Appendix H: Selected Water Reuse Case Studies

NATIONAL WATER REUSE
ACTION PLAN
DRAFT

Appendix H: Compilation of Water Reuse Case Studies

Several compendia of case studies have been published in recent years, including the 2017 Potable ReuseCompendium and 2012GuidelinesforWaterReuse. Appendix H of the draft Action Plan is not a comprehensive compilation, but includes a select number of water reuse case study summaries that were provided in response to outreach during draft Action Plan development and from the public docket. Along with the abbreviated summaries located in the main body of the draft Action Plan, these examples illustrate the variety and complexity of water reuse projects happening around the United States.

This Appendix demonstrates how information provided from interested stakeholders was integrated in the draft Action Plan. It highlights specific water reuse applications, intended to spark interest and ideas, forming the foundation for implementation of future water reuse projects. The table below identifies the case studies presented in this Appendix and their source. The summaries below are as provided by the responsible organization and unedited for inclusion in this report. They are presented in no particular order.

Disclaimer

The case studies included within this Appendix are included for illustrative purposes only and are not intended to be exhaustive. Each case study is unique and site-specific, and technology may not be as effective as demonstrated. Inclusion in this Appendix does not imply that the draft Action Plan endorses, approves, or supports these actions in this or any other location.

Title	Source
1. Pure Water Monterey	Monterey One Water
2. City of Roseville	City of Roseville
3. City of Altamonte Springs, FL	EPA Region 4
4. Emory University	EPA Region 4
5. Indiantown Cogeneration Facility	EPA Region 4
6. Water Conserv II	EPA Region 4
7. Wichita Falls, Texas	Docket EPA-HQ-OW-2019-0174-0010
8. El Paso, Texas	Docket EPA-HQ-OW-2019-0174-0010
9. San Diego Pure Water	Docket EPA-HQ-OW-2019-0174-0010
10. Silicon Valley Advanced Water Purification Center	Docket EPA-HQ-OW-2019-0174-0010
11. Orange County Water District Groundwater Replenishment	Docket EPA-HQ-OW-2019-0174-0010
12. Sanitation Districts of Los Angeles County Recycled Water Information	Docket EPA-HQ-OW-2019-0174-0033
13. Sanitation Districts of Los Angeles County Stormwater Services Program	Docket EPA-HQ-OW-2019-0174-0033
14. California's Reuse of Produced Water for Human Consumption Crops	EPA Region 8
15. Denver Water	Denver Water
16. Water Reuse for Golf Course and Green Areas Irrigation at Palmas del Mar Resort and Residential Development, Puerto Rico	EPA Region 2

Pure Water Monterey
A Groundwater Replenishment Project

PURE WATER MONTEREY

Safe • Local • Sustainable

The Monterey Peninsula is situated along California's picturesque Central Coast. With the longest coastline of any California county, the area's mild climate attracts more than 9 million visitors annually and is home to diverse agriculture fields that generate $4.4 billion for the county's economy.

As a region isolated from state or federal water projects, the area must rely solely on its limited, local water resources. For Monterey Peninsula residents and businesses, water has historically come from two sources: 1) a local river (Carmel River) and 2) the ground (Seaside Groundwater Basin). Due to state and court-ordered reductions, these supplies are about to become very limited. To help address this challenge, Monterey One Water and its partners have come together to create a new, drought-resistant, and independent water supply: Pure Water Monterey (PWM).

Using a proven, advanced, multi-stage treatment process, Pure Water Monterey will turn used water into a safe, reliable, and sustainable water supply that complies with or exceeds strict state and federal drinking water standards. The purified water will then be used for groundwater replenishment.

3,500 ACRE FEET / YEAR
of Advanced Purified Recycled Water
produced for injection into the Seaside Groundwater Basin

~22% of the Monterey Peninsula's
water supply will be provided by Pure Water Monterey

1,000 ACRE FEET
potable water drought reserve **to increase availability of recycled water for ag use during dry years**

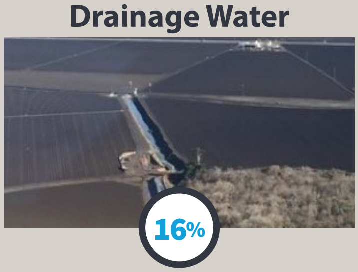
New Source Waters
will help increase tertiary treated recycled water for agricultural irrigation up to
4,400 ACRE FEET / YEAR

WHERE DOES THE USED WATER COME FROM?

For decades, Monterey One Water has helped diversify the local water supply through recycled water production for agriculture – helping irrigate 12,000 acres of freshly-edible food crops and prevent seawater intrusion. To address both the non-potable and potable water demands, PWM has identified additional used water sources to bring into its existing wastewater treatment system, including:

Secondary Treated Wastewater

Agriculture Drainage Water



Agriculture Wash Water

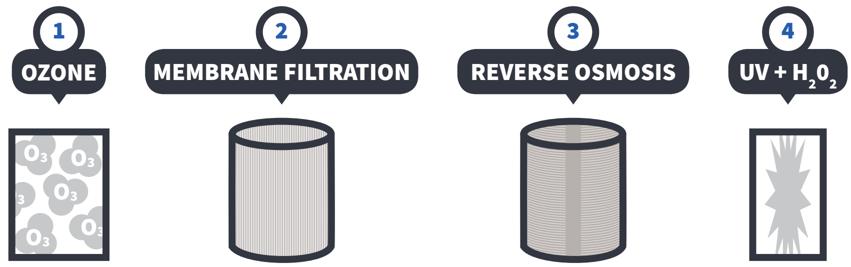
Urban Storm Water Runoff

Pure Water Monterey

A Groundwater Replenishment Project

ADVANCED PURIFICATION TECHNOLOGY

Indirect potable reuse occurs in many communities in the Southwest United States and around the world. Protecting public health and safety is paramount, and PWM utilizes a four-step advanced purification treatment process to meet or exceed all state and federal drinking water regulations.



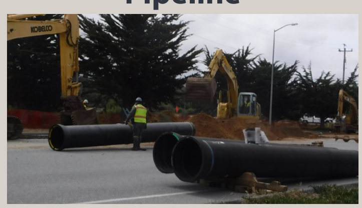
PROJECT COMPONENTS

PWM has four distinct project components. Overall project construction is nearing completion with water delivery to the Seaside Groundwater Basin expected to occur in late summer / early fall of 2019.

Source Waters

Advanced Water Purification Facility

Conveyance Pipeline



Basin Injection Wells

COOPERATIVE SOLUTIONS

PWM is a multi-benefit, regional project. In addition to creating a new drinking water source for the Monterey Peninsula, the Project also:

+ Increases available water for ag irrigation
+ Removes impaired waterways (ag drainage water) from the environment
+ Restores river habitats by reducing extraction from the Carmel River and decreasing pollutants flowing to the Salinas River

These regional benefits have created a network of project partners helping make PWM possible!

Monterey One Water

Monterey Peninsula Water Management District

Marina Coast Water District

Monterey County California 1850

Salinas

Seaside California

FORA Fort Ord Reuse Authority

Monterey County Water Resources Agency 1947

Best Solid Waste System in North America MRWMD

Water Reuse Case Study

City of Roseville

Sector: Municipal Utility

Subsector: Wastewater utility

Location: Roseville, CA

Water Source(s): Muncipal wastewater

Water Use(s): Irrigation, industrial, and future groundwater augmentation

Technology: Tertiary wastewater treatment and future advanced treatment

Water Recovered: 4 MGD annual average

Project Costs: $25 million for advanced treatment

Implementation Date: 2020

EPA-816-F-XXX September 2019

Overview and Drivers

Roseville is an inland Northern California community of approximately 140,000 residents and has been recycling tertiary CA Title 22 water for nearly 20 years. Roseville's primary source of drinking water is a federally operated surface water reservoir designed and used primarily for flood control. Presently 20% of all wastewater treated, about 1 billion gallons per year, is recycled for irrigation and industrial needs. Roseville's traditional surface water supply is challenged by significant past and projected population growth as well as environmental demands, climate change and periodic drought. Increasing water recycling is among the strategies Roseville plans to meet this water supply challenge. However all economically viable recycled water needs are being met presently through a traditional purple pipe distribution system. In order to improve recycled water utilization, significant changes to the recycled water program are needed.

Roseville has successfully employed aquifer storage of potable surface water which provides storage and groundwater management capability when surface water is plentiful to ensure that groundwater is always a viable backup water supply. A similar strategy is envisioned for recycled water.

Process or Technology

To utilize its groundwater aquifer for seasonal storage of recycled water and improve distribution options to new areas of the City, Roseville must employ advanced treatment to create indirect potable reuse opportunities. CA presently requires that reverse osmosis (RO) be part of any advanced treatment process unless an alternative is shown to provide equivalent water quality. As an inland community without access to an ocean discharge, the brine waste generated by RO cannot be disposed of economically thereby eliminating RO as a treatment option for Roseville.

To meet this challenge, Roseville will pilot alternative advanced treatment that incorporates ozone biologically active filtration (BAF), in addition to other processes needed to meet water quality based criteria. Benefits of including ozone-BAF in the treatment train include lower energy requirements, no brine disposal and improved removal of certain CECs.

Once treatment is proven, a system of injection and recovery groundwater wells can be utilized to store and recover advanced treated water in nearly all areas of the City.

Outcomes and Benefits

The ultimate goal of this effort is to fully utilize all available recycled water to maximize the City's water supply reliability and ensure the groundwater aquifer remains a healthy backup to the City's strained surface water supplies. By maximizing storage opportunities, Roseville believes that water shortages can be eliminated through management strategies even when drought conditions exist. Through increased Roseville reuse, more surface water remains to meet environmental and human water supply needs elsewhere. Proving an alternative advanced treatment option also allows other inland CA communities to benefit from increased water management options.

Challenges and Solutions

The key challenge for Roseville is to dramatically increase recycled water storage and use options. Roseville understands that the proposed alternative treatment train does not conform to current CA regulations for indirect potable reuse via groundwater replenishment. The first challenge is to demonstrate that an alternative treatment technology can deliver the same water quality as the presently accepted FAT process.

With advanced treatment and storage, a network of groundwater injection wells would allow advanced treated water to be stored in the aquifer when supply exceeds demand. The aquifer can then be used to "distribute" stored recycled water to all areas of the City using recovery wells. This eliminates the need for a recycled water pipe distribution network, allows the City to provide "recycled water" to areas that are not presently served, and ensures that the aquifer's water is not depleted and remains available to backup surface water supply.

Acknowledgements

Kenneth Glotzbach, PE
City of Roseville, CA
kglotzbach@roseville.ca.us

Marisa Tricas, MS
City of Roseville, CA
mtricas@roseville.ca.us

Todd Jordan, PE
City of Roseville, CA
tjordan@roseville.ca.us

References

Water Environmental Reuse Foundation (WE&RF), 2017. Final Report: Controlling Trace Organic Contaminants Using Alternative, Non-FAT Technology for Indirect Potable Water Reuse.

WateReuse Research & National Water Research Institute, 2013. Examining the Criteria for Direct Potable Reuse.

City of Altamonte Springs-Florida, Project: *pureAlta*®

International and National Awards

Sector: Municipal

Subsector: Potable Pilot project

Location: Altamonte Springs, Seminole County, Florida

Water Source(s): Effluent from the City of Altamont Springs WRF

Water Use(s): Proposed Potable

Technology: Advanced treatment

Water Recovered: Currently able to treat up to 28,800 gpd, scale up to 500,000gpd.

Project Costs: pureAlta® is co-funded with the St. Johns River Water Management District (SJRWMD) under its REDI Community & Innovative Cost-Share program. SJRWMD is contributing 50 percent of the $1 million construction cost for the project. pureAlta® is one of two potable reuse projects to be funded under this program.

Implementation Date: on or about 1994

Overview and Drivers

City of Altamonte Springs proactively created pureAlta® to address their community's future water needs and diversify the City's water portfolio. The project utilizes cutting-edge technology to purify reclaimed water to drinking water standards. Due to population increases and dwindling Floridan aquifer levels, experts have long predicted the state will not have enough groundwater to satisfy the public's drinking water needs.

Process or Technology

The advanced treatment process includes the following components: ozonation and biological activated carbon filtration (O3/BAF), ultrafiltration (UF), granular activated carbon filtration (GAC) and ultraviolet light with advanced oxidation process (UV AOP) all coupled with advanced system monitoring techniques.

The source flow used for this process comes directly from the effluent train of the City of Altamont Springs WWTF/DPR, operating under NPDES permit # FL0033251. It is currently returned to the effluent discharge and released. This is only a pilot project.

Outcomes and Benefits

The resulting purified water is tested to ensure it meets drinking water standards and removes pharmaceuticals and personal care products (PPCPs) which are not currently regulated. The potable reuse pilot project will treat approximately 28,800 gallons per day (gpd), which is less than 1 percent of the total water currently produced in the City (6 MGD). If the pilot project is successful, they might build a full-scale treatment system with a capacity of 300,000 to 500,000 gpd (approximately 5 percent of the City's future water demand, 9 MGD) to provide a purified water supply that supplements the City's drinking water system.

The pilot project is operating in a testing phase. During this testing, the purified water is blended with reclaimed water from the Water Reclamation Facility and beneficially reused for irrigation in the City's existing urban reclaimed water system. In the future, based on the success of the pilot, the City might build a full-scale treatment system to produce purified water to supplement the City's drinking water system by up to five percent.

Challenges and Solutions

Funding and design; regulatory rules (WQ) criteria. Facility space came from repurposed storage building on-site. Component selection.

Acknowledgements

EPA Region 4 staff (Pamala Myers) completed this template and acknowledges the City of Altamonte Springs management and staff.

References

www.altamonte.org/754/pureALTA, EPA PQR draft-report 2018.

Emory University, Atlanta, GA Project: WaterHub, Hydroponic Reactor Design

Sector: Institution/Commercial collaboration

Subsector: Non-Potable

Location: Atlanta, GA. Campus of Emory University.

Water Source(s): Effluent from Emory

Water Use(s): Campus Chiller Plants, Steam Plant, Toilet Flushing

Technology: Hydroponic w/ Submerged Fixed-Film Reactors, Reciprocating Wetland

Water Recovered: The WaterHub has processed over 150 million gallons of water.

Project Costs:

Implementation Date: May 2015

Overview and Drivers

Emory stated: In the last decade, Atlanta has witnessed numerous water related stresses, including: severe drought, EPA mandates to resolve critical infrastructure failures and an extended political dispute over water rights in the so-called "Tri-State Water Wars." As a result of these challenges, Emory University set out to explore ways to minimize its impact on community water resources and the environment with a more strategic and impactful water management solution: campus wide water reclamation and reuse.

Process or Technology

Sustainable Water designed Emory's reclamation system, the WaterHub, to integrate into the existing campus framework using two small parcels near Chappell Park Field. Up to 400,000 gallons of wastewater is mined directly out of the campus sewer system daily. Water is cleaned to Georgia Reclaimed Water Standards through an energy efficient, eco-engineered treatment process supported by solar (PV) energy production. The system has 50,000 gallons of clean water storage capacity, providing N+1 redundancy for campus district energy systems. Recycled water is distributed to multiple utility plants and select dormitories for toilet flushing via a 4,400 linear foot "purple pipe" distribution system. The system reduces Emory University's draw of potable water by up to 146 million gallons annually.

Outcomes and Benefits

The first system of its kind installed in the United States, the WaterHub® is a decentralized, commercial-scale water reclamation and reuse system serving Emory University's main campus just outside of Atlanta, GA. Producing up to 400,000 gallons of reclaimed water per day, the WaterHub mines wastewater directly from the campus sewer system and utilizes ecological treatment processes to treat the wastewater for beneficial reuse. The system recycles up to two-thirds of campus wastewater for non-potable demands including heating, cooling and toilet flushing. Moving the field of water reclamation forward, the WaterHub serves as a model for commercial-scale sustainable water management in urban areas.

The WaterHub enables the University to reduce its draw of potable water by up to 146 million gallons annually – displacing nearly 40% of total campus water demand. The system enhances campus resiliency by providing a consistent, reliable and redundant source of water for extensive non-potable demands and critical heating and air conditioning needs. The WaterHub is designed to de-risk campus operations from potential water service disruptions resulting from drought and aging municipal water infrastructure.

The WaterHub was made possible through an innovative Water Processing Agreement (WPA). The WPA allowed Sustainable Water to fully design, construct and operate the WaterHub at no capital expense or development risk to the University. The WaterHub creates lower cost water at a long-term stable rate and is expected to save millions of dollars in water utility costs to Emory over a 20-year period. The WaterHub aligns with the University's vision for a sustainable campus and reduces the overall water demand on one of the smallest municipal watersheds in the United States.

Challenges and Solutions

The WaterHub reduces Emory University's draw of potable water by up to 146 million gallons annually. WaterHub is designed to promote research and community outreach, enhancing the concept of the campus as a "living laboratory." With built-in lab space and easy access ports for water quality testing, the facility enables research in a variety of topics. The lower site also includes a demonstration reciprocating wetland system (ReCip®) as a showcase to visitors interested in other sustainable treatment technologies. The WaterHub at Emory University has earned 14 awards and has been featured in numerous publications such as **District Energy, Industrial WaterWorld, Sustainable Business Magazine, Georgia Operator, Treatment Plant Operator** and **CE News.**

Acknowledgements

EPA Region 4 staff (Pamala Myers) completed the template with information from The WaterHub @ Emory

References

http://sustainablewater.com/sw-overview/the-waterhub-at-emory/ http://sustainablewater.com/resources/frequently-asked-questions/

Water Reuse Case Study
Example Prototype Only

Indiantown Cogeneration Facility

Sector: Industrial

Subsector: Thermoelectric

Location: Indiantown, Florida
Water Source(s): Surface water, saline groundwater, and treated municipal water.
Water Use(s): Reuse within facility. Better water quality discharge.
Technology: Zero liquid discharge with use of microfiltration and reverse osmosis.
Water Recovered: Not available
Project Costs: not available
Implementation Date: 2012

Overview and Drivers

The Indiantown facility was using a zero-liquid discharge (ZLD) system using two brine concentrators to process the cooling tower blowdown water. These concentrators were expensive to maintain, used a load 1.4 Mega Watt Hour (MWH) electricity, and produced a high-volume waste water stream. Due to expensive maintenance, the facility decided to replace the concentrators with ZLD system consisting of Microfiltration (MF) and Reverse Osmosis (RO). The new ZLD system is less expensive to maintain and has lower wastewater discharges which returned a higher volume of filtered water back into the facility.

Process or Technology

In a typical application of MF, the incoming water passes through several thousand spaghetti-like hollow fiber polymeric membranes that remove suspended solids and bacteria. For removal of dissolved solids, the treated water from the MF unit passes through the spiral-wound RO membranes. This technology is employed before the demineralizers. The pores in the RO membrane are only a few angstroms in size and can remove a majority of the dissolved salts.

The brine concentrators were replaced by MF/RO systems in the ZLD system achieving higher quantities of filtered water.

Outcomes and Benefits

A typical cooling tower (500 ton, running 24 hours day,365 days per year) will flush over 3.9 Million gallons of water each year. Through use of ZLD systems, electric generation facilities can reuse a bulk of this wastewater stream. The new ZLD system used by the Indiantown facility helped increase the filtered water volumes, reduced maintenance cost for the facility and saved on 1.4 MWH electricity used in the old system. The new system was more effective in using briny groundwater from aquifers which are not sources of drinking water reducing reliance on fresh stream water.

Challenges and Solutions

The system encountered problems with microbiological fouling and scaling in second stage RO. These were resolved by introducing microbicide and lowering the pH of water to 5.

Acknowledgements

EPA Region 4 staff (Khurram Rafi) completed the template based on information from the following web references below.

References

https://www.waterworld.com/municipal/technologies/article/16211541/zld-treatment-of-cooling-tower-blowdown-with-membranes

Water Reuse Case Study

Water Conserv II

Sector: Agriculture and And Irrigation, Groundwater Recharge

Location: City of Orlando/Orange County, Florida
Water Source(s): Highly treated wastewater
Water Use(s): Agricultural, irrigation, & groundwater recharge
Technology: 35 MGD water reclaimed, pumped, stored for irrigation and aquifer recharge through rapid infiltration basins.
Water Recovered: >200 billion gallons of water over 30 years
Project Costs: $180 million[6]
Implementation Date: 1986

Overview and Drivers

The Water Conserv II project…"was started in 1986 to stop discharge of treated wastewater from Orlando and Orange County into Lake Tohopekaliga, an important recreational bass fishing lake." (1)

"Faced with a need to expand wastewater treatment service and a state requirement to eliminate discharge to surface waters, the City of Orlando and Orange County formed a long-term partnership to develop an innovative water reclamation program. Following a lengthy and detailed review of potential projects, a combination of the two most promising was chosen and Water Conserv II was born. The project is best described as "A Cooperative Water Reuse Project by the City of Orlando, Orange County and the Agricultural Community"." (2)

"Water Conserv II is the largest reuse project of its kind in the world, combining agricultural irrigation with aquifer recharge via rapid infiltration basins (RIBs). The primary focus is agricultural irrigation. The RIBs are used for recharge of Florida's primary drinking water source, the Floridan aquifer, with daily flows that are not needed for irrigation and excess flows during wet weather periods. Water Conserv II is also the first reuse project in Florida permitted by the Florida Department of Environmental Protection (FDEP) to irrigate crops produced for human consumption with reclaimed water. The project's reclaimed water meets FDEP's public access reuse standards and is permitted for use on all public access sites including residences and golf courses, food crops, foliage and landscape nurseries, tree farms, pasture land, the production of soil cement, and can also be used for fire protection." (2)

Process or Technology

"Reclaimed water is pumped from the City's McLeod Road and the County's South Regional Water Reclamation Facilities through a 54-inch diameter transmission main approximately 21.5 miles to the Water Conserv Distribution Center in western Orange County. The water is temporarily stored in four 5-million-gallon prestressed concrete flow-equalization reservoirs and then distributed [for irrigation and] to the RIBs through a network of distribution pipes…The entire process is monitored and carefully controlled by computers housed at the distribution center." (3)

The Water Conserv II Distribution Center spans "…approximately 65 square miles, serves over 3,250 acres [including 2,700 acres of citrus groves], seven nurseries, two ferneries, three golf courses, a sand mine, two landfills, several residential communities, and eight rapid infiltration basin (RIB) sites that help replenish the regional drinking water aquifer." (4)

"…[T]he system consists of 63 RIBs, each made up of one to five cells, for a total of 129 individual cells measuring approximately 350 feet long by 150 feet wide. The facility is built over a natural sand ridge ranging in thickness from 30 to 200 feet. Beneath these surficial sands is a dense concentration of semipermeable clays known as the Hawthorn formation…[which] acts as a barrier separating shallow groundwater flow…from deeper, confined flow in the Floridian aquifer…" (3)

As of 2017, irrigation and commercial use customers use 60% of the reclaimed water, and the remain 40% in excess of customer needs are used to recharge the Floridian aquifer. (5)

Outcomes and Benefits

Benefits realized by Water Conserv II have included: elimination of discharge to surface water; turned a liability into an asset for beneficial use; proven, beneficial and cost effective year-round reclaimed water reuse; reduces the demand on the Floridan aquifer by eliminating the need for well water for irrigation; helps to replenish the Floridian aquifer through the discharge of reclaimed water to the Rapid Infiltration Basins (RIBs). (5) Established a preserve within the RIB sites for endangered, threatened and concerned species of plants and animals. (5) Benefits realized by the participating citrus grove owners: A dependable long-term source of irrigation; water that is not subject to water restrictions during droughts; elimination of installation, operation and maintenance costs for deep well or surface water pumping systems; increased crop yields; better tree growth; enhanced freeze protection capabilities; detailed research at the Mid Florida Citrus Foundation. (5)

Challenges and Solutions

"When city and county officials approached growers with the proposal of providing free Reclaimed W that could be used to irrigate their citrus groves, the growers initially rejected the idea. Even though the city and county would provide the water free and nearly eliminate pumping costs, growers were wary of this "unknown" water. There were concerns about heavy metals, salinity, disease organisms, or flooding from excessive water (Parsons et al. 2001a). After much negotiation, nearly all of the grower demands were satisfied. Dr. Robert Koo of the University of Florida established water quality standards that met most drinking water standards. Parsons et al. (1981) had recently demonstrated that microsprinkler irrigation could provide some frost protection, and the RW would provide additional water on freeze nights. The frost protection advantage convinced some growers to start using the water, and eventually, other growers accepted the water. Because there have been no major problems and the treatment facilities have consistently met water quality standards, most growers in the area now understand that this is a good quality resource for year-round use." (1)

Acknowledgements

EPA Region 4 staff (Catherine York) completed the template based on information provided at the Water Conserv II website in addition to various references cited below. The Water Conserv II Project Manager is Scott Ruland (407-656-2332 ex.228, scott.ruland@waterconservii.com), additional information can be found at http://www.waterconservii.com/contact-water-conserv-ii/

References

(1) Parsons, L.R. December 2018. Agricultural Use of Reclaimed Water in Florida: Food for Thought. Journal of Contemporary Water Research & Education 165: 20-27. Also available at: https://onlinelibrary.wiley.com/doi/full/10.1111/j.1936-704X.2018.03290.x
(2) Water Conserv II. 2019. History. Available at: http://www.waterconservii.com/. Accessed May 15, 2019.
(3) Water Conserv II. 2019. Anatomy of a RIB. Available at: http://www.waterconservii.com/wp-content/themes/divi-child/dls/rib_anatomy0417.pdf. Accessed May 15, 2019.
(4) WSP. 2019. Water Conserv II. Available at: https://www.wsp.com/en-US/projects/water-conserv-ii. Accessed May 15, 2019.
(5) Water Conserv II. 2017. Water Conserv II Tour Materials. Available at: http://www.waterconservii.com/wp-content/themes/divi-child/dls/Tour_Pack.pdf. Accessed May 15, 2019.
(6) Florida Department of Environmental Protection. December 8, 2016. DEP Celebrates 30 Years of Cooperative Water Reuse with Water Conserv II. Available at: https://content.govdelivery.com/accounts/FLDEP/bulletins/177e1b4. Accessed May 15, 2019.

Recycled water for drinking: Direct potable reuse a temporary solution for Wichita Falls, Texas

In July 2014, the city of Wichita Falls, Texas, became one of the first in the United States to use treated wastewater directly in its drinking water supply. The scheme is a temporary solution to the city's drought-induced water crisis.

The drivers

Two lakes (Lake Chickapoo and Lake Arrowhead) have traditionally provided the water supply for Wichita Falls. No groundwater or other water sources are available within about 130 kilometres.
In the late 1990s, the city experienced a severe multi-year drought, driving the decision to add a reverse osmosis plant to the existing Cypress Water Treatment Facility to treat the brackish water from a third lake—Lake Kemp. The plant was completed in 2008.

Again in 2010, the area experienced severe drought which, coupled with extreme temperatures of over 38 °C (100 °F) for more than 100 days at a time, caused reservoir water levels to drop. In November of 2013, the water shortage escalated to a state of emergency and the city entered a stage-4 drought disaster (on a scale of 1-lowest to 5-highest), lowering production to about 65 million litres per day.

Evaluating the crisis, the city recognised that it was conveying 26 million litres of wastewater a day from its wastewater treatment plant to other cities downstream and that this treated wastewater could instead be further treated locally at the existing Cypress Water Treatment Plant and used to augment the public drinking water supply.

The scheme at a glance

- Treated wastewater is disinfected and pumped to the Cypress Water Treatment Plant where it goes through microfiltration and reverse osmosis before being released into a holding lagoon where it is blended with lake water (50:50). The blended water goes through an eight-step conventional surface water treatment process. The treated water is stored and then pumped to the distribution system.

- The scheme provides 19 million litres a day, satisfying one-third of the city's daily demand. Wichita Falls has a population of about 160,000.

- The scheme is considered a temporary drought response and will be replaced by a $US35 million permanent indirect potable reuse scheme whereby high quality effluent will be stored in Lake Arrowhead. The permanent scheme will recycle 45 to 60 million litres a day and will take three to five years to complete.

The path taken

Investigation

The City of Wichita Falls responded to the drought in 1999 by building a microfiltration/reverse osmosis plant. The plant, completed in 2008, enabled them to bring a third lake online as a water source, providing an additional 38 million litres of water per day.

During the most recent drought, which started in October 2010, the city evaluated 22 strategies, looking at quality, reliability and cost, before deciding in April 2012 to pursue both direct and indirect potable reuse schemes.

Pilot

In lieu of a pilot for the direct potable reuse scheme, the Texas Commission on Environmental Quality (TCEQ) allowed the city to conduct a 45-day verification trial, discharging the treated water to the river. The city already had a discharge permit for their reverse osmosis treatment plant at Lake Kemp, which speeded up the process. Installation was completed in late December 2013 and was followed by the 45 days of extensive quality testing by the city and the TCEQ. The TCEQ then requested an additional 30 days of tests, analysing the results and meeting with city staff to discuss the findings.

Approval for full-scale implementation

The TCEQ approved a permit for the scheme on 28 June 2014.

Construction

The only construction required was a 21-kilometre pipeline connecting the wastewater plant to the existing Cypress Water Treatment Plant where the water is purified for drinking.

Commissioning

The US$13 million scheme was launched on 9 July 2014.

Engaging the community

Engaging decision-makers, regulators and politicians

Leaders at the city's Public Works Department said that having the support of the City Manager and the City Council from the beginning of the scheme proposal was crucial to moving the project forward quickly.

Engaging customers

A public information officer and his staff were hired to create an aggressive public education campaign to inform customers about their water supply situation. Their work included developing city water reports and educating residents on water-related issues through a frequent newsletter.

An extensive speaking campaign targeted at civic organisations was run, including appearances by the mayor and city manager. The public information team worked closely with media (TV and newspaper) and also had their own television channel. The city produced videos of local physicians and university professors for the channel and these were also published on YouTube and on the city website.

Many residents could visually see the water levels in their reservoirs fall and this helped them to understand the urgency for considering alternative water supplies.

Success factors

City and state government support

Policymakers at both city and state levels were very supportive during the process, particularly as it became apparent there was no supply alternative and no groundwater reserves to draw upon as lake levels were visibly falling.

High levels of trust in wastewater utility

For 40 years, the city had operated a state-of-the-art wastewater system with a pre-treatment program. This track record, and the wastewater utility's excellent regulatory history, helped make the scheme possible. At the beginning of the proposal the utility staff strongly advocated for a high level of treatment to ensure the public could be very confident in the safety of the scheme.

Extensive testing

Because this scheme was one of the first of its type in the US, permitting and regulating the new facilities presented challenges. The state government required extensive testing, some of which required new analytical methods to be developed.

Water quality not compromised

The wastewater is treated to a level that meets 97 percent of drinking water standards. It is then piped to the Cypress Water Treatment Plant, where it is purified using reverse osmosis to a quality that exceeds the current TCEQ drinking water standards.
The city created an extensive system of checks and balances to ensure quality, building a state-of-the-art control room where state operators monitor quality daily.

Sustained community support

The city's rate-payers approved an 8.5 percent rate increase for the initial funding of the scheme. They have shown their continuing support by approving an additional 10 percent rate increase to fund the proposed indirect potable reuse scheme.

Lessons learnt

- Hiring a public information officer to execute the speaking campaign helped gather concerns and get project information out to residents.
- The public needed to see the water levels drop in the city's reservoirs and know that all alternative water sources had been exhausted before they accepted the concept of drinking purified wastewater.
- Demonstrating to the public that the quality of advanced treated water was adequate for drinking water purposes was a challenge for the small staff at the City.
- Educating the public and policymakers on the cost difference of other options that may not produce water to the same high quality as potable reuse, or may produce less water, was difficult.
- Getting academics and medical professionals on-board at the start, and working with the media from the outset, helped develop credibility among the public and water users.
- Showing the need for the scheme and starting early with regulatory agencies reduced the approval timeline.

Recycled water for drinking:
The greater metropolitan area of El Paso, Texas

The greater metropolitan area of El Paso, Texas, is home to one of the first plants in the United States to treat wastewater to drinking water standards. El Paso Water Utilities (EPWU) has met the challenges that come with living in a desert city by diversifying its water supply. Water reuse is a very important part of the water portfolio. .

The drivers

El Paso is located in the Chihuahuan desert. The city gets its water supply from groundwater and from the Rio Grande. Water from the Rio Grande is only available during spring, summer and early autumn and is further limited in dry years. Extreme drought conditions over many years has shown a drying trend which has continuously reduced river flows, leaving less water available for the city.

The scheme at a glance

- El Paso Water Utilities Department (EPWU) controls the water systems that supply nearly 90 percent of all municipal water to more than 800,000 residents of El Paso County.

- EPWU uses groundwater and surface water for its potable supply, producing about 34 billion gallons a year of potable water for its customers.

- EPWU operates an Indirect Potable Reuse (IPR) facility at the Fred Hervey Water Reclamation Plant and recently expanded the plant. This plant treats wastewater to drinking water standards. The treated water is then injected into the Hueco Bolson (an aquifer) through a series of wells and infiltration basins to replenish the aquifer.

- The Fred Hervey Water Reclamation plant serves as a model and centre of learning for other inland cities facing diminishing supplies of fresh water.

- Through an agreement with the El Paso County Irrigation District, EPWU treats wastewater at other facilities and discharges it into the Rio Grande. EPWU plans to send some of the treated water directly to a proposed Advanced Water Purification Facility rather than downstream for other users. The facility will turn the treated water into drinking water and put it directly into the distribution system. Purified water will be a new source of drinking water to augment the water supply.

The path taken

Investigation

EPWU was one of the first departments in the U.S. to recognise the need to diversify its water resources and reduce its reliance on groundwater. In 1991, it completed a 50 year Water Resource Management Plan (1991-2040).

EPWU has been working with the Texas Commission on Environmental Quality (TCEQ) on its plans for the Advanced Water Purification Facility for the past year. A possible site has been selected near the Roberto Bustamante Wastewater Treatment Plant. There is sufficient effluent at this facility and there is a demand for resources in this area of the city.

Pilot

TCEQ has given EPWU the go ahead to build a pilot plant for the Advanced Water Purification Facility. The pilot plant is being constructed and expected to be complete in July of 2015. EPWU will test the plant for 6-9 months before sending results to the TCEQ.

Approval for full-scale implementation

EPWU will need final approval from TCEQ to build the full scale facility. The facility is expected to go on-line in 2018.

Engaging the community

Engaging decision makers, regulators and politicians

In 1952, the El Paso City Council established a Public Service Board, a seven-member board of trustees that manages and controls EPWU and its systems. Members are appointed by the El Paso City Council and have expertise in financial management; general business management; engineering; environmental or public health; consumer/citizen advocacy; and communications, public administration and education. The seventh member is the mayor, who represents municipal government. The board reports to city and county government on water-related activities and issues.

Engaging customers

Public outreach is a very important component of the Advanced Water Purification Facility project. A robust communications strategy includes proactive media relations, a speakers bureau, and tours of the pilot plant.

In November 2013, EPWU surveyed its customers to determine their attitudes and information level about water issues, in particular their perceptions of direct potable reuse. Interviews were conducted by trained, bilingual telephone interviewers using a random sampling method. Based on the survey, about 84% of the community supports direct potable reuse.

Along with the National Water Research Institute (NWRI), EPWU formed a panel of experts with different expertise (e.g. engineering, public health, public affairs) to get their feedback on the technical and public outreach portions of the project. Communications staff is publishing a video featuring interviews from the panel of experts.

Success factors

Proven technology already in use in Texas

The proposed advanced water purification process of uses rigorous and proven technologies that the Texas Commission on Environmental Quality had approved for similar plants in other parts of Texas.

Drought severity led to quicker approvals

Due to the severity of the drought, regulatory agencies have been supportive of EPWU in their efforts to get the plant approved.

Water quality not compromised

Drinking water regulations establish that surface and ground waters must be tested for inorganic chemicals. Drinking water must also be tested for Organic Chemicals (pesticides and insecticides), disinfectants and disinfection by-products, and microbial contaminants as specified by the State.

Sustained community support

Residents have continuing and increasing confidence and satisfaction with EPWU. Over a 22-year period, confidence in the safety of drinking water has steadily increased from 60 percent in 1993 to 80 percent in 2015. Research also shows that EPWU customers express continued high satisfaction with the cost of water, customer service, communication, and the management of water resources.

Lessons learnt

- Public acceptance will be one of the most significant challenges for the project. People want reassurance in terms of water-borne disease and industrial contamination and wanted to know that water from the purification facility will be the same quality as the water they are receiving.

- Talking to regulatory agencies as far in advance as possible is proving helpful. Once the concept was developed, the EPWU started meeting with regulators who were very keen to ensure they developed a relationship with the design team early on. EPWU is following the same strategy in regards to the proposed Advanced Water Purification Facility.

- The extensive preparation exercised in order to proceed with the construction of the facilities — studies, pilot plants, research, and the state / federal permitting processes — assured the success of the project and the EPWU believes it is a good example for other communities looking to develop inland desalination plants.

Recycled water for drinking: The City of San Diego, California: Pure Water Purification Process

After a successful 5-year wastewater purification trial, the City of San Diego is planning to implement a full-scale scheme as a local source of drinking water. The city is currently exploring options of storing the purified water in an existing reservoir or distributing it directly to the city's 1.3 million residents. The scheme is expected to be completed in 2035 and will supply one-third of the city's water needs.

The drivers

More than 85 percent of the San Diego region's water supply is imported, most of it being conveyed by aqueducts from the California Bay-Delta and the Colorado River. The region's reliance on imported water leaves the City of San Diego's water supply vulnerable to drought, competing demands, and rising costs of imported water.

'Pure Water San Diego' is the city's 20-year program to develop a local source of drinking water to reduce its dependence on imported water; keep up with population growth; and combat water supply challenges such as recurring drought.

The scheme at a glance

- The City's long-term goal, targeted for 2035, is to produce 314 million litres (ML) of purified water per day—one-third of San Diego's future drinking water supply.

- The City has successfully trialled a process that purifies recycled wastewater through membrane filtration, reverse osmosis and UV advanced oxidation.

- While the state of California has yet to approve or develop regulatory frameworks for direct and indirect potable reuse, San Diego continues to explore both options.

- If San Diego goes the indirect potable reuse route, the purified water would be conveyed 37 kilometres to the San Vicente Reservoir where it would be blended with imported water supplies in the reservoir before going to a standard drinking water treatment plant.

- The City is also testing additional barriers that could potentially be used in lieu of the reservoir. This direct potable reuse route could provide additional operational flexibility and reduce the need for the costly pipeline needed to convey the purified water to the reservoir.

- When fully commissioned, the program will produce 314 ML of purified water per day for the city's 1.3 million residents.

- A separate project is underway to increase the capacity of the San Vicente Reservoir, where the purified water could be stored.

The path taken

Investigation

The City of San Diego began addressing the need for a new, locally controlled, drought-proof water supply in the 1990s, when it first proposed purifying wastewater into potable water. The initial plans were met with opposition—opponents adopted the phrase "toilet to tap" and raised the public's fear of the drinking water quality.

In 2004-2006, a water reuse study stated that purifying water by adding it to a reservoir was the preferred water reuse strategy for the area. The study recommended a project that would convey purified water to the San Vicente Reservoir.

In 2009, the City partnered with several stakeholder groups, including the San Diego Coastkeeper and the San Diego County Water Authority, to launch the Recycled Water Study. This study helped the City identify opportunities for making more recycled wastewater available for both potable and non-potable uses and the costs of implementing such projects. Groups also included trade unions and ratepayer advocates. It was successful because of its diversity.

Pilot

In 2009, the City launched the Water Purification Demonstration Project to:

- determine whether advanced water purification technology could provide safe drinking water to residents; and
- evaluate the feasibility of a full-scale scheme where the purified water would be added to the San Vicente Reservoir.

The demonstration project produced 3.8 ML of purified water per day at the test Advanced Water Purification Facility. One year of extensive testing determined that the test facility produces water that meets all federal and state drinking water standards.

Approval for full-scale implementation

The two agencies with primary regulatory authority (California Department of Public Health and the San Diego Regional Water Quality Control Board) evaluated the demonstration project and approved the City's concept and approach to add the purified water to the San Vicente Reservoir.

California's State Water Quality Control Board is evaluating the feasibility of direct potable reuse and has yet to establish the framework for regulating direct potable reuse schemes.

Construction

Pure Water San Diego components include the construction of water purification facilities and the continued operation of the test facility.

A separate project is underway to increase the capacity of the San Vicente Reservoir, where the purified water could be stored.

Commissioning

A 57 ML per day water purification facility is planned to be in operation by 2023.

The long-term goal of producing 314 ML of purified water per day—one-third of San Diego's future drinking water supply—is targeted for 2035.

Engaging the community

Engaging decision makers, regulators and politicians

From past experience, project leaders of 'Pure Water San Diego' knew that engaging local government officials, including their city council members and the mayor, would be critical for the success of the project. Therefore, the City kept decision-makers, regulators and politicians involved in the program by engaging them in presentations and tours and keeping them up to date on project developments.

Engaging customers

To inform and engage the public, the City developed a public outreach program that includes informational materials and events; tours of the test facility; email updates; website content; presentations at city council meetings and community meetings; press releases for newspaper, radio and TV; and blog posts.

Residents are notified of tours through a flier included as a bill insert, websites and other media. Public surveys were conducted from 2004 to 2012 and have shown a significant increase in support from the community.

The City also formed the Pure Water Working Group to capture diverse viewpoints and input on the city's efforts to ensure a safe, reliable and cost-effective drinking water supply for San Diego. An invitation to join the working group was sent to community planning groups, businesses, city council district offices, non-profit environmental organisations and community leaders.

Success factors

High levels of trust in water authority

The role of the Water Purification Demonstration Project was to show the public that the water purification process consistently produces water that meets all state and federal drinking water standards. The test facility allows the community to see firsthand how this is technically possible.

Clear roles and responsibilities for developing policy regulation

By creating a partnership of stakeholder agencies (including San Diego Coastkeeper, Surfrider Foundation, City of San Diego Independent Rates Oversight Committee, San Diego Metro Wastewater Joint Powers Authority and the San Diego Water Authority) the City was able to open up the communication lines and outline responsibilities of groups.

Water quality not compromised

During the pilot program, more than 9000 water quality tests confirmed the absence of contaminants in the water. The water has met all federal and state drinking water standards.

Sustained community support

The test facility is still operating as the City conducts additional research, allowing for continued community engagement. The City feels that "seeing is believing," and says that by the end of a tour of the test facility the concerns of doubters are alleviated.

Lessons learnt

- Working with the Water Reliability Coalition, an independent group of organisations partnering on water reuse in the region, was helpful as the City began public outreach. This coalition had already been making strides in educating the public on water supply.

- The City continues to study the potential of a direct potable reuse scheme so that it understands the permit requirements and is ready to implement a project when regulations are approved by the California state regulators.

- Information about recycled water projects is technical and complex, and distilling it down to a brief message is difficult but important. Having a 15 to 20 minute presentation with clear points is a useful tool when briefing elected officials and media.

- Having a well thought out and extensive public outreach plan is vital. It needs to be maintained continually through the long cycles of environmental review, technical feasibility evaluations, and local government approval. Audiences may vary through time, so gaining the public's understanding and acceptance requires a continual and often costly effort.

- Having a demonstration facility where elected officials, regulators and the public can see the technical processes in action has proven, by far, to be the most important component of the public outreach process in gaining public support.

Recycled water for drinking: Purifying wastewater for replenishing groundwater in the Santa Clara Valley, California

The Silicon Valley Advanced Water Purification Center which opened in 2014 purifies up to 8 million gallons of treated wastewater a day. The local Water District is now investigating the possibility of storing this purified wastewater in local groundwater basins which are no longer being naturally replenished due to population growth, and the ongoing drought.

The drivers

The Santa Clara Valley Water District is a water wholesaler providing water to 1.8 million residents in the southern region of the San Francisco Bay Area including the well-known Silicon Valley. Currently, the Water District is meeting its supply from the California State Water Project, the Central Valley Project (a regional water supplier), local groundwater, local surface water (reservoirs), recycled wastewater (about 5 percent of total supply), and conservation measures (10 percent).

More than 55 percent of the water consumed in the Santa Clara Valley is imported from surrounding watersheds and stored in underground aquifers. Due to a reduction in rainfall over the past four years, very little local water is flowing into the District's reservoirs and groundwater basin.

Combined with the California statewide water shortage, and a severe reduction in water available from both federal and state water projects, the Water District has been forced to use its imported water for drinking water, conveying it directly to its drinking water treatment plants, instead of storing it underground. As a result, drawing water from underground is no longer sustainable and another source of water to replenish the groundwater basin is needed. Purified wastewater is being investigated as an option.

The scheme at a glance

- To improve the quality of its recycled wastewater, the Water District designed the Silicon Valley Advanced Water Purification Center which opened in 2014 and produces up to 30 million litres of purified recycled water a day.

- The Water District is investigating the possibility of using this purified recycled wastewater to replenish its groundwater basins. The project is currently in the pre-feasibility phase, and locations for pipelines are being determined.

- Construction of a groundwater replenishment scheme would also establish the framework for potential indirect potable reuse.

- The Water District developed an overarching recycled water and infrastructure master plan for the entire County, which will incorporate individual plans by each of the four recycled water producers.

- The Water District's long-term goal is to save (through recycling and conservation) more than 145 billion litres of water a year by 2030.

- California's State Water Quality Control Board is establishing the regulatory framework for Direct Potable Reuse schemes by late 2016.

The path taken

Gaining public support for recycled water

Through community surveys conducted routinely over a period of years, the Water District found that residents were not supportive of recycled water use initially, but that acceptance grew as more information was provided. With the Silicon Valley Advanced Purification Center now open, the Water District provides tours of the center, continues to survey visitors and believes the current level of support is high.

Pilot

The concept of a pilot project was included in the California Environmental Quality Act, and quality testing at the Purification Center is now being performed. The District is currently examining whether it can perform the engineering to get to a groundwater basin or use their existing recycled water pipe system to replenish groundwater via existing percolation ponds.

Feasibility study

A feasibility study, including pilot research studies, will be conducted before a decision is made on whether to use highly purified recycled water as a potable water supply option. The study, community acceptance, and subsequent District Board approval, is anticipated to be achieved by 2020 (if not sooner, given current drought conditions).

Construction/Commissioning

If a groundwater replenishment scheme using recycled water is selected as a water supply option, operation of a fully built system would likely commence in 10 to 15 years.

Engaging the community

Engaging decision-makers, regulators and politicians

A water recycling subcommittee, including three City board members, was created.

The district provided hard-hat tours of the Silicon Valley Advanced Purification Center for major stakeholder groups and the media, followed by an aggressive tour schedule for residents. A virtual tour is on the District's website (http://purewater4u.org) which also includes discussing purified water in the context of the urban water cycle. In addition the site provides information into the ways water is reused, provides information about what experts are saying and also provides frequently asked questions.

Engaging customers

The District has a comprehensive strategic public outreach plan and has maintained an ongoing, award winning, water educational program for grammar-school-aged children.

Educational materials were developed, including factsheets and age-specific books ranging from first-time readers to college-aged readers. Materials are distributed at events, the plant is discussed at customer workshops, a speakers bureau is available to make community presentations, and the Water District has an active social media program. The Water District also partnered with an ethnic media organisation, and the new professional football stadium uses recycled water and makes public service announcements for recycled water at games.

Success factors

Protecting fish and wildlife

The district works closely with the California Department of Fish and Wildlife (CDFW) to manage species impacted by the scheme. CDFW is the state agency responsible for managing local fish and wildlife, issuing permits and granting access to work in habitat areas.

Partnerships

Partnerships for both potable and non-potable reuse are important in Santa Clara Valley. A partnership between the City of Sunnyvale (a District water customer), Cal Water (a local retail water company) and Apple Inc. (a retail water customer) was established to allow the county to expand its recycled water programs and help the Water District take a step closer to meeting their goal of increasing recycled water from 5 percent to 10 percent by 2025.

A partnership with the City of Sunnyvale was also created to share the cost of upgrading their water pollution control plant and to develop an option to use most of the recycled water produced by Sunnyvale (approximately 10 million gallons per day) for future potable reuse.

High levels of trust in water authority

Recent focus groups and telephone surveys conducted in 2014 have shown that residents in the District trust the utility and are satisfied with water quality.

Challenges of moving to a potable reuse scheme

The District Board has been discussing and evaluating the potential for various potable reuse schemes. Since they are a wholesaler, they have been working closely with their customers (surrounding cities) in sharing the responsibilities for negotiating policies affecting their respective jurisdictions. They also anticipate potential brine disposal challenges with regulatory agencies in the area.

Water quality not compromised

The District has three surface water treatment plants with ozone which help to eliminate any odour and taste issues. The District also has a tasting room where people can sample and rate water.

Lessons learnt

- Cost comparisons for ratepayers, showing recycled water and other supply options, are important and could be a driver for or against the project. The 10-year rate forecast includes the cost of the recycled water project and the District has had to explain this to the retail agencies they sell to.

- Briefing and keeping elected officials informed is vital– different communities or areas may see things in different ways. Gaining the support of respected opinion leaders can help influence others in their community - people listen to these leaders.

- The Silicon Valley Advanced Water Purification Center has proven to be an excellent vehicle to increase the public's understanding of the treatment process and technology, including elected officials and regulators. The associated Visitor Center helps build public interest and trust in the utility's capability by demonstrating quality treatment. The tours engage the community and make them feel apart of the evaluation process for examining this new water supply.

Recycled water for drinking:
Orange County: a role model for groundwater replenishment

Orange County's groundwater replenishment system is the world's largest water recycling system of its kind. Treated water is purified to near-distilled quality and then piped to a location where it naturally seeps into a groundwater basin that provides 60% of the potable water needs of 2.4 million residents.

The drivers

Orange County in southern California is a semi-arid region that receives on average 330 mm (13 inches) of rain a year. The population of more than 3 million is projected to grow by more than 10% by 2035.

A large groundwater basin provides 60% of the potable water needs of 2.4 million residents in north and central Orange County.

Water from the basin is also injected into a barrier on the coast to prevent seawater from intruding into the basin.

The Santa Ana River was once the main source of water for replenishing the basin but increasingly unreliable flows meant that the Orange County Water District was forced to import water from other rivers to replenish the basin—an expensive option.

By the mid-1990s, demand had increased and there were continued problems with seawater intrusion. At the same time, the county's increasing volume of wastewater had become a disposal problem for the Sanitation District.

The two agencies saw the opportunity to use some of the wastewater to replenish the groundwater basin.

The scheme at a glance

- Treated sewer water is purified to drinking-water quality standards using a three-step process consisting of microfiltration, reverse osmosis and ultraviolet light with hydrogen peroxide.

- The purified water is stored in the Orange County groundwater basin. Half of it is pumped into a string of wells to form a hydraulic barrier that prevents seawater from contaminating the county's groundwater supplies. The other half is piped about 21 kilometres through the cities of Fountain Valley, Santa Ana, Orange, and Anaheim, to recharge basins where, as a precautionary measure, it is blended with other water (75:25), before it seeps underground.

- The quality of the purified water exceeds all state and federal drinking water standards.

- The system can purify up to 265 million litres (70 million gallons) of water a day—enough to meet the needs of nearly 600,000 residents. By 2015, capacity will increase to 378 ML (100 million gallons) a day, ultimately expanding to 492 ML (130 million gallons). The system recycles 35% of the Sanitation District's wastewater and contributes about 20% of the water that refills the basin.

- The US$481 million project was jointly-funded by the Orange County Water District and the Orange County Sanitation District.

- The Water District manages and protects the groundwater basin. It is a special district, unaffiliated with the County of Orange or any city government. It was created by the California State Legislature in 1933 to protect Orange County's rights to Santa Ana River water and to manage the groundwater basin. The Sanitation District supplies the Water District with the secondary treated wastewater at no charge. The Water District, in turn, manages and funds the operations.

The path taken

Holding back the sea with treated wastewater

In the 1960s, so much water was extracted from Orange County's underground basin that the resulting drop in water pressure allowed the Pacific Ocean to seep in through the sandy soil. The situation prompted the Water District to investigate whether it could use treated wastewater to replenish the basin and protect it from further seawater intrusion.

After a successful technology trial, in 1976 the Water District built the internationally-known Water Factory 21, which treated wastewater, supplied by the Sanitation District, using a state-of-the-art purification process that included reverse osmosis. The purified water was injected into a string of 23 wells to form a hydraulic barrier to seawater intrusion and its associated saltwater contamination.

Win-win solution identified for waste disposal and water supply

By the 1990s, water demand was on the rise and there were continued seawater incursion problems. As more water was extracted from the basin, the barrier required more water than Water Factory 21 could produce.

At the same time, the volume of wastewater had increased so much that the Sanitation District was facing a US$200 million price tag to build a second pipe to convey it into the Pacific Ocean.

The two agencies agreed to collaborate and co-fund the construction of an advanced water treatment facility that would solve both problems—not only would it provide the additional purified water needed to keep the ocean at bay, but also enough water of drinking-water standard to replenish the basin groundwater.

Pilot

The first step was to pilot test the treatment processes. In 1995, the Water District began pilot testing microfiltration, reverse osmosis and ultraviolet light with hydrogen peroxide to purify the Sanitation District's already highly treated wastewater. Testing results proved that this technology could purify the wastewater to near-distilled water quality.

In February 1997, the two agencies signed the agreement to plan and build the scheme.

Design

In March 1999, the environmental impact report received final certification and preliminary design of the scheme began in July 1999. Board approval to progress to final design was given in March 2001 and the final design was completed in November 2003.

In March 2004, the California Department of Public Health and the Santa Ana Regional Water Quality Control Board approved the system design.

Construction

The scheme consisted of seven separate construction projects including an expanded seawater barrier and a 21-kilometre pipeline to carry purified water to recharge basins in Anaheim.

In April 2004, the contract to build the advanced water purification facility was awarded.

By June 2004, the Phase 1 (1.9 ML/day, 5 million gallons a day) Advanced Water Purification Facility was operational and Water Factory 21 ceased operations. This Phase 1 facility operated for two years while the groundwater replenishment system was being built. While continuing to prevent seawater intrusion, it also served as a training facility, enabling staff to become familiar with the treatment processes they would operate at the groundwater replenishment system. New treatment processes were introduced, resulting in increased energy efficiency and more effective removal of contaminants.

The Phase 1 facility ceased operations in 2006 and potable water was imported for injecting into the seawater barrier until the groundwater replenishment system was completed in January 2008.

Regulatory approval

The system was reviewed, approved and permitted by the California Department of Public Health and the Santa Ana Regional Water Quality Control Board, to ensure public health, water quality and environmental compliance. The permit establishes criteria for water treatment, total organic carbon limits, and travel time and blending requirements. The groundwater replenishment system has been operational since January 2008.

Engaging the community

A creative and proactive outreach campaign was designed to secure support for the project from:

- local, state and federal elected officials
- business and civic leaders
- health experts
- environmental advocates
- regulatory agencies
- media
- the general public.

The campaign's primary objectives were to:

1. secure positive media impressions
2. be prepared to address significant opposition
3. educate people to overcome the negative "toilet-to-tap" perception of recycling wastewater
4. start the outreach campaign nearly 10 years prior to the project's start-up and continue it throughout the project's life to maintain support for future expansions
5. create a positive perception of recycling wastewater to increase support of indirect and direct potable reuse.

An extensive range of strategies was employed, including forming relationships with media, briefing elected officials, selecting respected community spokespeople, being transparent, offering facility tours, securing commitment from supporters, and reaching out specifically to minority groups, women, mothers and seniors.

Success factors

The system meets Orange County's water needs

The groundwater replenishment system gives the growing population of Orange County a locally-controlled reliable source of safe, clean water which reduces the regions dependency on imported water.

Insistence on the highest water quality

The Board of Directors insisted that the purified water be of the highest quality. The purified water used to replenish the groundwater basin exceeds all state and federal drinking water standards.

Engaging minority groups and health/medical experts

Proactive face-to-face engagement garnered the support of minority groups and experts in the medical field (health experts, doctors, hospitals, pharmacists and scientists).

A history of successful water reuse

Orange County Water District has been treating wastewater to drinking-water standards since 1976 when they built Water Factory 21, and has earned a worldwide reputation for supporting a culture of innovation. Its professionalism and increasingly sophisticated water analyses instilled confidence in the health and regulatory community and the general public in allowing the Water District to continually push the frontiers of water recycling.

The final destination is the basin, not the tap

The purified water is piped to two recharge basins in nearby Anaheim where it percolates through the sand and gravel, and is naturally filtered, by the time it reaches the groundwater basin.

An outreach campaign that won over the public

From the project's outset, the boards of the water and sanitation districts recognised that public relations would be critical to the success of the groundwater replenishment system. They knew they had to overcome the negative public perception of recycling wastewater to drinking water.. Similar projects in Los Angeles and San Diego were defeated because of this issue.

The two agencies decided the 'clean water' agency, the Water District, would manage and be the face of an outreach campaign to earn and maintain support for the project. The campaign, which began 10 years before construction started, is recognised as the main reason the public accepted the project.

High profile and credible speakers and tours of the facility were used to educate people from local colleges, water agencies, international organisations and local residents.

The success of the campaign was demonstrated by the absence of any organised opposition, and strong support from policymakers and politicians allowed the project to move forward, and secured $92 million in state, federal and local grants. Letters of support were obtained from every city council and chamber of commerce in the Water District's service area. The Governor of California was an important supporter.

Ongoing independent scientific review

The permit to operate requires that an independent advisory panel provide an ongoing periodic scientific peer review of the groundwater replenishment system. The permit specifies minimum qualifications for the panel members and requires that the panel meet annually during the first five years, and then every two years thereafter. The panel is administered by the National Water Research Institute, and made up of experts in toxicology, chemistry, microbiology, hydrogeology, environmental engineering, public health and water treatment technology.

Lessons learnt

- Extensively communicate and engage with the community about the problem, need and potential solutions.
- Key messages must address health and safety.
- Proactively reach out to the media. Use language that is easy to understand; jargon generates mistrust.
- Understand and use social media but don’t discard traditional tactics.
- Have an open-door policy and tell the truth—have no secrets.
- Interact with people directly, face to face, including those who oppose the potable reuse.
- Understand that with social media the same things happen, only faster. Have a crisis management plan and a social media protocol.
- Tours of the pilot/facility and taste tests are important to build public confidence.
- Embrace “toilet to tap”. Be creative and have fun with it, especially with young people.

The GWRS website: http://www.gwrsystem.com/

Sanitation Districts of Los Angeles County
Recycled Water Information
March 2019

OVERVIEW

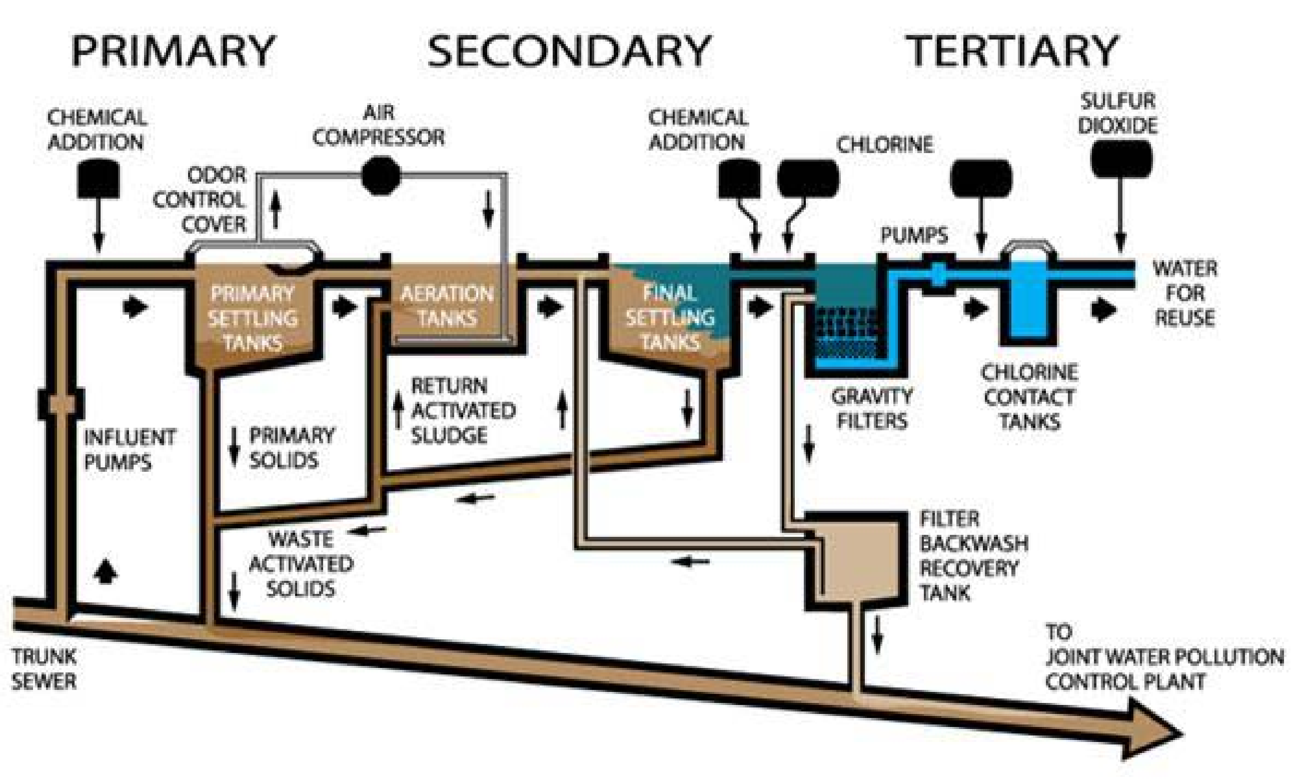
The Sanitation Districts of Los Angeles County (Sanitation Districts) were formed in 1923 to serve the wastewater collection, treatment and disposal needs of the now approximately 5.6 million people in 78 cities and unincorporated areas within Los Angeles County. We currently operate 11 wastewater treatment facilities (Figure 1), 10 of which are classified as water reclamation plants (WRPs). The Sanitation Districts' original treatment plant, the Joint Water Pollution Control Plant (JWPCP) in Carson, is an ocean discharge facility. Using these facilities, the Sanitation Districts operate one of the largest wastewater recycling programs in the world, with a long history of providing affordable, high-quality recycled water to public and private water suppliers to help meet the water supply needs within our service areas. The 10 WRPs produce treated and disinfected recycled water, most of which meets nearly all State and Federal drinking water standards. By the end of FY 17-18, the recycled water was being used at approximately 900 sites for a variety of purposes, including indirect, potable groundwater supply augmentation at the award-winning Montebello Forebay Groundwater Recharge Project. This resource is a safe, affordable, and reliable supply of water for industrial, commercial, and recreational applications; groundwater replenishment; agriculture; and the irrigation of parks, schools, golf courses, roadway medians, and nurseries.

FIGURE 1: LOCATION OF SANITATION DISTRICTS' WASTEWATER TREATMENT FACILITIES

WHAT IS A WATER RECLAMATION PLANT?

Recycled water produced by all but one of the WRPs is filtered, disinfected tertiary effluent, the highest quality currently regulated by the State of California Division of Drinking Water for direct, non-potable application (a very small amount of our recycled water is treated to a disinfected secondary level). A wastewater treatment plant is just like a natural river but in a concrete box (Figure 2). First, materials settle to the bottom of the primary settling tanks by gravity or float to the top and are removed for further treatment. Second, microbes use air to breathe while they eat up the remaining organic material in the aeration tanks, then the microbes settle out in the secondary settling tanks. Third, sand and coal filter out leftover particles in the filters like the bottom of a river. At the very end, the recycled water is disinfected with either chlorine or UV radiation to kill off any remaining bacteria or virus prior to reuse or discharge into a local waterway.

FIGURE 2: FLOW SCHEMATIC OF A WATER RECLAMATION PLANT

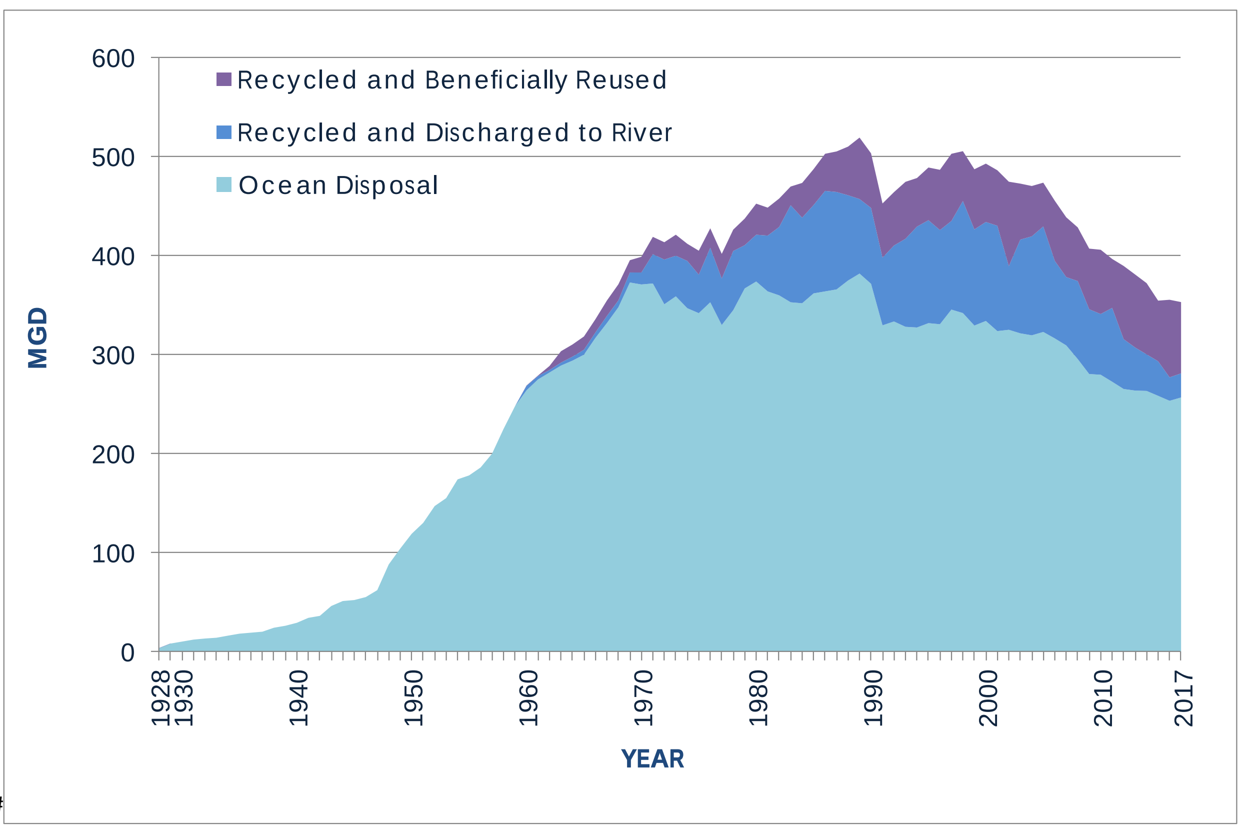


HISTORY OF WATER RECYCLING PROGRAM

Rudimentary water recycling has taken place in Los Angeles County in various forms since the late 19th and early 20th centuries. However, the Sanitation Districts embarked on their modern water recycling program in 1949 when it was determined that upstream WRPs would allow us to not only handle wastewater generated by the burgeoning post-war development in our service area, but to produce a useful by-product (i.e., recycled water), which would be a critical resource in a semi-arid and chronically water short area. The Sanitation Districts' first WRP, Whittier Narrows, began operation in August 1962 and nearly every drop of recycled water produced by that facility has been put to beneficial use since then, mainly for groundwater replenishment and later also for irrigation of nearby urban parks and green areas.

In the 1960s and 1970s, additional WRPs were constructed by the Sanitation Districts and were located strategically to better handle locally produced wastewater. This network of facilities is known as the Joint Outfall System (JOS), which is comprised of seven Sanitation Districts' treatment plants that are part of the same wastewater collection system, which treats approximately 90% of the Sanitation Districts' wastewater. Solids from the six upstream water reclamation plants are returned to the collection system and conveyed downstream to JWPCP for further treatment (anaerobic digestion and dewatering) prior to transport for reuse or disposal. This system design allowed the Sanitation Districts to supply a greater number of communities with recycled water with less distribution infrastructure and reduced energy usage (and therefore more cost-effectively), as compared to what would have been required with a single, centralized wastewater treatment facility located near the bottom of the watershed. These early decisions regarding upstream facilities followed the Sanitation Districts' policy of prioritizing distributed recycled water production, while still allowing for centralized solids processing. Figure 3 illustrates that the development of the WRPs have allowed the increases in sewage flows in the JOS that have occurred as population has grown to be recycled for potential beneficial reuse. However, it should be noted in recent years, overall flows in the system have dropped to levels last seen in 1969, even with 1.4 million more people in the JOS service area, mainly as a result of drought and water conservation. Thus, in the Sanitation Districts' Los Angeles Basin service area, more wastewater is being recycled and less is being discharged to the ocean even than had been anticipated when the JOS was conceived. Although there is less flow, it is still 2-3 times as much as currently reused.

FIGURE 3. JOINT OUTFALL SYSTEM FLOW DIVERSION TO RECLAMATION, 1928-2018



#

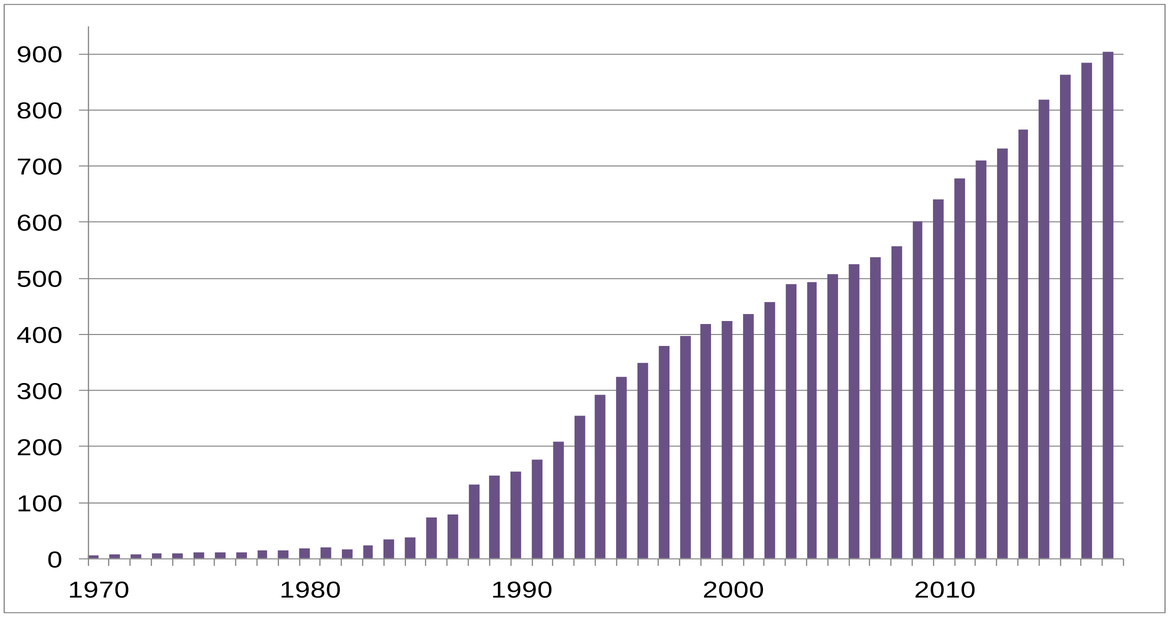
As a result of prolonged drought conditions in 1976-77, a number of water purveying entities began to see the value in adding recycled water to their supply portfolio to mitigate the effects of potable water shortages during droughts. Recycled water distribution systems were developed in the ensuing years by the Long Beach Water Department, Walnut Valley Water District, the Cities of Industry, Cerritos, Lakewood, Palmdale and Lancaster, Central Basin Municipal Water District, Upper San Gabriel Valley Municipal Water District, and Castaic Lake Water Agency (now called Santa Clarita Valley Water Agency). The Sanitation Districts also operate a limited local recycled water distribution system primarily to serve its own facilities; namely, the Puente Hills Landfill, the Puente Hills Energy Recovery from Landfill Gas Facility, and the adjacent Rose Hills Memorial Park.

Initially, most recycled water use was for groundwater replenishment activities (known as the Montebello Forebay Groundwater Replenishment Project), as this project could rely on existing flood control and water conservation facilities owned and operated by Los Angeles County, along with gravity for transport of tertiary-treated recycled water from the Whittier Narrows and San Jose Creek WRPs to the point of reuse, which allowed for large amounts of reuse at reasonable cost. The Sanitation Districts and their partner, the Water Replenishment District of Southern California (WRD), have been working together to increase reuse even further. In mid-2003, WRD completed construction of the Leo Vander Lans Advanced Treatment Facility (LVLATF) adjacent to the Sanitation Districts' Long Beach WRP to augment and eventually replace imported water used to prevent saltwater intrusion into the Central Basin Aquifer through Los Angeles County Department of Public Works' Alamitos Seawater Intrusion Barrier. Deliveries to the barrier began in 2005, and in 2014 WRD completed an expansion of the LVLATF. Approximately 80% of the injected water moves inland and becomes part of the groundwater supply. It should be noted that the project was originally conceived decades ago, but due to the high cost and regulatory barriers took many years to come to fruition.

Additionally, the permit for the Montebello Forebay Groundwater Replenishment Project was modified in recent years by the Los Angeles Regional Water Quality Control Board to allow greater amounts of recycled water to be used for groundwater recharge. Further, WRD, in conjunction with the Sanitation Districts, have continued to design, construct, and implement modifications to the existing recycled water delivery system to allow for greater quantities of recycled water to be diverted into the San Gabriel Coastal Spreading Grounds. These efforts now allow for all of the recycled water produced in the San Gabriel Valley not being delivered for direct uses to be captured for groundwater recharge (excluding periods of heavy rainfall runoff).

Figure 4 shows the growth in the number of reuse sites receiving recycled water. To distribute the recycled water, the Sanitation Districts partner with nearly three dozen water entities, which have developed an extensive recycled water distribution system (roughly 265 miles of transmission lines). The Sanitation Districts are not a water purveyor and, in fact, are not allowed to compete with the distribution of potable water in other agencies' domestic water service areas (i.e., due to the Service Duplication Act (*see* CA Public Utilities Code, Div. 1, Part 1, Chapter 8.5)). Therefore, the Sanitation Districts depend on the local water purveyors to incorporate the delivery of recycled water in their water portfolio and to develop the infrastructure necessary to make use of the recycled water we produce.

FIGURE 4. GROWTH IN NUMBER OF REUSE SITES, 1970-2017



The JWPCP has not supplied recycled water in the past, as the salt concentration in its effluent has been too high for any beneficial use, such as irrigation or industrial process water, without costly advanced treatment to remove salt. However, advancements in technology have reduced these costs and, for the past several years, the Sanitation Districts have been working in partnership with the Metropolitan Water District of Southern California (MWD), the regional importer of water for some 19 million people, on a potential advanced treatment facility to be located at the JWPCP. MWD and the Sanitation Districts have recently completed construction of a 0.5 million gallon per day demonstration plant, and MWD has finalized a Conceptual Planning Studies Report that presents a path to implementation of project that would include building up to 150 million gallons per day (which is equivalent to 168,000 acre-feet per year) of production capacity to be used to produce recycled water for groundwater replenishment in Los Angeles and Orange.

Tables 1 through 3 and Figure 5 below provide details on the Sanitation Districts' recycled water activities for Fiscal Year 2017-18.

TABLE 1: SANITATION DISTRICTS RECYCLED WATER FACTS (FY 17-18 DATA)

Total Effluent Produced: 390 MGD (437,000 AFY) (Secondary and Tertiary)

Total Recycled Water Used: 94 MGD (105,000 AFY)

Total Reuse Since Inception: 3.20 million acre-feet (1.04 trillion gallons)

Transmission Lines: 1,401,220 linear feet (265 miles)

Acreage Served: 16,059 acres (direct non-potable use)

Jurisdictions Served: 33 (32 cities plus unincorporated Los Angeles County)

Recycled Water Purveyors: 34

Greenhouse Gas Reduction[1]: 237,000 tons of carbon dioxide-equivalent

[1] The use of locally produced recycled water eliminates the need to pump State Project water into the Los Angeles Basin at a net energy cost of approximately 3,000 kWh/AF with the attendant CO_2 production.

#4954185

TABLE 2: RECYCLED WATER PRODUCED AND REUSED AT WATER RECLAMATION PLANTS (FY 17-18)

Water Reclamation Plant	Nominal Treatment Capacity (AFY)	Quantity Recycled (AFY)	Quantity Reused (AFY)	Percent of Recycled Water Used
La Cañada	225	90	90	100
Long Beach	28,015	10,931	5,667	52
Los Coyotes	23,330	23,001	6,630	29
Pomona	16,810	6,389	6,334	99.3
San Jose Creek	112,055	58,038	54,566	94
Whittier Narrows	16,810	7,884	7,840	99
Valencia	24,205	15,041	493	3.3
Saugus	7,285	5,600	0	0
Lancaster	20,170	12,947	14,179	100
Palmdale	13,445	7,952	8,030	100
TOTAL	281,040	147,873	103,829	70

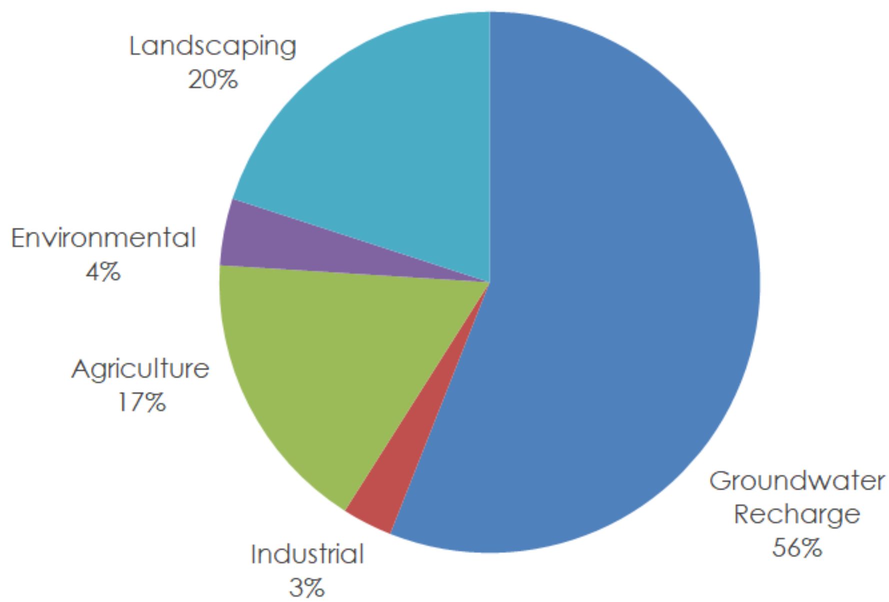
TABLE 3: CATEGORIES OF RECYCLED WATER USAGE (FY 17-18)

Reuse Application	No. of Sites	Area Applied (acres)	Usage (MGD)
Parks	125	3,682	5.07
Golf Courses	24	2,766	4.67
Schools	123	1,361	2.19
Roadway Greenbelts	133	709	0.917
Public Facilities[1]	34	500	1.73
Commercial Buildings[2]	266	562	1.24
Nurseries	19	112	0.161
Cemeteries	9	1,107	2.02
Residential Developments	24	186	0.301
Churches	14	19	0.055
Industrial[3]	110	378	3.30
Agriculture[4]	11	4,316	15.8
Environmental Enhancement	1	400	4.25
SUBTOTAL	892	16,094	41.7
Groundwater Recharge	4	646	51.9
TOTAL	896	16,741	93.6

NOTES:

1. "Public Facilities" includes police stations, libraries, post offices, city halls, government offices, landfills, etc.
2. "Commercial Buildings" includes offices, warehouses, retail, car dealerships, hotels, restaurants, etc.
3. Industrial processes receiving recycled water include carpet dyeing, concrete mixing, cooling towers, metal finishing, oil field injection, toilet flushing, and construction applications such as soil compaction and dust control.
4. California Polytechnic University, Pomona, while technically a school, uses most of its recycled water for agricultural purposes and is thus included in this category.

FIGURE 5: DISTRIBUTION OF RECYCLED WATER USAGE (FY 17-18)



Water Reuse Case Study

Sanitation Districts of Los Angeles County Stormwater Services Program [Los Angeles County, California]

Reuse Application:

Augmentation of municipal recycled water with urban runoff/stormwater

Approach:

Where hydraulic capacity exists, divert, store and control releases of urban runoff to the sanitary sewer system.

Reuse Outcome:

- *Improve water quality and promote MS4 compliance*
- *Increase recycled water supplies in flow-limited areas*

Further information:

www.lacsd.org
Kristen Ruffell, Program Manager
kruffell@lacsd.org
(562) 908-4288, ext. 2826

Overview and Reuse Approach

The Sanitation Districts of Los Angeles County have a program to assist local jurisdictions with development of stormwater projects that promote MS4 compliance by improving water quality, and where feasible, achieve co-benefits such as enhancing water supply and resiliency. One type of project is a controlled, permitted diversion from storm drains to storage facilities with managed releases to the sanitary sewer system owned by the Sanitation Districts and city and county satellite sewer systems. In some cases, these projects can add to the water reclamation facility's recycled water supply and assist the region in meeting its local supply and water resiliency goals.

Reuse Drivers

-MS4 permit requirements include strict numeric limits based on TMDLs and encourage capture and use or infiltration of runoff and stormwater.

-Wastewater treatment plants have experienced 25% or more decline in flows due to drought and water conservation, providing available capacity in sewers and reducing available supplies of recycled water.

-Drought and water conservation have increased demand for recycled water.

Outcomes and Benefits

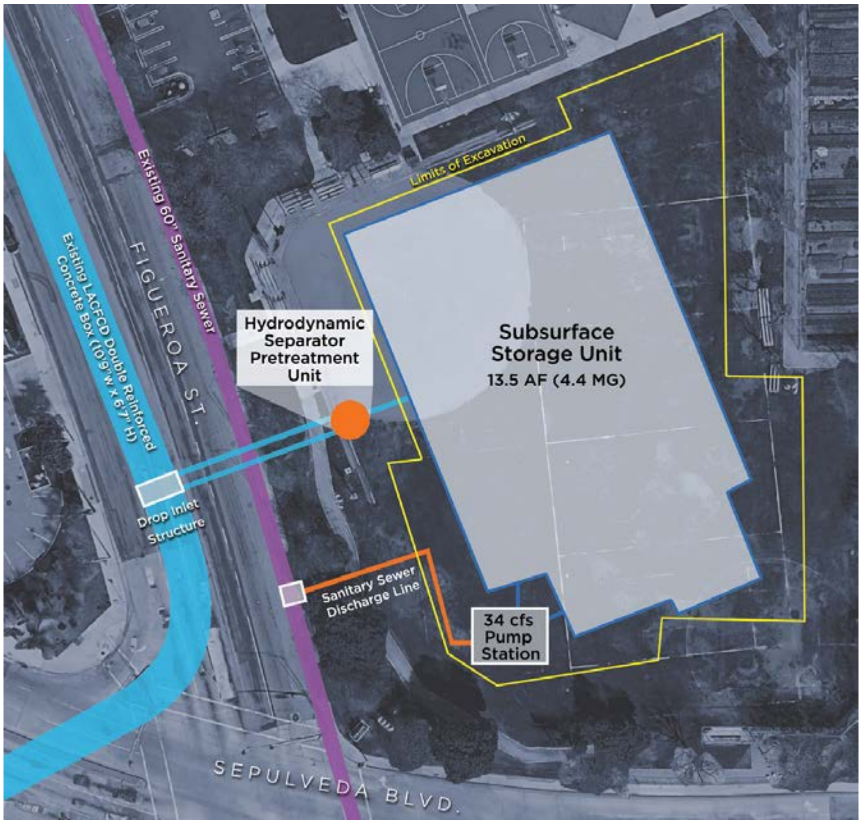
This program is in early stages, and each project is tailored to the city's needs and local situation. Because many sanitary sewers have some available capacity during dry-weather and significant capacity during off-peak hours, use of existing infrastructure presents an opportunity to achieve multiple benefits. Analysis of several stormwater capture and infiltration project proposals has demonstrated that, in many cases, adding a modest sewer discharge component to the projects can help lower capital costs by reducing the storage volume required to capture back to back storms. A collaborative regional study being led by Las Virgenes Municipal Water Districts is underway to assess the potential for using existing sanitary sewers throughout Los Angeles County in a similar manner.

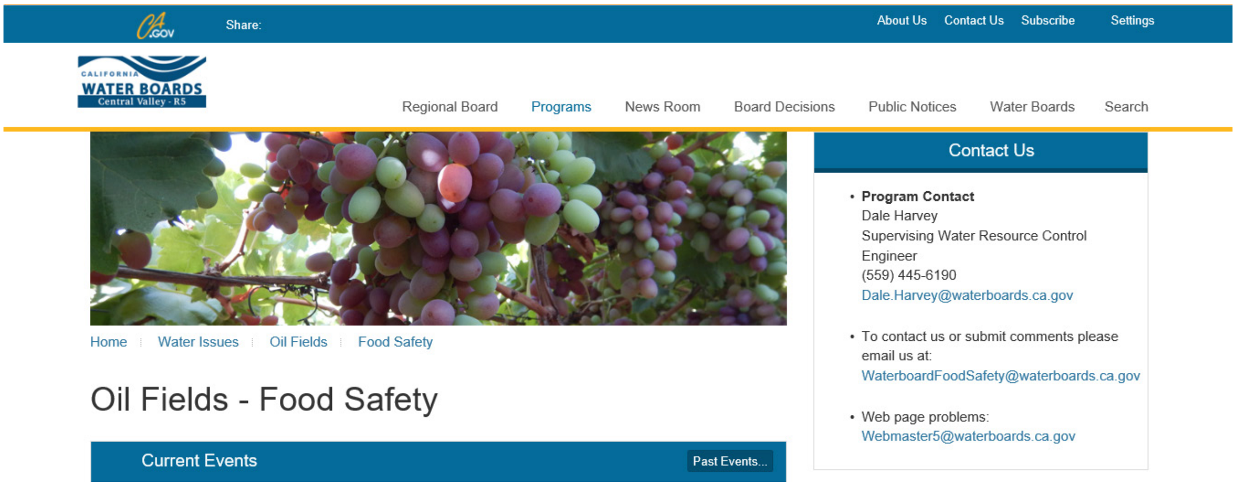
Challenges and Solutions

Challenges include:

- Limited flow data for the sanitary sewer systems and for storm drains;
- Lack of a dynamic sanitary sewer model to analyze episodic inputs of stormwater to the sewer;
- Jurisdictional coordination between dozens of different agencies with jurisdiction over sewers, water, and stormwater;
- Existing adjudications of local groundwater basins and rivers may limit the ability to divert water to sewers; and
- Funding is needed for the diversion, storage and control structures, which cost millions of dollars.

Carson Carriage Crest Stormwater Project (Carson, CA):





Irrigating Human Consumption Crops with Oilfield Produced Water

In California, produced water has been reused to irrigate human consumption crops in a region of the Central Valley for decades. Near Bakersfield, particularly north and east of the city, petroleum is extracted from relatively shallow formations containing groundwater with low concentrations of salts. The resulting produced water is generally low in total dissolved solids. Following oil removal the water is further treated by dissolved air flotation followed by filtration through a walnut shell filter. In the interest of ensuring public safety and confidence in the practice, staff of Central Valley Regional Water Quality Control Board (CVRWQCB) convened a Food Safety Expert Panel to seek input from epidemiologists, toxicologists and other experts on this topic. To understand chemical use in oil fields that provide produced water for agricultural irrigation, livestock watering, and aquifer recharge, the CVRWQCB ordered seven California oil and gas producers to provide information regarding their chemical use in production and associated processes. The resulting disclosures included information from oil and gas development operations from January 2014 to June 2016 and included the types and amounts of chemical additives used in oil and gas development operations as well as the volume of produced water provided for irrigation.

In a preliminary assessment by Shonkoff et al. (2016)[1], more than one third of the 173 different chemical additives were not able to be sufficiently identified for preliminary hazard evaluation, largely due to proprietary claims or the lack of disclosure of their Chemical Abstracts Services Registry Number (CASRN). Over 100 chemicals (62%) were identified by CASRN for acute toxicological properties and environmental persistence using available data and toxicological screening approaches. Of the chemicals with a CASRN, the study found that 46 (43%) of them can be classified as potential chemicals of concern from human health and/or environmental perspectives and require more thorough investigation. As a result of this study, the CVRWQCB updated its discharge permits to include the requirement to monitor for any chemical additives used in the oilfield that could be in the produced water. The CVRWQCB also issued 74 informational orders to chemical suppliers and manufacturers. Based on the resulting disclosures a list was compiled of 318 chemical constituents used in the oil fields that supply water for irrigation. These chemicals are currently being evaluated.

The CVRWQCB also evaluated whether produced water constituents were present in food grown with produced water. To date, crops that have been tested include: almond, citrus, garlic, grape, pistachio, potato, carrot, cherry, tomato, and apple. Crop samples were tested for volatile and semivolatile organic compounds and 18 inorganic elements that were selected based on their association with oil and gas production. Results did not show presence of these constituents; however, the analytical methods used were not designed for sampling of food. Currently a CVRWQCB contractor is developing a list of chemicals of interest and has been evaluating toxicity values for constituents on the additive list. Many of the disclosed chemical constituents have no toxicity data and the contractor is using a variety of methods to develop toxicity values for these compounds. The aim of these activities is to evaluate the human health risk of consumption of crops that have been irrigated with oil and gas produced water from these oilfields and to help to inform the CVRWQCB's approach to the issue in the future with respect to other operators and water districts that may apply for discharge permits. An additional question to be addressed is the produced water monitoring methods that can provide accurate and comprehensive results. Given the complexities of produced water chemistry, reliance on individual constituent monitoring may not be fully informative. Non-target and bioanalytical approaches may be needed to understand the overall toxicity of the produced water. These approaches will likely be used for the analysis of chemicals of emerging concern in recycled municipal wastewater in California based on recommendations from a recent California State Water Resources Control Board expert panel report (Drewes et al., 2018)[2].

Website:
https://www.waterboards.ca.gov/centralvalley/water_issues/oil_fields/food_safety/index.html

References:
[1]Shonkoff SBC, Domen JK, Stringfellow WT. 2016. Hazard Assessment of Chemical Additives Used in Oil Fields that Reuse Produced Water for Agricultural Irrigation, Livestock Watering, and Groundwater Recharge in the San Joaquin Valley of California: Preliminary Results. PSE Healthy Energy. September 2016.

[2] Drewes, J. E., Anderson, P., Denslow, N., Jakubowski, W., Olivieri, A., Schlenk, D., & Snyder, S. (2018). *Monitoring Strategies for Constituents of Emerging Concern (CECs) in Recycled Water: Recommendations of a Science Advisory Panel*.

Water Reuse Case Study

Denver Water's One Water Journey

Sector: Municipal
Subsector: Nonpotable Pilot Project

Overview and Drivers

Colorado has unique features that makes water management in the state challenging. First, Colorado is a headwaters state, meaning that while some rivers originate in or traverse Colorado, none of that water stays in the state. Colorado is also subject to frequent and prolonged droughts. For water utilities like Denver Water that rely on mountain snowpack to replenish water supplies annually, each year can be boom or bust. A warming climate and unprecedented population growth are also challenging water managers to ensure that supply meets demand.

To help deal with these challenges, the Colorado Water Conservation Board drafted the first Colorado Water Plan in 2015. This plan called for actions across the water sector, including conservation and efficiency, reuse and development of new supply. This holistic approach is needed to solve the complex water problems facing Colorado in the coming decades. https://www.colorado.gov/pacific/cowaterplan

As the state's oldest and largest potable water provider, Denver Water was highly involved in the development of the water plan. Denver Water serves 1.4 million customers, nearly 25 percent of the state's population, with only two percent of the water used in the state. And with already limited water supplies being stretched thinner by a warming climate and growth, Denver Water has a responsibility to seek long-term solutions for a sustainable, resilient water supply for its customers.

That's where "One Water" comes in. This water management strategy incorporates emerging trends with traditional water management strategies to ensure the right water source is put to the right use.

The Project at a Glance

Currently Denver Water is piloting a One Water strategy as part of its Operations Campus Redevelopment, hoping to provide a path forward for other developments wanting to manage on-site water supplies holistically. In order to pilot these water management strategies and provide a template for future implementation, Denver

Addressing Challenges Posed by Regulatory Constraints

At the time of design, the Colorado Department of Public Health and Environment's regulation governing reclaimed water treatment and use, Regulation 84, did not allow for flushing toilets and urinals with reclaimed water. So, Denver Water took part in legislative and regulatory development efforts with CDPHE to expand Regulation 84. After a stakeholder process lasting more than a year, CDPHE expanded Reg 84 in October 2018 to allow the use of reclaimed water for toilet and urinal flushing and developed the first state regulation with criteria for utilizing smaller, localized treatment systems to provide reclaimed water. These criteria are based on quantitative risk assessments which evaluate the risk of various source, treatment and use combinations to ensure the protection of public health. The basis for much of the technical and management requirements in Colorado's regulation came from the work of a national blue-ribbon panel of experts convened by the U.S. Water Alliance.
https://www.sos.state.co.us/CCR/GenerateRulePdf.do?ruleVersionId=7824&fileName=5%20CCR%201002-84

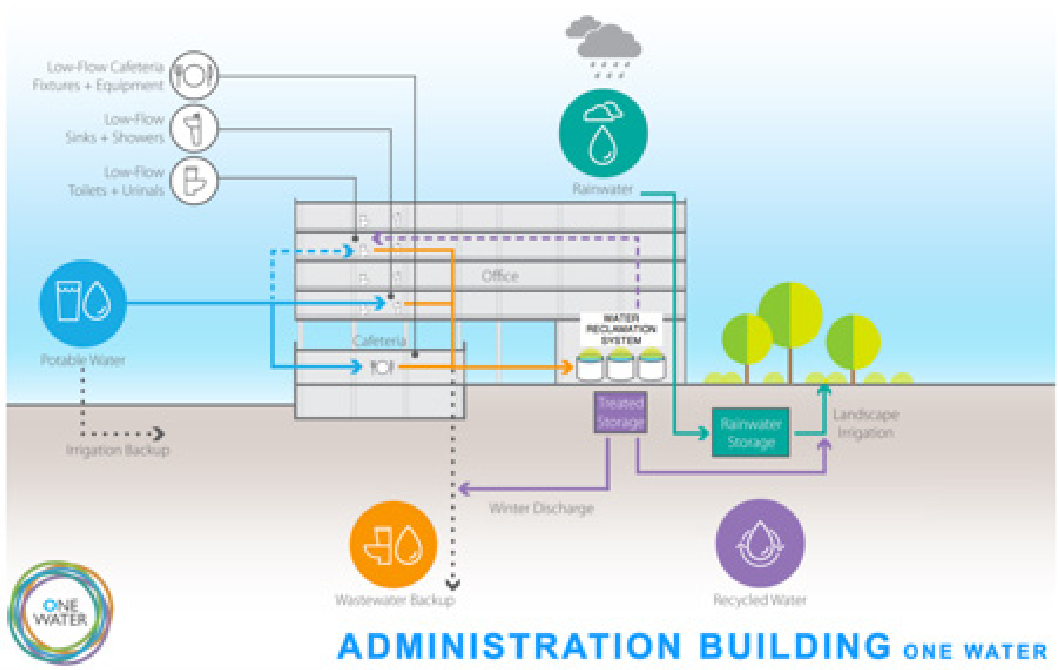
Water embarked on an ambitious mission to showcase what could be done when a development focused on water from the start. The OCR project is revitalizing Denver Water's decades-old headquarters in central Denver with a modern, sustainable, innovative operations complex.

In terms of water use on the redeveloped complex, project designers started with local water, in the form of rainwater capture, to be stored on site in a 50,000-gallon cistern and used for irrigation. But irrigating with rainwater depends on precipitation intensity and timing, and therefore would not completely meet the irrigation needs of the complex in most years. So, Denver Water needed to look for a more consistent water supply.

Wastewater turned out to be that supply, and a system to collect, treat and distribute reclaimed water generated on site was designed. This treatment involves an anoxic and aerobic moving bed biofilm reactor, clarifiers, indoor wetland polishing, cartridge filtration and ultraviolet and chlorine disinfection. The water produced will be used for toilet flushing and comingled with rainwater for irrigation.

Outcomes and Benefits

Construction of Denver Water's new Administration Building and localized reuse system will conclude in fall 2019. The project not only focuses on sustainability and water efficiency, but it also aims to be a learning hub for developers, utilities and the public. Denver Water looks forward to sharing more accomplishments and lessons learned as commissioning, permitting and validation activities wrap up in the following months. To find out more about this model for efficient water use in Colorado, please visit https://www.denverwater.org



Moving Bed Biofilm
Reactor placement

Water Reuse for Golf Course and Green Areas Irrigation at Palmas del Mar Resort and Residential Development

Sector: Private non-profit
Location: Humacao, Puerto Rico
Water Source: Secondary treated wastewater
Water Use: Golf courses and green areas Irrigation
Technology: Secondary treatment capacity of 1.2MGD using Stählermatic technology and disinfected with MIOX system
Project Costs: $7.65 M
Implementation Date: 1978

Overview and Drivers

Puerto Rico, like other regions in the world, drought events have been manifested more frequently due to complex weather changes. In the last 25 years Puerto Rico has had two major drought events triggering the Puerto Rico Aqueduct and Sewer Authority (PRASA) to take extreme measures by rationing the water up to three consecutive days. With this in mind, it is highly essential to manage efficiently the water sources for present and future generations and to consider water reuse as viable alternative to achieve this goal.

Palmas del Mar is a resort-oriented community with approximately 2,750 acres of land dedicated to a variety of residential, commercial, and resort uses. It is in the southeast coast of Puerto Rico, approximately 35 miles from San Juan. This tourist residential complex has a year around population around 6,000 and during high season it reaches approximately 10,000. It's composed of approximately 3,500 housing units, (2) hotels, (1) marina, (1) tennis court complex, two (2) golf courses, a private school, approximately 20 restaurants, (1) equestrian center, among other amenities. For more than 35 years Palmas del Mar Utility, Corp. (PDMU) has provided the treated wastewater from the wastewater treatment plant (WWTP) to irrigate its golf courses and green areas. Furthermore, the digested and dewatered sludge produced during the process in combination with vegetative landscaping waste form the community is used to manufacture compost that is utilized for landscape soil preparation projects inside the complex.

Process or Technology

In 1978, Palmas de Mar built its WWTP as secondary treatment plant and since its origin the plant was conceptualized and operated under a zero-discharge permit from the Puerto Rico Environmental Quality Board (PREQB). This plant is owned and managed by PDMU, a nonprofit corporation. This private utility operates under a franchise agreement issued by the Puerto Rico Public Service Commission that allows PDMU to buy potable water from PRASA and distribute it inside the complex on PDMU's piping network. It also provides for the operation of the sanitary sewer collection system and a WWTP. In 1986, the WWTP was converted on an aerobic treatment / activated sludge facility, installing a Stählermatic technology which combines the biological contactor with the recirculating and activated sludge process. In 2003, the WWTP increased its treatment capacity to 1.2MGD. Currently, the plant manages between 400,000 to 500,000 gallons per day and during peak season flow can reach 750,000 gallons per day. The plant effluent is disinfected using a system known as MIOX where a sodium chloride solution (NaCl) goes through electrostatic plates. By electrolysis there is a separation of sodium and chlorine being this last one injected into the water and the sodium solution (brine) is returned to the WWTP for treatment. After disinfection the effluent is discharged into retention ponds where Golf Operations Department manages the volume to be irrigated between the two (2) Championship Golf Courses.

Outcomes and Benefits

PDMU produces enough reuse water to irrigate the golf courses and to keep them in optimal conditions. It has kept the operation costs competitive by providing adequate operation and maintenance and installing a high-end technology at a lower cost. The treated waters comply with PREQB parameters and allow to fulfill the standards for a safe irrigation process. Other benefit is the use of de-watered sludge mixed with vegetative gardening waste to produce compost that goes back to the community. This vegetative material comes from the Palmas del Mar landscape contractor's daily maintenance work. Once is received, is crushed using a Wood hog, leaving it as "mulch", ready to be mixed with the bio-solids. PDMU has also incorporated in the compost mixture a measured volume (approx. 10% of Bulk Mixing pile) of horse manure and Sargassum, a genus of brown macroalgae that reaches the coast and becomes a public issue when it discomposes. The retention ponds of Palmas del Mar serve as habitat for migratory birds, pelicans, turtles and fish species, and other wildlife.

Challenges and Solutions

"The correct reuse of wastewater for irrigation on golf courses complying with quality standards allows the use of available water for irrigation of agricultural crops, being equally attractive and creative when situations of high need for this precious resource comes." (Torrellas-Cruz et al. 2016)

Acknowledgements

EPA Region 2 staff (Evelyn Huertas) completed the template based on conference transcript cited bellow and the phone conversation of Daniel E. Torrellas-Cruz, Operations & Engineering Manager of PDM Utility Corp. (787-285-0202, pdmutorrellas@coqui.net).

References

(1) Torrellas-Cruz, D.E. June 2016, Irrigation Project for Golf Courses and Green Areas with Wastewater in Palmas del Mar (conference transcript). Journal Perpectiva en Asuntos Ambientales, Volume 5: 76-82. Also available at: https://issuu.com/panorama_pr/docs/p_perspectivas_5
(2) Puerto Rico Department of Environmental and Natural Recourses. 2005. Plan for Water Reuse in Puerto Rico. Available at: http://www.recursosaguapuertorico.com/InformeReuso_Plan_Aguas_22nov_04.pdf. Accessed August 7, 2019