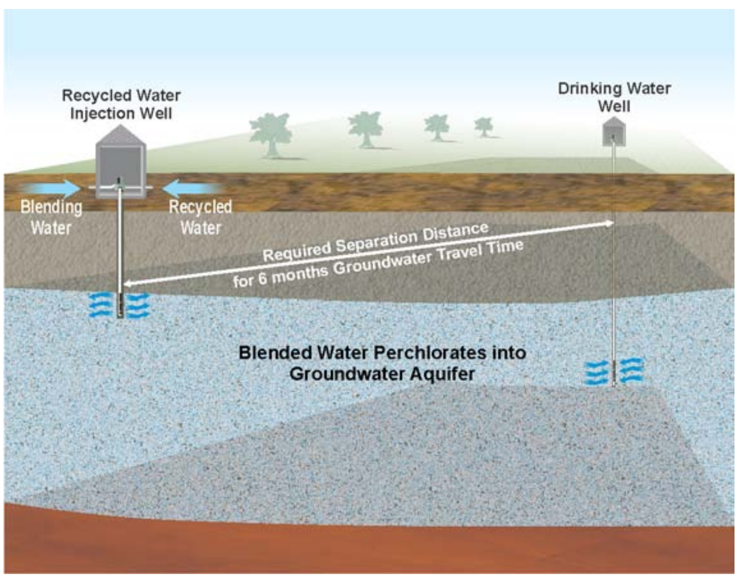
2.5.1 Groundwater Recharge

In concept, a supplemental water supply project for the City and District could be the regional use of highly treated recycled water for injection into the over-drafted Soquel-Aptos area groundwater basin. While the final regulations for IPR-groundwater recharge are not complete, the City and District could work with the CDPH on a case-by-case basis to evaluate an IPR project. Secondary effluent from the City of Santa Cruz Wastewater Treatment Facility (WWTF) could be treated with an advanced water treatment process including coagulation, filtration, full desalination, advance oxidation and ultraviolet light, and disinfection. The advance recycled water treatment facility would be a similar size to the proposed **scwd**[2] Regional Desalination Facility and could be located on the Westside of Santa Cruz to be near the wastewater plant effluent supply. The recycled water supply could be pumped to a series of multiple injection wells in the District service area through a new distribution network of purple pipes and related improvements. Injection, monitoring and extraction wells would be built to operate the system and recover the injected recycled water.

Kennedy/Jenks and City and District staff reviewed previous technical studies for the City (Carollo, 2000 and 2002) and District (Black & Veatch, 2005, 2009) regarding a potential IPR project, and discussed the groundwater recharge concepts and potential with geologists from University of California Santa Cruz and the local USGS. The challenges to establishing an IPR groundwater recharge program in the Santa Cruz area Soquel-Aptos groundwater basin include, the lack of available blending water (e.g. excess surface or groundwater available for blending recycled water), physical constraints with the complex geology and groundwater basin characteristics, avoiding the high number of private and municipal wells regulatory restrictions and uncertainties, and high project cost.

1. **There is limited or no blending water available**. To be able to inject 1 mgd of recycled water into the groundwater basin, the IPR project could require up to 1 mgd of blending water. The injection well and underground geology would then need to be able to absorb a total injection of 2 mgd of water. The blending water could be groundwater or treated surface water. However, there is limited groundwater and treated surface water sources that could serve as blending water. As a result, the lack of blending water would limit the amount of recycled water that could be recharged into the groundwater basin.

2. **The local geology is not conducive to significant volumes of recharge**. The Soquel-Aptos area groundwater basin, especially the Purisima formation, is comprised of complex geology and hydrogeologic conditions that limit the volume of water that could be injected and then recovered. The areas for injection are limited by bedrock and proximity to the ocean and other wells (both private and municipal). Numerous small injection wells, monitoring wells and extraction wells, with costly distribution piping, would be likely be required to inject and withdraw the recycled water. The volume of additional supplemental water that could be recovered following injection is not clear and would typically be less than the volume that is injected.



Under current regulations, recycled water injection wells need to be located away (minimum 6 months travel time) from drinking water wells. The physical distance depends on underlying geology.

Figure 3: Concept for Groundwater Injection

3. **There is limited space to locate injection wells away from drinking water wells**. Locating recycled water injection wells to meet the physical and travel time separation requirements would be very challenging as there are over a thousand private potable water wells within the area referred to as the Soquel-Aptos area groundwater basin, as well as the nineteen municipal wells for District and City. Figure 3 shows the concept for spacing injection wells away from drinking water wells. Figure 4 below shows the extent and distribution of private and municipal wells in the Soquel-Aptos area. While the agencies could try to buy out private well owners to create sufficient separation space, the combination of large numbers of existing wells, the rugged terrain and underlying

geology, and the urban areas over the basin limit the ability to locate injection wells that comply with the CDPH separation requirements.

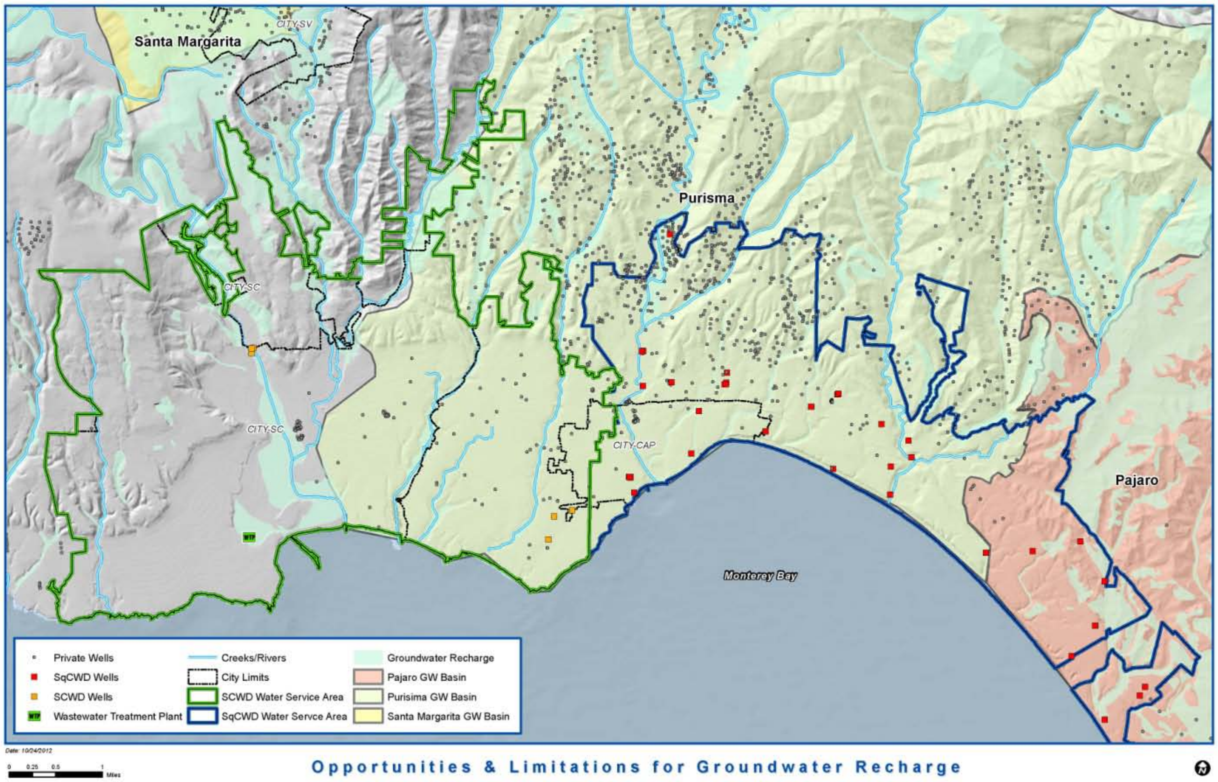


Figure 4: Distribution of Private and Municipal Drinking (or Potable) Wells within and around the Soquel-Aptos Groundwater area

4. **New recycled water infrastructure would be expensive**. The recycled water would need to be treated by coagulation, filtration, full desalination, advance oxidation and ultraviolet light, and disinfection, and would then have to be conveyed in new dedicated recycled water pipelines long distances from the treatment plant to the injection sites. The advanced water treatment facility for a similar IPR project for the Santa Clara Valley Water District has a project cost of approximately $56 million. The cost of the proposed piping system to deliver the advanced treated recycled water for percolation or recharge could be an additional $50 to $60 million or more.

An IPR groundwater recharge project for the City and District would face significant challenges due the lack of available blending water, physical constraints with the complex geology and groundwater basin characteristics, avoiding the high number of private and municipal wells regulatory restrictions and uncertainties, and high project cost. For these reasons an IPR groundwater recharge project is considered to be not practical and not viable to meet the City and District objectives for a supplemental water supply.

2.5.2 Seawater Intrusion Barrier

A variation of an IPR groundwater recharge project that may benefit the over-drafted aquifer is an injection barrier along the edge of the aquifer near the coast to prevent seawater intrusion. This would be accomplished by delivering the recycled water through an independent distribution system to injection wells along the coast to create a mound of recycled water that creates a seawater barrier. There are many such systems throughout the state that use treated wastewater in this capacity. The Orange County Water District, West Basin Water District and other Southern California agencies have implemented recycled water injection as a seawater barrier.

This type of project to help prevent seawater intrusion for the Soquel-Aptos area groundwater basin could have similar treatment and distribution system infrastructure requirements to the groundwater recharge project described above, but the treated recycled water could be injected at the coastline to create a mound of recycled water that provides a seawater barrier. A seawater intrusion barrier project would face similar challenges due to lack of blending water, basin geology and high costs. While this type of project could be viable for the Soquel-Aptos area groundwater basin to aid in reducing the migration of seawater into the over-drafted groundwater basin, it does not directly provide supplemental water to meet the City and District objectives for supplemental water supply needs.

2.5.3 Reservoir Augmentation

A reservoir augmentation concept (Figure 5 below) could entail treating secondary effluent from the Santa Cruz WWTF at an advanced recycled water treatment facility and conveying the purified recycled water, via a new pipeline, to Loch Lomond Reservoir for storage. After storage, Loch Lomond Reservoir waters would be transported downstream to the City of Santa Cruz's Graham Hill Water Treatment Plant (WTP) via the Newell Creek pipeline. Treatment processes would include membrane filtration (microfiltration), reverse osmosis, and advanced oxidation (UV and hydrogen peroxide) prior to storage in Loch Lomond Reservoir, and potable water treatment after the reservoir.

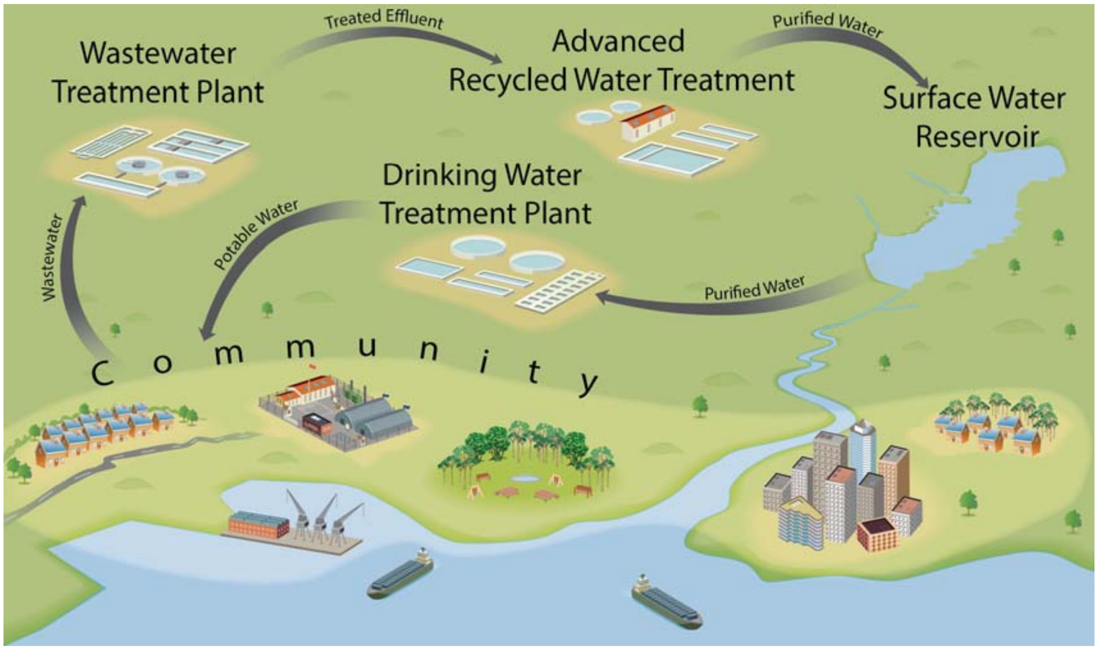


Figure 5: Concept for IPR Reservoir Augmentation

Preliminary exploration of this concept identified a potential opportunity to provide up to approximately 1.5 mgd of advanced treated recycled water to augment water in Loch Lomond Reservoir. However, due to the small reservoir capacity, the reservoir would equalize to be 50-percent or more recycled water in normal years and nearly 100-percent recycled water during periods of drought. This would not meet the general regulatory framework for IPR reservoir augmentation conditionally approved by the CDPH as part of the proposed San Diego reservoir augmentation project (recycled water would make up approximately 5-percent of San Diego's San Vicente Reservoir).

Significant challenges were identified due to the quantity and quality of water in Loch Lomond Reservoir, regulatory uncertainties, infrastructure requirements and associated costs and energy to treat and convey water up to the reservoir. As examples, water quality considerations include the effect of nutrients on bio-stimulation in Loch Lomond; and the costs and energy use would be relatively high due to the requirement to pump the purified recycled water up to Loch Lomond and then re-treat it through the Graham Hill WTP.

An IPR project using Loch Lomond Reservoir would not meet the general regulatory framework conditionally approved by the CDPH due to the small capacity of the reservoir, high percentage of recycled water present upon equalization and inability to meet hydraulic retention times. For these reasons, in addition to the other challenges described above, an IPR reservoir augmentation project is considered to be not practical and not viable to meet the City and District objectives for a supplemental water supply.

Section 3: Direct Potable Reuse

3.1 Direct Potable Reuse – What is it?

Direct potable reuse (DPR) is where highly purified recycled water is purposefully introduced into an untreated drinking water supply source, immediately upstream of a water treatment plant or directly into the potable water supply distribution system downstream of a water treatment plant.

"Recycled water purification technologies have the capability to remove very small particles and constituents that are in the source water. These technologies can produce water that's more pure than your tap water, exceeds standards and makes it suitable for drinking again." (WRF 2012)

3.2 Approaches to DPR with Recycled Water

As discussed in more detail in Section 3.3, DPR is not currently permitted in California. However, in concept, DPR could be accomplished using two general approaches:

1. **Source water augmentation.** Blending the advanced treated water with source water ahead of a drinking water plant.

2. **Finished water augmentation.** Blending the advanced treated water with potable water after a drinking water plant.

Figure 6, below, shows the general water cycle and approaches to DPR with recycled water.

In addition to advanced treatment of the recycled water, an "engineered buffer" (storage tank) would be provided for a DPR project to ensure that water quality leaving the facility always met regulatory standards. The engineered buffer could be an appropriately sized storage tank that could provide additional time to monitor the water quality and allow for corrective action in the event that the product water does not meet all regulatory requirements prior to introduction into the potable supply (WateReuse 2011).

After the advanced treated recycled water has been monitored through the engineered buffer system, it could be blended with untreated source water before the inlet to a drinking water treatment plant. The blended water would then receive additional water treatment and disinfection prior to addition into the potable water system.

In the concept for finished water augmentation, the advanced treated recycled water could enter the potable water system after it has been monitored through the engineered buffer system.

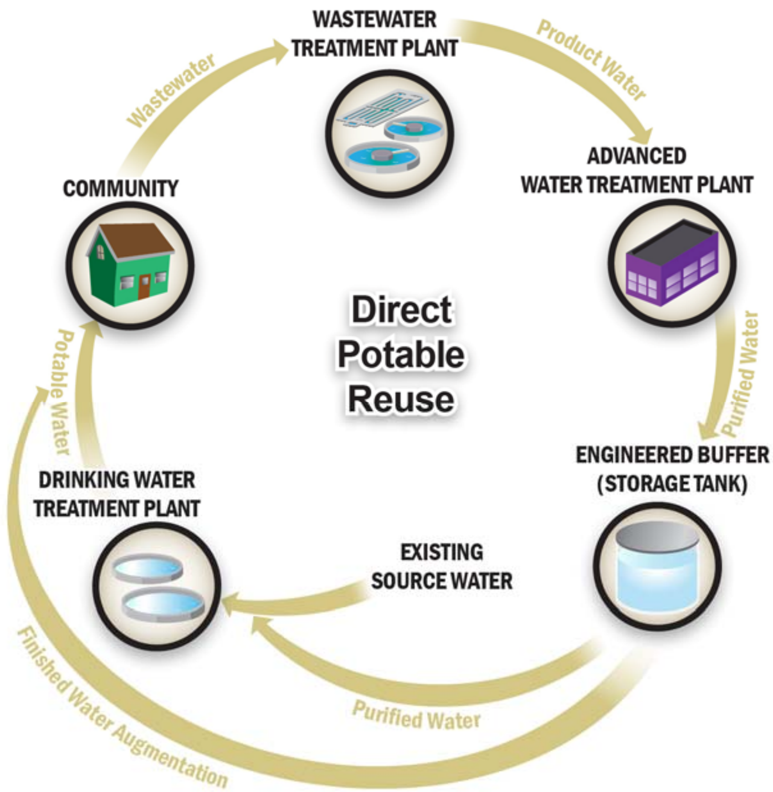


Figure 6: General Direct Potable Reuse Approach

3.3 Current DPR Regulations

Currently DPR is not permitted in California.

The most recent development in DPR regulations has been the adoption of SB918 that was signed into law in 2010, which directs the CDPH to investigate the feasibility of developing uniform water recycling criteria for DPR and to provide a final report on that investigation to the Legislature by December 31, 2016. Based on the estimated timeframe for adoption of uniform water recycling criteria for IPR, preliminary DPR regulations may not be available in California until 2020 at the earliest.

While CDPH has been willing to work with agencies on a case-by-case basis to evaluate IPR projects such as San Diego’s IPR-reservoir augmentation project, the CDPH has not, to date, considered any DPR projects. However, the CDPH may be willing to consider and evaluate a DPR-source water augmentation project, if requested by a water agency. It is not likely that CDPH would be willing to consider and evaluate a DPR-finished water augmentation project.

3.4 DPR Project Case Studies

The following case studies represent agencies in the United States that are successfully using or planning to use recycled water for DPR by augmenting source water supplies, prior to the water treatment plant, and in one case in Africa augmenting finished water supplies. Because DPR is not permitted by CDPH, there are no DPR projects in the state of California.

3.4.1 Big Springs, Texas

The Colorado River Municipal Water District (CRMWD), which supplies water to a number of cities within the basin, undertook an initiative to “reclaim 100% of the water, 100% of the time” to respond to extensive periods of limited rainfall and water supply shortages (WateReuse 2011). The advanced wastewater treatment process will employ membrane filtration with reverse osmosis and advanced oxidation, disinfection and water quality monitoring. The advanced treated recycled water will then be blended with untreated source water in the transmission line flowing from a reservoir to a drinking water treatment facility. The project is expected to begin operation in 2013.

3.4.2 Village of Cloudcroft, New Mexico

The limited water supply from springs and wells for this small mountain community in southern Albuquerque was extremely low, requiring the Village of Cloudcroft to haul water to meet peak weekend demands. A plan was developed for DPR through source water augmentation. The treatment process includes a membrane bioreactor followed by an advanced treatment process with membrane filtration, reverse osmosis and advanced oxidation, and disinfection. The purified water is then blended with natural spring and groundwater and placed in an engineered storage tank that serves to blend the three sources and provide an additional buffer for monitoring water quality. Water from the storage tank is then treated by ultrafiltration, UV disinfection, activated carbon and disinfection before being introduced into the potable distribution system (WateReuse 2011).

3.4.3 City of Windhoek, Namibia

Since 1968, Windhoek Namibia has been adding highly-treated reclaimed water directly into the potable water distribution system. The purified recycled water meets Namibia Drinking Water Guidelines, World Health Organization Guidelines and South Africa Rand Guidelines (WateReuse 2011). Over the last 40 years, the treatment plant has gone through a series of upgrades, and now includes additional filtration, ozonation, activated carbon, ultrafiltration and chlorination. Finished water augmentation takes place directly in the pipeline that feeds the potable water distribution network.

3.5 DPR Opportunities and Limitations for the City and District

3.5.1 Source Water Augmentation

As discussed in Section 2.5.3, an IPR project using Loch Lomond Reservoir would not meet anticipated CDPH requirements, and would not be viable due to the small capacity of the reservoir, high percentage of recycled water present upon equalization and inability to meet hydraulic retention times. However, there may be a potential variation on this concept that could be pursued as a DPR project.

- One variation could be to categorize this concept as a DPR source water augmentation project where the advanced treated recycled water is blended with source water in Loch Lomond Reservoir, but (as a DPR project) doesn’t incur the same criteria for percent recycled water concentration and hydraulic retention time as would be required for an IPR project.

- Another variation would be to categorize this concept as a DPR source water augmentation where advanced treated recycled water is blended with the source water before the inlet of the City's Graham Hill WTP (similar to the Big Springs, TX project). This would reduce the costs of pipeline construction and reduce the energy to pump water all the way up to Loch Lomond reservoir.

In either case, a supplemental water supply project for the City and District could use advanced treated recycled water for DPR source water augmentation. Secondary effluent from the City of Santa Cruz WWTF could be treated with an advanced water treatment process including coagulation, filtration, full desalination, advance oxidation and ultraviolet light, and disinfection. For DPR projects, an additional engineered buffer (storage tank) would likely be required by CDPH to permit close monitoring of the product water and permit redirecting the product water if it does not meet water quality requirements. The advanced recycled water treatment facility could be located on the Westside of Santa Cruz to be near the wastewater plant effluent supply. The recycled water supply could then be pumped via a new pipeline to Loch Lomond or to another existing source water pipeline before the inlet to the GHWTP. The blended water could then be treated through the existing GHWTP and enter the City's potable water distribution system.

Until DPR regulations are in place, the CDPH may be willing to work with agencies on a case-by-case basis to evaluate DPR-source water augmentation projects. As described above, the CDPH is working with the City of San Diego to evaluate an IPR reservoir augmentation project, and has established criteria and granted conditional approval for demonstration testing. However, the San Diego IPR reservoir augmentation project has taken over two decades to progress through conditional acceptance and demonstration testing, and is still years away from implementation and operation.

Therefore, a DPR project is not considered viable in the next decade or more, given that DPR projects currently are not permitted in California, the CDPH has not yet evaluated or conditionally approved any DPR projects, conditional approval, demonstration testing and implementation would likely take a decade or more, and DPR faces significant public perception challenges. Therefore, a DPR source water augmentation project is considered to be not practical and not viable to meet the City and District objectives for a supplemental water supply.

3.6 Potential Conversion of Seawater Desalination Facility for Direct Potable Reuse

The **scwd²** Regional Seawater Desalination Project would provide up to 2.5 mgd of potable water as a supplemental water supply. In the near-term (next 5 to 20 years), the seawater desalination facility could function as a supplemental source of water to help the City and District preserve coastal aquifers from seawater intrusion, protect coastal stream habitats, provide a reliable supply of water during a drought, and ensure protection of public health and safety.

In the long-term (next 15 to 30 years), should regulations change in the future and allow for DPR, the seawater desalination facility could potentially be modified into a DPR facility. Conversion of a seawater desalination plant to a DPR plant would lower the overall energy use of the facility, reduce or eliminate the withdrawal of seawater from the ocean, and reduce the concentration of the brine discharge.

The treatment technologies for removing solids and salts from seawater are very similar to those used to purify recycled water for potable reuse. Figures 7 and 8 below, present the overall treatment processes for seawater desalination and DPR treatment.

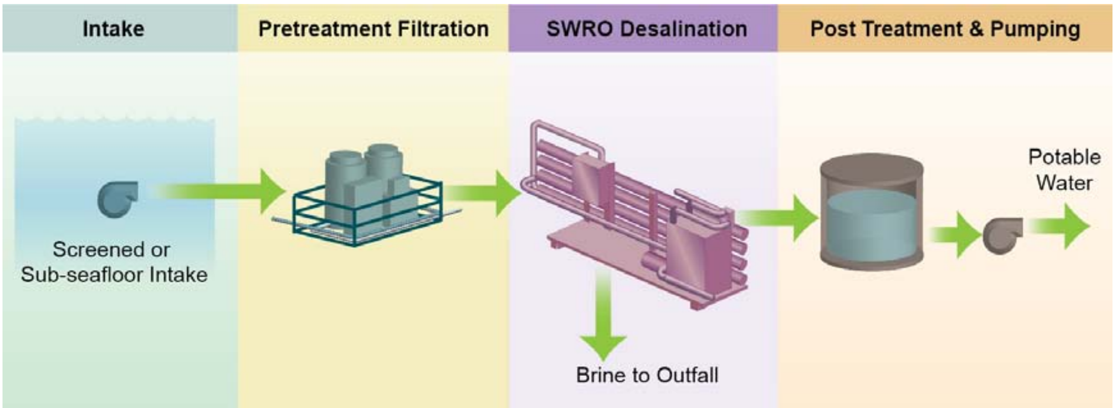


Figure 7: Overall Seawater Desalination Process

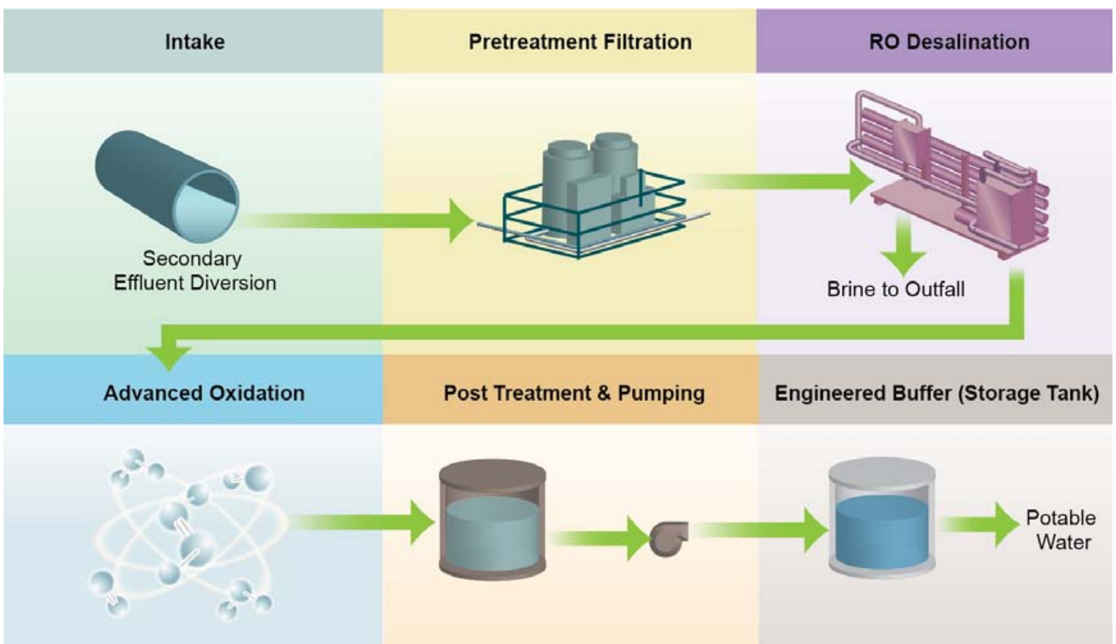


Figure 8: Overall Potable Reuse Process

Table 2 provides a description of the different processes for seawater desalination and potable reuse. As evident from the figures and table, the potable reuse treatment process is similar to the seawater desalination process with the following differences:

- Source water is secondary effluent from a wastewater treatment plant instead of seawater.

- Less energy is required as compared to seawater desalination since the recycled water salinity is less than seawater.
- An advanced oxidation step and an “engineered buffer” (storage tank with monitoring) is provided after the recycled water RO desalination step.

Table 2: Comparison of Water Purification Processes for Seawater Desalination and Potable Reuse

Treatment Process	Seawater Desalination	Potable Reuse	Description
Microfiltration (MF) or Ultrafiltration (UF)	✓	✓	A membrane-based, pressure-driven separation process that typically employs hollow fiber membranes to provide a barrier to the passage of solids and microorganisms (including bacteria, protozoan pathogens, and some viruses).
Reverse osmosis (RO)	✓	✓	A pressure-driven membrane separation process in which dissolved compounds (i.e., TDS and organic material) is separated from the water. RO also removes nearly all organic compounds, such as endocrine-disrupting compounds and pharmaceuticals and personal care products.
Advanced Oxidation Process (AOP)		✓	AOP is used to destroy natural and synthetic organic chemicals that may be present in recycled water at trace concentrations. AOP involves the addition of oxidizing chemicals (e.g. hydrogen peroxide, H_2O_2) that form hydroxyl radicals, which in turn react with (and degrade) the constituents in water and destroys the organic compounds.
Chlorine or Other Residual Disinfection	✓	✓	While disinfection may be accomplished via AOP, hydroxyl radicals do not provide residual disinfection. Therefore, additional disinfection would be used to provide a residual.
Storage Tank		✓	An engineered buffer storage tank may be required to allow for monitoring and redirection of water if needed. The residence time in the tank could be up to 24 hours.

Future conversion of the proposed **scwd²** Regional Seawater Desalination Project from a seawater desalination into a DPR facility could be accomplished by relatively minor modification to the proposed desalination facilities and related infrastructure. Based on a preliminary assessment for a full conversion of the plant, the changes would include:

- Decommission the seawater intake pump station since the source water would be treated wastewater effluent from the wastewater treatment plant.

- Provide a pump station at the Santa Cruz WWTF and connect to the intake pipelines to the seawater desalination facility thereby pumping treated effluent to the desalination facility instead of seawater.
- Change out the RO pumps with lower horsepower pumps since less energy is needed.
- Initially, the seawater RO membranes would not need to be changed out to treat the lower salinity recycled water. However, after the regular lifecycle of the RO elements, they could be changed to brackish water type elements.
- Add the advanced oxidation process after the RO step. This equipment could potentially be located in the space reserved for future equipment.
- Add on-site storage and water quality monitoring. This could be accomplished by converting the brine holding tanks to "engineered buffer" storage tanks. The brine holding tanks would not be needed for a DPR facility because the brine would have a lower salinity and could be continuously discharged to the Santa Cruz WWTF outfall.

3.7 Potential DPR Pilot System at the Desalination Facility

With recent regulatory developments and community interest in DPR, an opportunity exists to study the feasibility of incorporating DPR into the long-term water supply portfolios of the City and District. A small DPR pilot system could be constructed at the proposed **scwd**^{2} Regional Desalination Facility (Desalination Facility) and operated to provide CDPH with information to assist in their development of DPR regulatory criteria, and to demonstrate the ability of the treatment process to produce safe drinking water.

The DPR Pilot Study could be the first phase of a long-term evaluation of the use of advanced water purification technologies to provide recycled water as an additional safe and reliable supplemental water supply to the City and District. Should regulations change in the future and allow for DPR, the Desalination Facility could potentially be transitioned to a DPR facility. Conversion of a seawater desalination plant to a DPR plant would lower the overall energy use of the facility and reduce or eliminate the withdrawal of seawater from the ocean.

3.7.1 DPR Pilot Study Objectives

The **scwd**^{2} DPR Pilot Study could include construction of a small scale advanced recycled water treatment pilot system, located within the footprint of the proposed **scwd**^{2} Regional Desalination Project. The pilot equipment could be operated by the desalination plant operators and testing could take place over a period of several years. The objectives of the Study could include:

1. Demonstrate the ability of advanced purification technologies for DPR to consistently produce water that meets all regulatory standards.
2. Work with CDPH to develop a water quality monitoring process and program that ensures the reliability of the system to meet standards.
3. Provide study results to assist in the CDPH in their development of DPR regulatory criteria.

4. Confirm that the water would not affect water quality in the existing water supply and distribution systems.

5. Establish the regulatory feasibility of potentially transitioning the Desalination Facility into a DPR facility.

6. Demonstrate the technology to the community and evaluate public acceptance of DPR.

7. Confirm the cost and energy savings from a DPR project.

3.7.2 DPR Pilot System Components

The DPR pilot system would treat effluent from the Santa Cruz WWTF. The treatment processes would consist of oxidation and coagulation, microfiltration (MF) or ultrafiltration (UF) filtration, reverse osmosis (RO) desalination, advanced oxidation process with ultraviolet, granular activated carbon (GAC), and disinfection. Following treatment, the product water from the DPR pilot system would flow into a storage tank (engineered buffer) for water quality monitoring.

Downstream of the storage tank, the DPR product water would be re-combined with the DPR pilot RO concentrate in a blending tank and pumped to the Desalination Facility concentrate equalization (EQ) basin for disposal through the WWTF outfall. Figure 9 shows a general process schematic of the DPR pilot system.

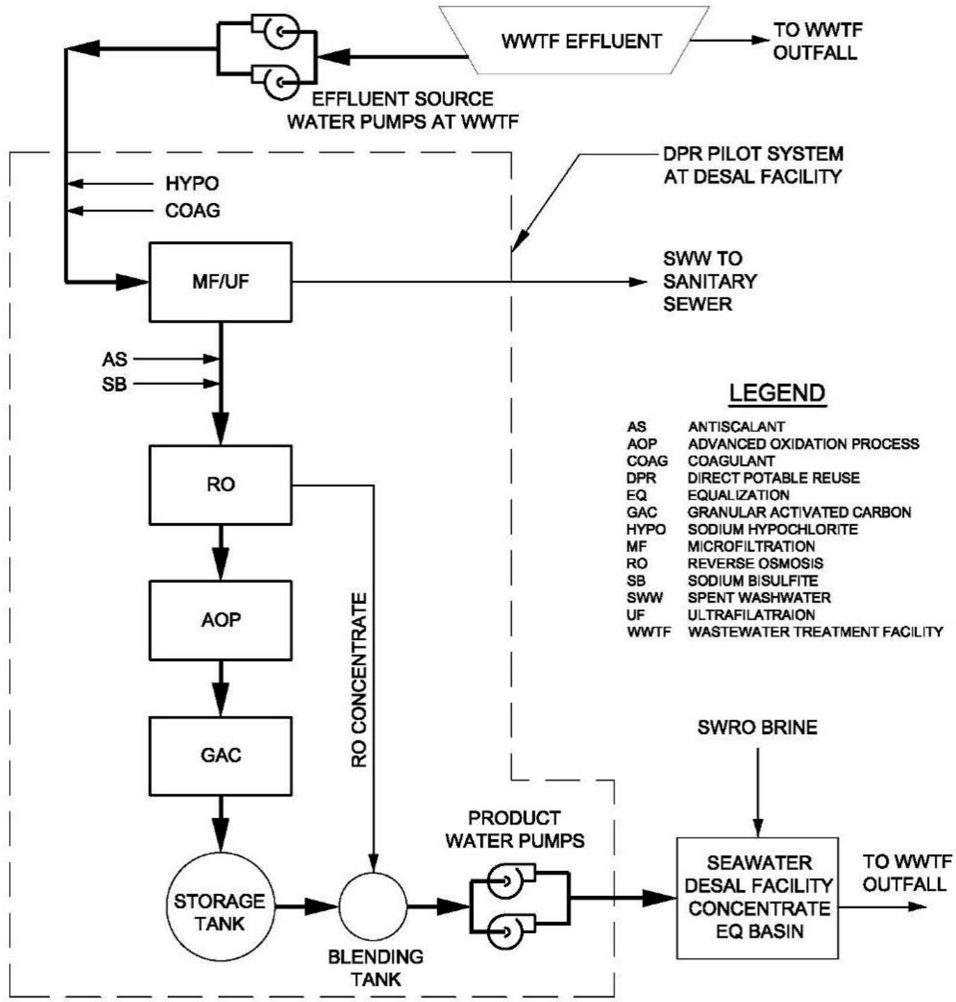


Figure 9: DPR Pilot Process Flow Schematic

As shown in Figure 10, a potential location for the DPR pilot equipment is in the area reserved for future SWRO membrane skids in the Desalination Facility Membrane Building. Figure 11 shows a potential layout for the equipment in this proposed location. The equipment would have a footprint of approximately 25-feet by 35-feet and would fit in this area. The DPR pilot system would be designed to process up to 20 gallons per minute (gpm) of secondary effluent. The DPR pilot system components are described in further detail in the subsections below and conceptual level design criteria for the DPR pilot system equipment are tabulated following the descriptions.

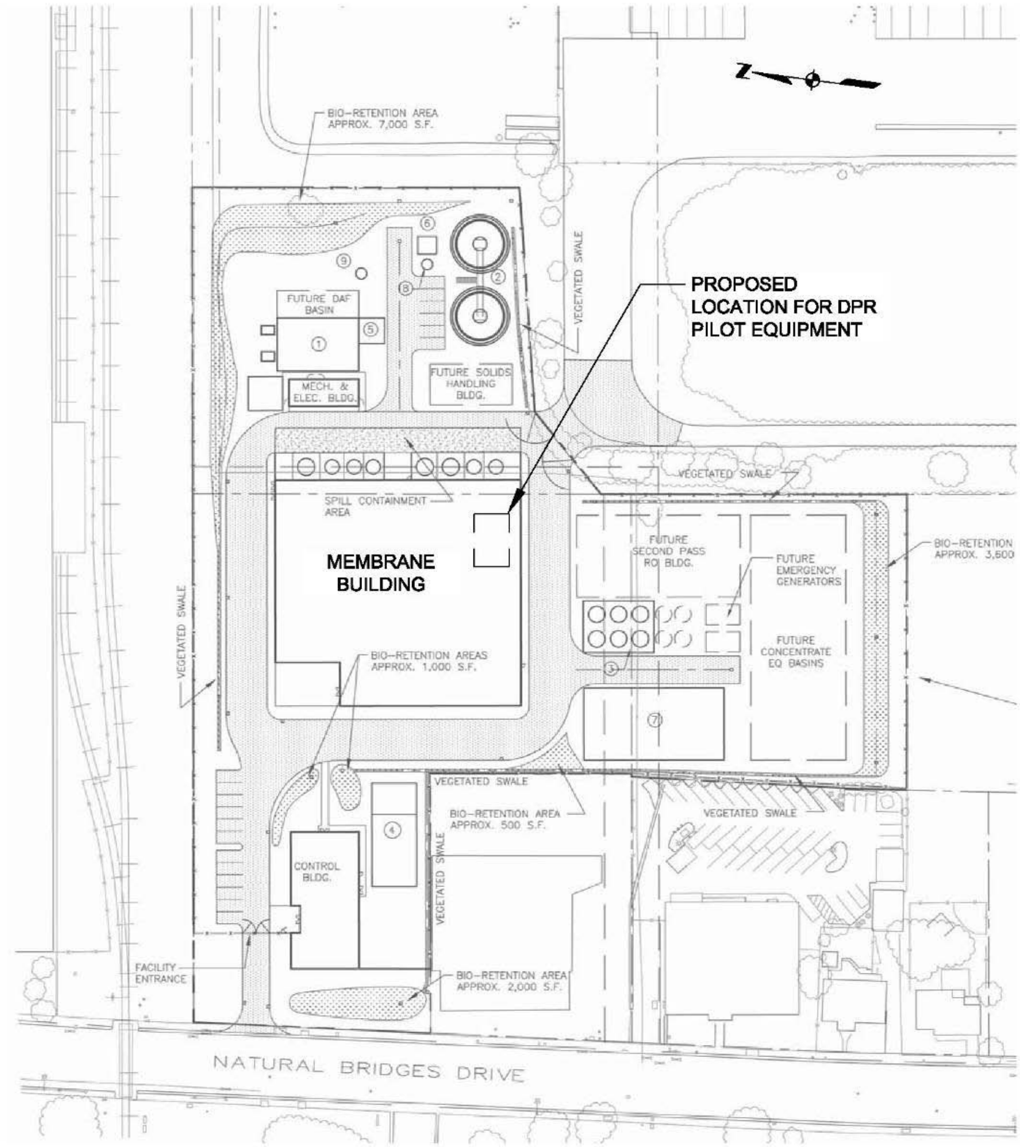


Figure 10: DPR Pilot Equipment Location

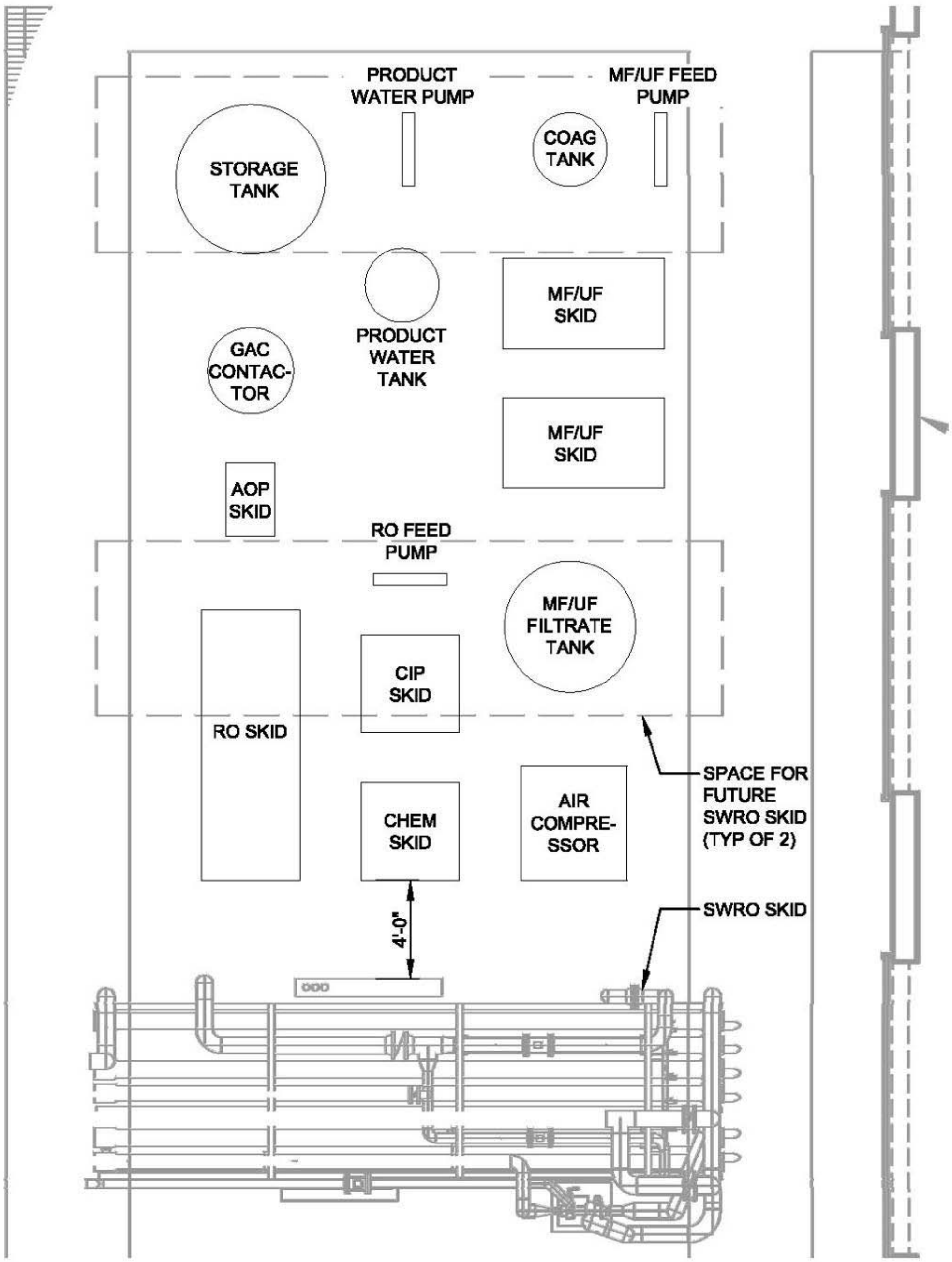


Figure 11: DPR Pilot Equipment Layout

3.7.2.1 DPR Pilot Source Water Feed System

Effluent from the City's WWTF could be pumped from the WWTF itself, or from a small pump station along the existing outfall pipeline alignment in Delaware Avenue, Oxford Way or West Cliff Drive. Regardless of its point of interception, up to approximately 10,500 feet of 4-inch diameter pipe would be used to convey up to 20 gpm of effluent to the DPR pilot system at the Desalination Facility. Depending on the location of the seawater intake pipeline, if dual seawater intake pipelines are constructed as part of the proposed **scwd**[2] Regional Desalination Project, one of the seawater intake pipelines could be used for pumping effluent for the pilot study. (Note that dual pipelines are being considered for system flexibility and redundancy and would not both be in use simultaneously. One pipeline could alternate functionality between seawater intake and effluent intake for the pilot study and could be converted to an effluent pipeline in the long term if DPR were to be approved.) Regardless of which approach is taken, the effluent transfer pipeline could be located within existing rights of way, and a pump station could be located either at the WWTF or in a small below grade vault.

3.7.2.2 Microfiltration (MF) or Ultrafiltration (UF) Pretreatment

After entering the Desalination Facility, the WWTF effluent would flow into a coagulant contact tank. Chemical injection points on the DPR pilot source water pipeline would be provided to permit addition of sodium hypochlorite and coagulant upstream of the coagulant contact tank. Sodium hypochlorite could be added for oxidation and to help control bio-fouling on the membranes. Coagulant would be added to destabilize and condition colloidal matter in the source water for removal by the membrane filters. The coagulant tank would provide approximately 10 minutes of contact time at a source water flow rate of 20 gpm. Two MF/UF feed pumps (lead and standby) would transfer coagulated source water from the coagulant contact tank to two MF/UF pretreatment skids.

Microfiltration pretreatment removes solids and microorganisms from the effluent using a membrane-based, pressure driven separation process. Either microfiltration or ultrafiltration (MF/UF) membranes can be used for this process. The MF/UF skid would be a pre-packaged, self-contained system that would include strainers, feed pumps, MF or UF membranes, a spent washwater capture system, a filtrate tank, and controls.

3.7.2.3 Reverse Osmosis (RO) Desalination

An MF/UF filtrate tank would be provided to capture filtrate from the MF/UF pretreatment skids. This tank would be sized to provide at least 45 minutes of retention time at a tank influent flow rate of 20 gpm, so that a continuous and constant flow of MF/UF filtrate can be delivered to the RO treatment process when the MF/UF pretreatment system is in cleaning mode.

Two chemical injections points would be provided to permit the addition of antiscalant and sodium bisulfite to the MF/UF filtrate upstream of the RO skid. Antiscalant would be added to inhibit scale formation that could foul the RO membranes. Sodium bisulfite could be added to dechlorinate the RO influent, if needed, as any free chlorine present in the RO influent would destroy the RO membranes. The chemical injection points would be located after the MF/UF filtrate tank. Two RO feed pumps (lead and standby) would transfer the MF/UF filtrate to the RO skid.

RO removes dissolved compounds, including total dissolved solids (TDS) and organic material, using a pressure-driven membrane separation process. Like the MF/UF skid, the RO skid would be a pre-packaged, self-contained unit that would include booster pumps, cartridge filters, RO membrane, and controls. The RO CIP system and chemical feed systems would be on separate skids.

3.7.2.4 Advanced Oxidation Process (AOP)

The RO permeate would flow from the RO skid directly into the AOP skid. The advanced oxidation process uses an oxidizing agent (hydrogen peroxide, H_2O_2) and ultraviolet (UV) radiation to form hydroxyl radical that would react with and destroy residual trace natural and synthetic organic compounds in the RO permeate. The AOP skid would consist of a UV reactor with chemical injection for hydrogen peroxide addition.

3.7.2.5 Granular Activated Carbon (GAC)

Following treatment through AOP, the water would flow into a granular activated carbon contactor. The GAC treatment process provides a final polishing step to adsorb any soluble organic and inorganic compounds, that is not removed or destroyed in the upstream processes. The GAC contactor would consist of a 3 to 3.5-feet diameter vessel with 3 to 4-feet depth of media to provide approximately 15 minutes of empty bed contact time at the product water flow rate.

3.7.2.6 Engineered Buffer Storage Tank

An “engineered buffer” system, such as a storage tank, would likely be required for a full-scale facility. The intent of an engineered buffer storage tank in a full-scale facility would be to permit monitoring of water quality at the inlet side of the storage tank, and to allow for redirection of the water leaving the storage tank, should an upset occur. This system would prevent poor water quality from entering the potable water system.

The DPR pilot product water from the GAC contactor would flow through a storage tank prior to disposal. The DPR pilot storage tank would be used to collect water quality samples, and demonstrate the effectiveness of buffer storage concept. The pilot storage tank would be sized for 1 to 2 hours of product water retention time at the product water flow rate. Sampling points would be provided to monitor the water quality at the inlet and outlet of the tank.

3.7.2.7 DPR Pilot Design Criteria

The conceptual design criteria for a DPR Pilot System is presented in Table 3 below.

Table 3: DPR Pilot Conceptual Design Criteria

PARAMETER	UNIT	DESIGN VALUE
DPR PILOT FLOW RATES		
Source Water	gpm	20
MF Product Water (Instanteous)	gpm	20
MF Product Water (Daily Average)	gpm	18
RO Product Water	gpm	13.5
RO Brine	gpm	4.5
EFFLUENT SOURCE WATER PUMP		
Number of Pumps	number	2
Design Capacity	gpm	20
Design Pressure	psi	25
Motor	HP	0.5

PARAMETER	UNIT	DESIGN VALUE
COAGULANT CONTACT TANK		
Number of Tanks	number	1
Operational Capacity	gallons	200
Hydraulic Retention Time	minutes	10
MF/UF FEED PUMP		
Number of Pumps	number	2
Design Capacity	gpm	20
Design Pressure	psi	10
Motor	HP	0.25
MF/UF PRETREATMENT SYSTEM		
Number of Skids	number	2
Capacity per Skid	gpm	20
Design Pressure	psi	25
Membrane Type	-	MF of UF
Membrane Material	-	PVDF
Instantaneous Flux	gfd	≤ 25
Recovery	%	90
Backwash Frequency	minutes	25 - 30
Spent Washwater Volume (per Day)	gallons	2,880
CIP Frequency	days	30 - 60
CIP Waste Volume (per Clean)	gallons	150
MF/UF FILTRATE TANK		
Number of Tanks	number	1
Operational Capacity	gallons	1000
Hydraulic Retention Time	minutes	50
RO FEED PUMP		
Number of Pumps	number	1
Design Capacity	gpm	18
Design Pressure	psi	10
Motor	HP	0.25
RO DESALINATION SYSTEM		
Number of Skids	number	1
Product Water Capacity per Skid	gpm	13.5
Design Pressure	psi	200.0
Membrane Material	-	TFC
Element Size	inches	4
Flux	gfd	12 - 15
Recovery	%	75
CIP Frequency	days	120
CIP Waste Volume (per Clean)	gallons	250

PARAMETER	UNIT	DESIGN VALUE
ADVANCED OXIDATION PROCESS		
Number of Units	number	1
Processes	-	Hydrogen Peroxide and UV
GAC CONTACTOR		
Number of Units	number	1
Diameter	ft	3
Media Depth	ft	4
Volume	cubic feet	28
Empty Bed Contact Time	min	15.7
STORAGE TANK (ENGINEERED BUFFER)		
Number of Tanks	number	1
Operational Capacity	gallons	1620
Hydraulic Retention Time	minutes	120
PRODUCT WATER/RO CONCENTRATE BLENDING TANK		
Number of Tanks	number	1
Operational Capacity	gallons	200
PRODUCT WATER PUMPS		
Number of Pumps	number	2
Design Capacity	gpm	18
Design Pressure	psi	10
Motor	HP	0.25
CHEMICALS		
Sodium Hypochlorite		
Dose	mg/L	2
Use	ppd	0.48
Coagulant		
Dose	mg/L	10
Use	ppd	2.40
Antiscalant		
Dose	mg/L	2
Use	ppd	0.43
Sodium Bisulfite		
Dose	mg/L	2
Use	ppd	0.43
MF/UF and RO CIP Chemicals	-	Sodium Hypochlorite, Caustic Soda, Citric Acid, Surfactant

3.7.3 DPR Pilot Operations

3.7.3.1 Labor

Operation of the DPR pilot system could be conducted by the Desalination Facility operations staff or by a temporary pilot plant operator. Typical duties that would be performed by the pilot operator include inspecting equipment operation, collecting water samples, completing operator logs (recording water quality data, operating data, conditions, and problems), and performing routine maintenance. Typical operation of the DPR pilot system is anticipated to require one full time operator.

3.7.3.2 Energy Requirements

The DPR pilot system daily energy use is estimated to be about 103 kWh. This is less than 0.5-percent of the seawater desalination system average projected electrical energy use of 22,560 kWh per day. The DPR pilot would not significantly increase the electrical use of the Desalination Facility, and the facility's electrical service would be able to accommodate the additional electrical loads from the DPR pilot system. Table 4 lists the estimated motor horsepower and daily energy use for components of the DPR pilot system.

Table 4: DPR Pilot Estimated Energy Use

Equipment	Motor Horsepower (hp)	Daily Energy Use (kWh)
Source Water Pump	0.5	8
MF/UF Feed Pump	0.25	3
MF/UF Skid	-	8
RO Feed Pump	0.75	10
RO Skid	20	60
Advanced Oxidation Unit	-	10
Product Water Pump	0.25	3
Total	**-**	**103**

A significant portion (about 60-percent) of the seawater desalination system energy use is for the operation of the high pressure RO pumps. A future DPR facility would use less energy compared to seawater desalination because the salinity of the wastewater effluent source water is significantly lower than that of seawater. Therefore, potentially transitioning the Desalination Facility into a DPR facility would reduce overall energy use and operating costs.

3.7.3.3 Noise

The DPR pilot system equipment is similar to the seawater desalination treatment process equipment. However, the DPR pilot system equipment would be much smaller in capacity and would generate less noise than the seawater desalination equipment. The Desalination Facility pumps in the membrane building have motor sizes that range between 50 and 600 HP. The largest DPR pilot system pump could have a motor that is approximately 20 HP. The DPR pilot system equipment would also be located indoors in the Desalination Facility Membrane Building.

3.7.4 Product Water and Wastewater Disposal

The product water and wastewater generated by the DPR pilot system will require disposal. Spent washwater (SWW) from the DPR pilot MF/UF pretreatment process will be discharged into the existing sanitary sewer. Waste solution from the MF/UF and RO recovery cleans (CIP) will be neutralized and also disposed of into the existing sanitary sewer. The DPR pilot product water will be combined with DPR pilot RO concentrate and other waste streams (e.g. GAC SWW, drain water) in a blending tank. The contents of blending tank will be pumped to the Desalination Facility concentrate EQ basin for disposal through the WWTF outfall. Table 5 summarizes the daily volumes and method of disposal of each DPR pilot waste stream.

Table 5: Summary of DPR Pilot Waste Streams and Estimated Volumes

Waste Stream	Average Flow Rate (gpm)	Daily Volume (gallons)	Disposal
Product Water	13.5	19,440	WWTF Outfall
RO Concentrate	4.5	6,480	WWTF Outfall
MF/UF Spent Washwater	2	2,880	Sewer
MF/UF CIP Waste Solution	-	250[a]	Sewer
RO CIP Waste Solution	-	150[a]	Sewer

(a) CIP waste volumes are generated once a month or less frequently and are not daily volumes.

Section 4: Separate Seawater Desalination and Potable Reuse Facilities

The implementation of the **scwd²** Regional Seawater Desalination Project would not impede future implementation of a DPR recycled water treatment facility. As conditions and regulations change in the future, it could be advantageous to have both a seawater desalination facility providing potable water and a DPR facility providing potable water or a seawater barrier injection system.

The current approach for discharging the brine from the proposed Project is to use the existing outfall from the Santa Cruz WWTF. This approach provides a simple, cost-effective approach to discharge the brine. This approach also has the benefit that the brine is mixed with the effluent in the outfall pipeline to help reduce the salinity of the brine before it is discharged. The brine and effluent mixture are then mixed and diluted into the ocean through the existing outfall to meet the current discharge requirements for the Santa Cruz WWTF discharge permit.

With the implementation of a potential future recycled water project, a percentage of the existing treated wastewater treatment plant effluent would become the source water for the recycled water treatment facility. If this were to occur, the brine from proposed **scwd**² Regional Desalination Facility, and the brine from the potential future recycled water facility, would both still be discharged through the existing outfall. To enhance mixing of the higher salinity brine discharges into the ocean to meet local, state and federal regulations related to ocean discharges, the existing outfall would be modified to enhance the exiting velocity of the brine as it leaves the outfall to provide more rapid mixing and dilution into the ocean environment. For example, desalination facilities operating in Australia discharge brine directly into the ocean through outfalls with high velocity mixing nozzles. A number of long-term studies have been conducted on the Australian desalination facilities to demonstrate that this direct brine discharge approach is appropriate and minimizes environmental impacts.

The future brine discharge would require a new discharge permit and would be designed and operated to meet dispersion and discharge requirements with reduced effluent flows to pre-dilute the brine in the outfall.

Section 5: Summary

The City of Santa Cruz Water Department and the Soquel Creek Water District have identified the need to protect coastal aquifers from seawater intrusion, protect coastal stream habitats, provide an adequate and drought proof water supply, and do so in a way that ensures public health and safety. Both agencies have developed plans that include continued conservation, drought period water curtailment, and a supplemental water supply project as a means to diversify their water portfolios and meet their objectives. They have also jointly identified the **scwd^2** Regional Seawater Desalination Project as the preferred option to provide a new, drought-proof source of supply for both agencies.

Since partnering together as **scwd^2** in 2007, a thorough evaluation and environmental review has been conducted for the proposed project and a draft Environmental Impact Report (dEIR) for the **scwd^2** Regional Seawater Desalination Project is underway. The California Environmental Quality Act (CEQA) sets forth the requirements for the environmental review process and it requires that EIR's evaluate potential alternatives to the proposed project. With many water agencies in California pursuing and implementing various types of potable reuse projects, the feasibility of these possible alternatives are being considered in the ongoing project dEIR.

While building on a previous white paper[1] prepared by Kennedy/Jenks Consultants, this white paper, *Current and Potential Future Opportunities for Indirect and Direct Potable Reuse:* summarizes the current regulatory status and ongoing regulatory developments for indirect and direct potable reuse; 2) comments on the feasibility of various potable reuse options that could potentially provide a of supplemental potable water supply and; 3) describes a potential DPR pilot study within the proposed **scwd^2** Regional Seawater Desalination Project that could provide research and an opportunity to further develop uniform water recycling criteria for DPR.

Major findings of this white paper include:

- Indirect potable reuse (IPR) regulations are in the process of being revised, and the California Department of Public Health (CDPH) is anticipated to adopt uniform water recycling criteria for IPR groundwater replenishment by December 31, 2013. In general, the revised regulations will provide greater flexibility on a case-by-case basis. In the interim, the CDPH is working with agencies to plan and implement both IPR groundwater and reservoir augmentation projects in California on a case-by-case basis.

- There are numerous challenges to establishing an IPR groundwater recharge program for the City and District. Groundwater recharge as a supplemental water supply is limited due to lack of blending water, geologic and groundwater basin constraints, and regulatory and operational constraints. Injection of recycled water as a seawater intrusion barrier could be technically viable, but would not provide a supplemental supply of water since the water is injected at the coastline and mostly moves seaward to prevent seawater moving inland.

[1] Recycled Water White Paper - Opportunities and Limitations for Recycled Water Use (Kennedy/Jenks 2010)

- An IPR reservoir augmentation project is technically achievable but is not viable due to the limited capacity of Loch Lomond Reservoir and inability to meet anticipated CDPH IPR regulatory restrictions for residence time and blending in the reservoir.

- Direct potable reuse (DPR) is not currently permitted in California. CDPH is investigating the feasibility of developing uniform water recycling criteria for DPR and will provide a final report on that investigation to the Legislature by December 31, 2016. While there are no current regulations specifying criteria for recycled water discharge into the source water supply upstream of a water treatment plant, the CDPH may be willing to work with agencies to explore DPR source water augmentation projects on a case-by-case basis.

- A DPR source water augmentation project would provide a supplemental water supply for the City and District by introducing recycled water into the source water supply. However, a DPR project is not considered viable in the next decade or more, given that DPR projects currently are not permitted in California, the CDPH has not evaluated or conditionally approved any DPR projects, conditional approval, demonstration testing and implementation would likely take a decade or more, and DPR faces significant public perception challenges.

- In the coming decades, should regulations change in the future and allow for DPR, the proposed **scwd**^{2} Regional Desalination Facility could potentially be transitioned to a DPR facility. Conversion of a seawater desalination plant to a DPR plant would lower the overall energy use of the facility, reduce or eliminate the withdrawal of seawater from the ocean, and reduce the concentration of the brine discharge.

- A DPR Pilot Study could be constructed and operated as part of the proposed **scwd**^{2} Regional Desalination Facility to provide CDPH with information to assist in their development of DPR regulatory criteria, and to demonstrate the ability of the treatment process to produce safe drinking water.

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