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FINAL PROJECT REPORT

Accelerating Drought Resilience Through Innovative Technologies

California Energy Commission

Gavin Newsom, Governor

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PREFACE

The California Energy Commission's Energy Research and Development Division supports energy research and development programs to spur innovation in energy efficiency, renewable energy and advanced clean generation, energy-related environmental protection, energy transmission and distribution and transportation.

In 2012, the Electric Program Investment Charge (EPIC) was established by the California Public Utilities Commission to fund public investments in research to create and advance new energy solutions, foster regional innovation and bring ideas from the lab to the marketplace. The California Energy Commission and the state's three largest investor-owned utilities—Pacific Gas and Electric Company, San Diego Gas & Electric Company and Southern California Edison Company—were selected to administer the EPIC funds and advance novel technologies, tools, and strategies that provide benefits to their electric ratepayers.

The Energy Commission is committed to ensuring public participation in its research and development programs that promote greater reliability, lower costs, and increase safety for the California electric ratepayer and include:

- Providing societal benefits.
- Reducing greenhouse gas emission in the electricity sector at the lowest possible cost.
- Supporting California's loading order to meet energy needs first with energy efficiency and demand response, next with renewable energy (distributed generation and utility scale), and finally with clean, conventional electricity supply.
- Supporting low-emission vehicles and transportation.
- Providing economic development.
- Using ratepayer funds efficiently.

This is the final report for the Accelerating Drought Resilience Through Innovative Technologies project (Contract Number EPC-15-093) conducted by Water Energy Innovations. The information from this project contributes to the Energy Research and Development Division's EPIC Program.

For more information about the Energy Research and Development Division, please visit the Energy Commission's website at www.energy.ca.gov/research/ or contact the Energy Commission at 916-327-1551.

ABSTRACT

Tulare County is the largest agricultural producing county in California and the county most severely impacted by the recent and ongoing California drought. Dairies within the county are at the epicenter of the region's highest priority resource and environmental challenges: drought, nitrates, air pollution, and greenhouse gas emissions. This project focused on identifying technologies and accelerating implementation of technologies that can achieve long-term water supply reliability ("drought resilience") while also increasing electricity reliability and reducing greenhouse gas emissions.

The project team conducted primary and secondary research over two years to identify technology needs and candidate solutions that could build drought resilience, support electric reliability, and reduce greenhouse gas emissions in Tulare County and the surrounding South San Joaquin Valley area. The team focused on existing and emerging technologies that could be fast-tracked for near-term, cost-effective benefits, and assessed solutions to determine technology readiness and anticipated implementation barriers.

Key findings of the research include: (1) no statewide program exists to help mitigate customers' costs and risks for investments in distributed water resources; (2) despite the critical need to build drought resilience, public investments in development of distributed water resources is low; (3) public investments in cross-cutting projects, programs, and strategies that achieve multiple benefits requires new policies, programs, metrics, and tools; and (4) accelerating early change-outs of water fixtures can provide substantial incremental water, energy, and greenhouse gas benefits.

Recommended actions to address challenges to building drought resilience include creating statewide distributed water resources program; accelerating retirements of inefficient water fixtures; leveraging state programs to improve data on water supplies and uses; and establishing centers of excellence in technologies that achieve California's vision for a clean and resilient future. Estimated annual benefits of these actions include savings of more than 30 billion gallons of water, nearly 60 gigawatt-hours of electricity, and 866 million pounds of carbon dioxide-equivalent emissions.

Keywords: market facilitation, drought resilience, water and energy savings, electric reliability, greenhouse gas emissions, drought resilient technologies, multi-benefit projects, comprehensive valuation, optimized public investments

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EXECUTIVE SUMMARY

Project Purpose

Although California has experienced many periods of drought, 2012 through 2015 were the driest four consecutive water years in the state's recorded hydrological history. Hardest hit were communities in California's Central Valley, particularly Fresno, Kern, Kings, Madera, and Tulare counties in the South San Joaquin Valley.

Given the urgency of building drought resilience, this project focused on identifying technologies that can achieve substantial water benefits within three years while also increasing electricity reliability and reducing greenhouse gas emissions. The geographic focus was Tulare County, the largest agricultural producing county in California and the county most severely impacted by the ongoing drought.

California's agricultural sector is vital to the state's economy and relies on water, as well as affordable and reliable supplies of energy. According to the California Department of Water Resources, agriculture accounts for about 45 percent of all water used within the state during normal water years. In 2015, however, agriculture in Tulare County accounted for 95 percent of net water use during 2015, a very dry year, and 86 percent during 2002, a close to normal water year.

> "Prior to 2017, California had experienced a decade of largely dry conditions. Eight of the ten preceding water years were dry, and the water years of 2012-15 set a record for the driest consecutive four-year period of statewide precipitation."
>
> *Water Year 2017: What a Difference a Year Makes*, California Department of Water Resources, September 2017.

Reducing water and energy use in California's agricultural sector contributes to California's goals to mitigate the effects of drought and to ensure reliable, affordable supplies of electricity for the state's inhabitants.

Project Process

The project team conducted both primary and secondary research over two years to identify technology needs and candidate solutions that could build drought resilience, support electric reliability, and reduce greenhouse gas emissions in Tulare County and the surrounding South San Joaquin Valley area. Southern California Edison provided electric data and information about new and emerging water-related technologies with electricity benefits. A Technical Advisory Committee comprised of individuals knowledgeable about California's water, energy, and climate policies, regulations, codes and standards recommended strategies for effective engagement of Tulare County stakeholders. Numerous subject matter experts provided information about candidate technologies and anticipated implementation challenges.

Guided by local team members' insights about regional issues and priorities, the project team searched for high potential technology solutions. Secondary research was supplemented with

facility tours, workshops, and interviews with key stakeholders along all segments of the technology adoption cycle.

Priority attention was given to existing and emerging technologies that could be fast-tracked for near-term, cost-effective benefits. Candidate solutions were assessed to determine their state of technology readiness and anticipated implementation barriers. A wide network of stakeholders—local government officials, business owners, industry associations, community-based organizations—recommended changes to policies, regulations, legislation, financing, and programs needed to accelerate implementation of high potential drought resilient solutions.

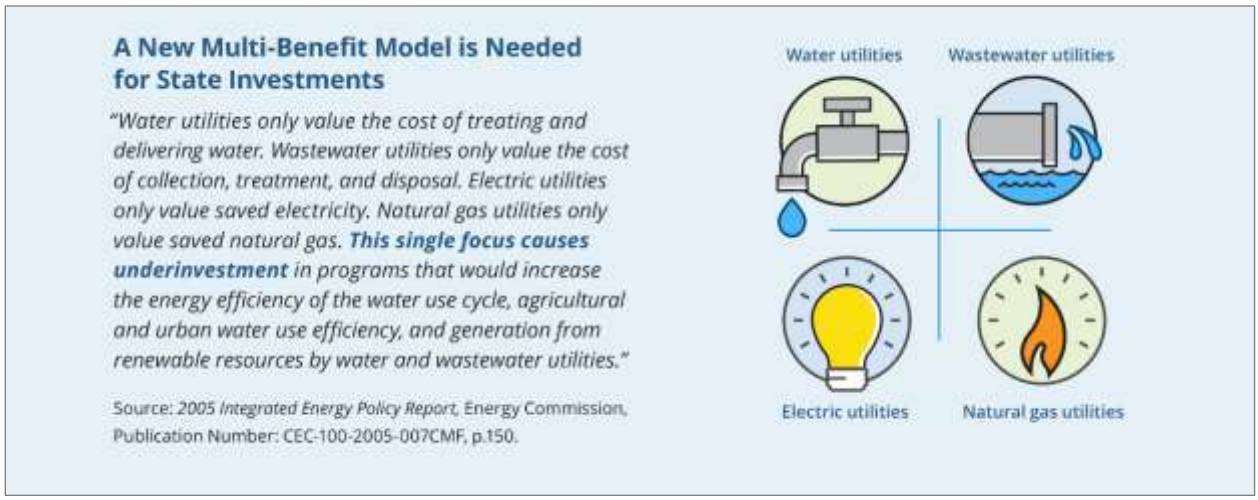
Project Results

Stakeholders throughout Tulare County and the surrounding region shared their insights and perspectives about the region's drought challenges and potential solutions. Three common themes emerged:

1. Many high potential drought resilient technologies exist today that could begin achieving substantial water, energy, and greenhouse gas emissions benefits within three years or less. Some technologies are relatively simple to implement and may be cost-effective without need for subsidy or incentives; others may need incentives, subsidies, or low interest loans to mitigate the costs and risks of adoption by water and wastewater utilities and their customers.
2. Building drought resilience requires that customers make investments and take risks. Most drought resilient technology opportunities involve actions and investments by water users in water conservation and efficiency, on-site wastewater treatment, or on-site production and use of recycled water. These customer-side strategies alleviate pressure on centralized municipal water and wastewater treatment systems. Over time, less municipal water and wastewater treatment capacity will be needed, reducing capital and operating costs of centralized municipal water and wastewater systems. In many cases, customer-side actions also reduce electric consumption and associated greenhouse gas emissions from centralized water and wastewater utility systems and operations.
3. Optimizing public investments in cross-cutting projects, programs, and strategies that achieve multiple benefits requires new policies, programs, metrics, and tools. Presently, the state invests in individual resources on a separate basis. Accelerating drought resilience will require new business models that enable optimizing state investments on a holistic, comprehensive basis that cuts across water, energy, and climate boundaries (Figure ES-1).

The project team's conclusion was that there is no lack of technically viable solutions; the primary barriers are technology adoption costs and risks.

Figure ES-1: Multi-Benefit Investment Model



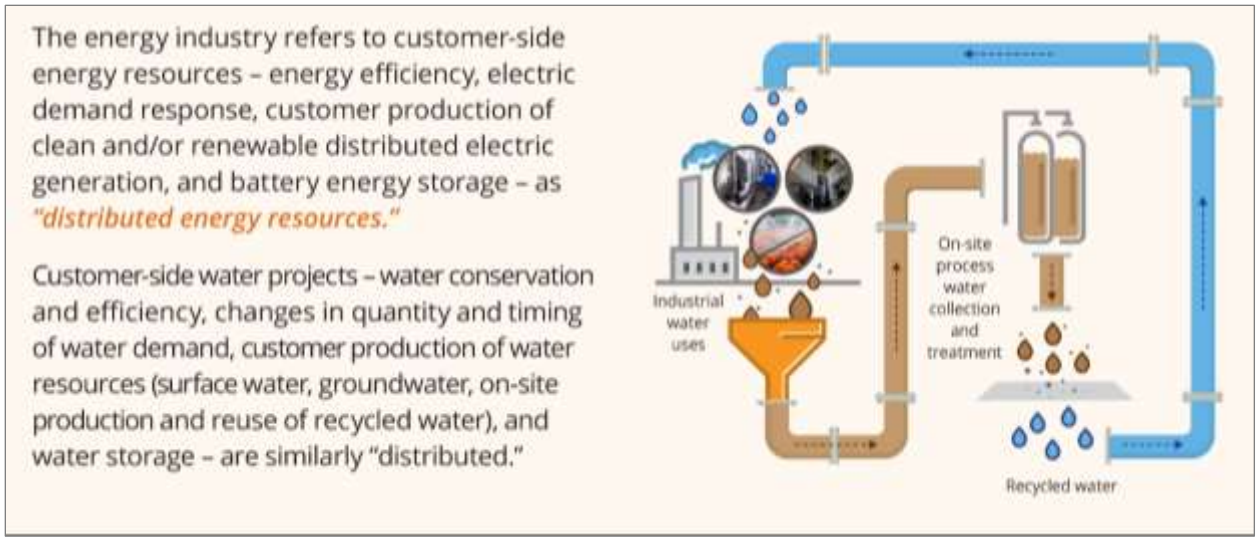
Source: 2005 Integrated Energy Policy Report, California Energy Commission.

Key Findings

The project team's recommendations are based on the following findings.

First, there is no statewide program to help mitigate customers' costs and risks for investments in distributed water resources (Figure ES-2).

Figure ES-2: Distributed Water Resources



Source: Water Energy Innovations, Inc.

California's water utilities develop, fund, and implement their own customer-side water conservation, efficiency, and recycled water programs. This is both unreliable and economically inefficient since California has thousands of water agencies of many types—municipal agencies, special districts, investor-owned water corporations, mutual water companies, and community water systems. Most are very small and do not have funds or staff to develop and manage

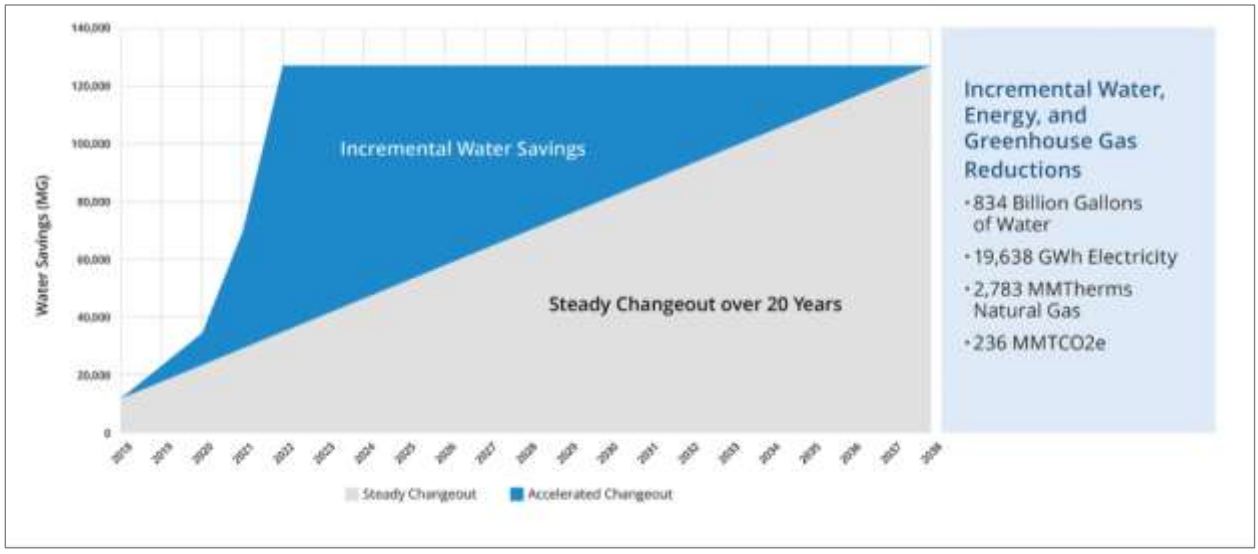
customer programs. In addition, since costs for water and wastewater services are much lower than those for energy services, it is difficult for individual water and wastewater utilities to raise sufficient funds to support customer-side distributed water projects solely through water and wastewater surcharges.

Second, although California has a critical need to build drought resilience, public investments in development of distributed water resources are low. The amount of water sector investments in customer conservation, efficiency, and recycled water development is unknown, but water conservation investments made by large wholesale urban water suppliers and their member agencies indicate that investments may be about 10 percent of average annual investments made by electric utilities for comparable purposes.

Third, optimizing public investments in cross-cutting projects, programs, and strategies that achieve multiple benefits requires new policies, programs, metrics, and tools. Presently, the state invests in individual resources on a separate basis. Accelerating drought resilience will require new business models that enable optimizing state investments on a holistic, comprehensive basis—cutting across water, energy, and climate boundaries.

Finally, substantial incremental water, energy, and greenhouse gas benefits are achievable by accelerating early change-outs of water fixtures. Title 20 Appliance Efficiency Regulations requires sellers of fixtures, appliances, and equipment to certify that products "sold or offered for sale" in California comply with then-current code (Figure ES-3).

Figure ES-3: Incremental Statewide Benefits by Accelerating Title 20 Change-outs



Source: Water Energy Innovations, Inc.

Title 20 does not require that all fixtures and appliances be brought up to code by a certain date, except that properties offered for sale must bring their fixtures and appliances up to code prior to sale or disclose that the fixtures are not in compliance. Studies conducted by Energy Commission staff estimate that incremental annual water, energy, and greenhouse gas emissions benefits that will be achieved by 2038, the year during which "full turnover" of non-

compliant fixtures is expected, exceed estimated 2018 benefits by a factor of 10. Substantial incremental water, energy, and greenhouse gas emissions benefits could be achieved by bringing existing fixtures into compliance as soon as possible.

Recommendations

The project team's recommendations reflect the insights shared by multiple key stakeholders.

- Create a statewide distributed water resources program. State programs can be leveraged now to support customer-side water conservation and efficiency and development of on-site recycled water production and use, while the process of developing the needed policies, programs, and funding to support such a comprehensive statewide program proceeds in parallel. For example, California could:
    - Convert historical state policies governing investments of public funds from a "compliance" mindset, to a comprehensive public benefits perspective that employs new metrics valuing all resource, environmental and economic benefits on a holistic statewide basis and enables optimizing public funds in a manner that rewards multiple benefits.
- Award preference points for water and wastewater infrastructure grants to public agencies that commit to establish technical and/or financial assistance programs that help their customers purchase and install distributed water resource systems.
    - Implement a pilot program that combines funds from electric, gas, water, wastewater, and greenhouse gas emissions reduction programs to help water customers implement high priority drought resilient measures that achieve multiple benefits.
    - Create a Water Investment Loan Fund that streamlines access to low interest loans to water users that are willing to make investments in distributed water resource projects.
    - Help water and wastewater utilities mitigate the costs and risks of assets that may become stranded when encouraging customers to develop on-site distributed water resources and systems.
- Accelerate retirements of inefficient water fixtures by:
    - Funding accelerated retirements of water fixtures that are not yet compliant with the 2015 Title 20 Appliance Efficiency Regulations and its successors.
    - Considering all water, energy, and greenhouse gas benefits when determining which funds can be used to achieve early retirements of non-compliant water fixtures.
    - Modifying state policies, programs, and funding to enable investing in early retirements as "procurements" of resource and environmental benefits (differentiated from "utility incentives" that protect ratepayers from over-investing in measures that are expected to occur at a future date without intervention).

    - Continuing to increase water and energy efficiency and greenhouse gas reductions through continuous upgrades to codes and standards.
- Leverage state programs to improve data about water supplies and uses. There is little reliable and current data about the amount of water needed by commercial and industrial customers by type of end use. Every grant, subsidy or incentive provided to a water user is an opportunity to collect information. Water and wastewater agencies that receive state funds should also provide information about water use by industry sector and customer or business segment. More granular and current water use data will streamline both the cost and time to match candidate technology solutions to targeted adopters. Better data will also improve estimates of potential water and energy savings, and energy related greenhouse gas reductions, providing a rational basis for determining the appropriate level of state investment in projects and technologies.
- Establish centers of excellence in technologies that achieve California's vision for a clean and resilient future. California drives technology advancement through visionary policy goals that are supported with billions of dollars in public investments. This rare combination of policy commitment and investment distinguishes California from many entities, both public and private, that may have ambitious goals but lack either the resources or the commitment needed to build markets and industries. California is ideally positioned to serve as a global center for collaborative research, development, and commercialization of products and technologies needed to achieve the state's vision for a clean, healthy, affordable, and resilient future.

Benefits to California

The "Big Three": Water, Energy, and Climate

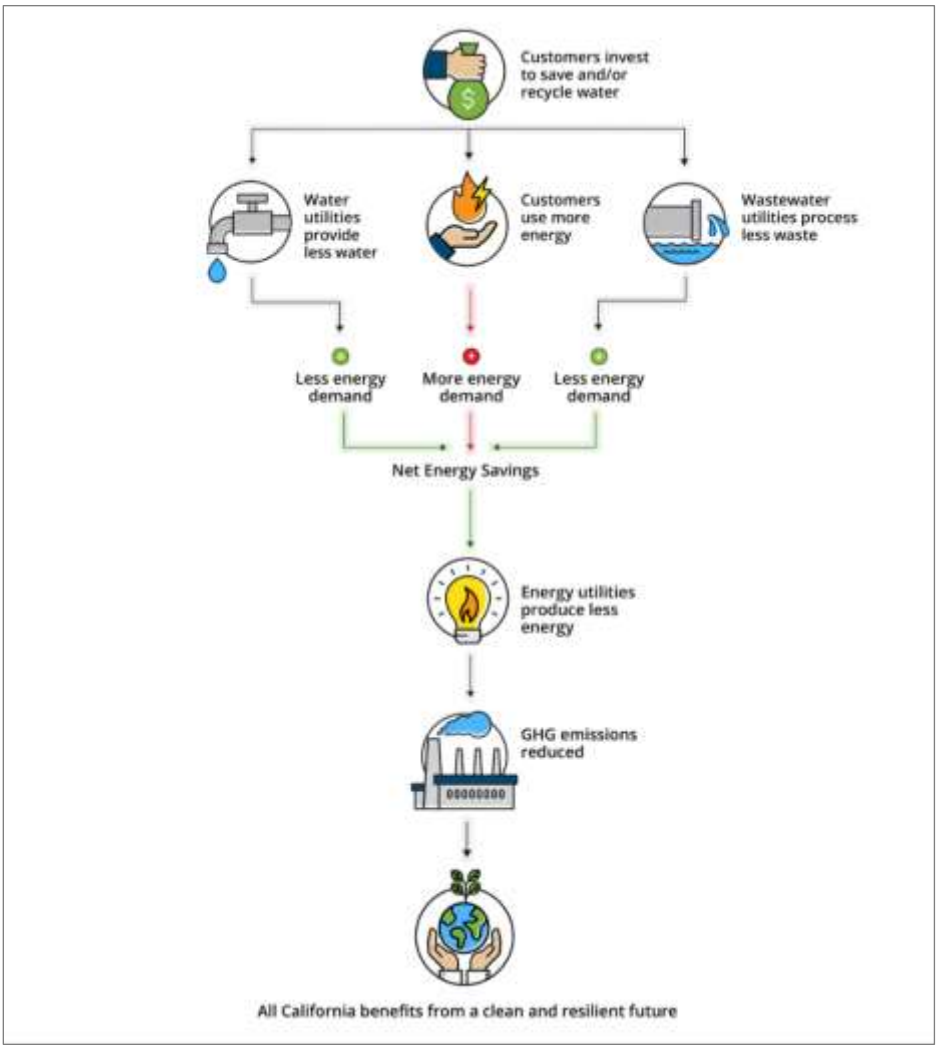
Optimizing investments requires a holistic perspective on total net benefits (Figure ES-4). Evaluated solely from the perspective of a single resource or single customer site, California's current policies discourage customers from investing in distributed resources. When water users invest in onsite collection, treatment, and recycle/reuse of their own wastewater, they increase electric use at their site since they are now performing functions that would otherwise be performed by centralized municipal water and wastewater treatment facilities. Customer-side water treatment, recycle and reuse projects thus become ineligible for electric efficiency incentives.

This single resource, single-site impact model ignores the true benefits to California:

- A water user makes an investment to treat, recycle, and reuse their own wastewater, substantially reducing its potable water demand and reducing municipal wastewater treatment.
- The water utility reduces its energy use by reducing the amount of water it needs to supply, treat, and deliver.

- The wastewater utility reduces its energy use by reducing wastewater collection and treatment; and, where applicable, also reduces energy associated with production and delivery of recycled water.
- Greenhouse gas emissions are reduced by the amount of statewide electric savings.

Figure ES-4: Benefits to Investing in Distributed Resources

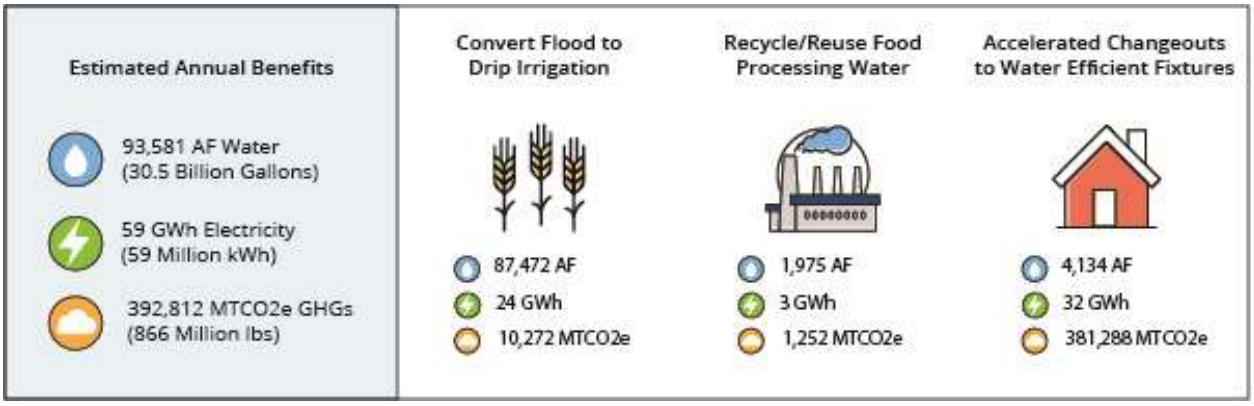


Source: Water Energy Innovations, Inc.

The net impacts for California are thus positive.

The potential water, energy, and greenhouse gas benefits that can be achieved by implementing the recommendations in this report are substantial. Figure ES-5 summarizes annual savings benefits that can be reached in Tulare County alone by implementing just three of the technology solutions and strategies identified in this report.

Figure ES-5: Estimated Annual Savings Benefits from Technology Solutions and Strategies



Water savings from these three technology solutions exceed Tulare County's annual urban water demand.

Source: Water Energy Innovations, Inc.

The estimates of electric and greenhouse gas emissions benefits are conservative. The first two examples in the figure—converting flood irrigation to drip and recycle/reuse of food processing water—only consider the estimated amount of electricity embedded in water, and the greenhouse gas emissions associated with embedded electricity, that could be reduced by saving the water. The third example—benefits of accelerated change-outs to water efficient fixtures—shows high electric and greenhouse gas emissions savings relative to the quantity of water saved because it includes estimated energy inputs and related greenhouse gas emissions that would be avoided (saved) by reducing use of hot water. These estimates were computed by Energy Commission staff in support of the 2015 updates to California's Title 20 Article 4. Appliance Efficiency Regulations that includes codes and standards for water fixtures.

Additional Benefits

California advances its market leading water, energy, and climate policy goals through continual enhancements to policies, codes and standards, supported by billions of dollars of public investment. California's commitment to a drought resilient and clean energy future has already driven technology innovation in multiple key markets: energy efficient lighting, solar photovoltaics, battery energy storage, and water efficient fixtures. There is every reason to expect that when California establishes performance standards for agricultural water efficiency, sustainable groundwater management, groundwater quality, and greenhouse gas emissions, technology developers and markets will rush to accept the challenge, bringing new industries and jobs.

Knowledge Transfer

The research, data, analyses, insights, tools, and other work products developed by this project, including video interviews of diverse stakeholders and the project recommendations, are on the project website: http://droughtresilience.com.

The project team designed an online toolkit to accelerate the implementation of technologies that can eventually achieve long-term water supply reliability. The toolkit provides technology solutions and recommendations to ensure drought resiliency for California by organizing the

project's findings and recommendations and presenting them in an easy-to-access format, allowing the entire state of California to utilize the information. These technology solutions and recommendations facilitate drought resiliency by increasing agricultural, commercial and industrial, residential and outdoor urban water use efficiency. The toolkit presents the project's research and work products, including technology profiles; financing opportunities and barriers; key water legislation within the state; and multiple stakeholder interviews.

CHAPTER 1: Introduction

On January 14, 2014, Governor Edmund G. Brown, Jr. issued a proclamation declaring a drought state of emergency.[1] At the time, California was well into its fourth consecutive year of "critically dry" hydrological conditions. By the spring of 2015, it was clear that drought relief was not on the horizon. The April 1, 2015 snow course measurement, a key indicator of California's water supplies, shown in Figure 1, reported that the Sierra snowpack water content was about 25 percent of "normal" ("historical average" for that time of year).[2] The same day, Governor Brown issued an Executive Order implementing mandatory statewide urban water use reductions and restrictions on water waste.[3]

Figure 1: Snow Course Measurement

Left to right: Frank Gehrke, chief of the California Cooperative Snow Surveys Program for the Department of Water Resources; Governor Edmund G. Brown, Jr.; Mark Cowin, then director of the Department of Water Resources. Where typically snow would be 5-6 feet high, there was none on April 1, 2015 (Nagourney, Adam. *California Imposes First Mandatory Water Restrictions to Deal With Drought*. New York Times (New York, NY), April 1, 2015.)

Photo credit: AP Photo/Rich Pedroncelli, APImages 268351470709.

April 1, 2016, showed an increase to 85 percent of normal. On April 7, 2017, with substantially higher than average precipitation throughout most of the state, the Governor lifted the Drought

1 Governor Edmund G. Brown, Jr. Press Release: *A Proclamation of a State of Emergency.* January 17, 2014.

2 Summary of Water Conditions. *Department of Water Resources Bulletin 120.* https://cdec.water.ca.gov/snow/bulletin120/b120apr15.pdf.

3 Governor Edmund G. Brown, Jr. *Executive Order B-29-15.* April 1, 2015.

Emergency Declaration for all but four counties: Fresno, Kings, Tulare, and Tuolumne.[4] Although Tulare County's precipitation index for water year (WY) 2017 was 162 percent, the county remained under a drought emergency. April 1, 2018 indicated a return to dry conditions, with snowpack water content at about 60 percent of normal.

Presently, California has entered yet another dry year. The California Department of Water Resources (CDWR) May 1, 2018 report predicted that WY2018 would end at about 75 percent of historical average.[5] Water years record hydrology from October 1 through September 30, so WY2018 represents total precipitation from October 1, 2017 through September 30, 2018.

Is the Drought Over?

CDWR defines "drought" as "Hydrologic conditions during a defined period, greater than one dry year, when precipitation and runoff are much less than average."[6] CDWR further explains that "Defining drought is based on impacts to water users. … Hydrologic conditions causing impacts for water users in one location may not represent drought for water users in a different part of California, or for users with a different water supply."[7]

CDWR's definition provides important context. "Drought" is not determined merely by counting the number of consecutive years during which precipitation has been less than "historical average," nor is there a single statewide drought benchmark. With hundreds of microclimates and unique water resource portfolios throughout the state, just as occurred during WY2017, some areas may experience "drought," while others are addressing flood risks.

Tulare County is a marked example. The county typically experiences considerably less precipitation than many other areas in California. In addition, there is little diversity in the county's water resource portfolio, leaving residents and businesses vulnerable to shortages of surface water and groundwater. Residents that are wholly dependent on a single resource (groundwater) are susceptible to health and safety risks when wells fail. At the height of drought impacts, the Tulare County Office of Emergency Services reported 1,988 well failures.

The CDWR recorded two "droughts" over the past ten years: one from 2007-2009,[8] and a second that started in 2011 (WY2012) that was declared "over" five years later during spring of WY2017 for "most" of the state.[9] The Governor's drought emergency declaration is a policy tool that enables bringing funding and other types of emergency assistance. It is important to note that the Governor's 2017 Executive Order declaring an end to the emergency specifically

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4 Governor Brown. *Executive Order B-40-17*. April 7, 2017.

5 Department of Water Resources Bulletin 120, *Summary of Water Conditions*. https://cdec.water.ca.gov/snow/bulletin120/b120may18.pdf.

6 California Department of Water Resources, *California Water Plan Update 2013 Glossary*, (Sacramento, CA, 2014), 11.

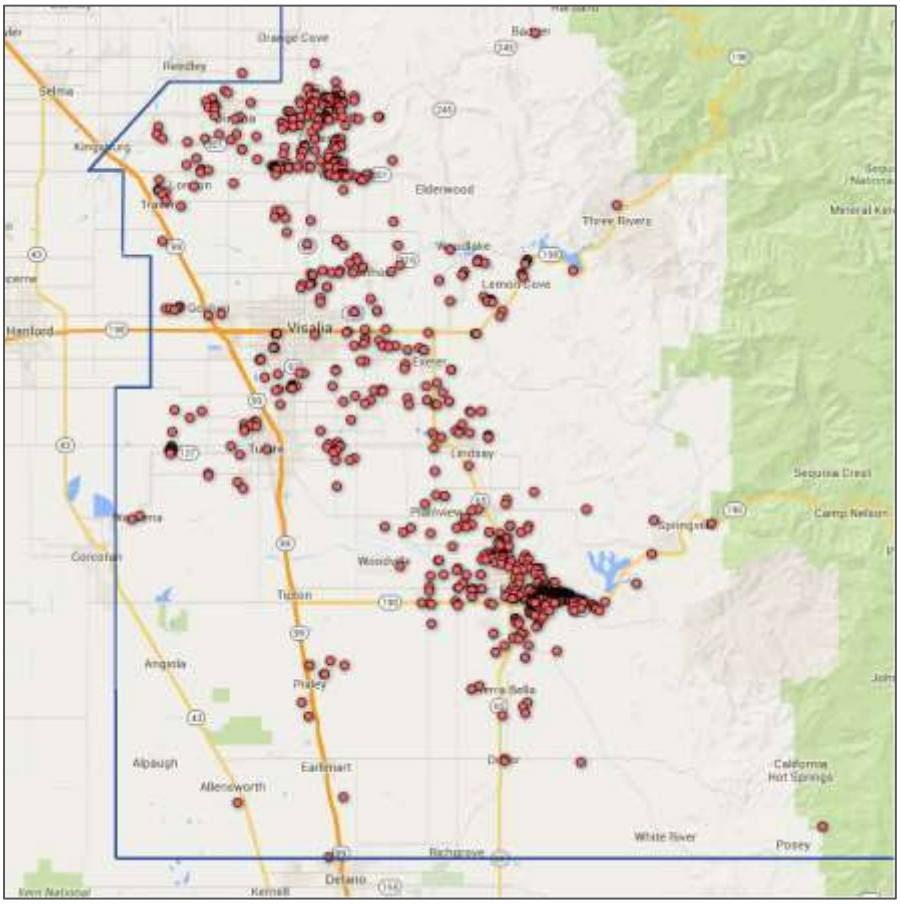
7 California Department of Water Resources, *Drought*, https://www.water.ca.gov/Water-Basics/Drought.

8 California Department of Water Resources, *California's Drought of 2007-2009, An Overview*, 2010.

9 Governor Brown's Executive Order B-40-17 lifted the drought emergency in all California counties except Fresno, Kings, Tulare and Tuolumne, where emergency drinking water projects continue to help address diminished groundwater supplies. *Governor Brown's Office Press Release*. April 7, 2017.

exempted four counties—Fresno, Kings, Tulare, and Tuolumne—that continued to experience significant public health challenges in some areas.

Figure 2: Reported Well Failures in Tulare County as of November 2, 2015



Source: Tulare County Office of Emergency Services, Report for Week of November 2, 2015

In Tulare County, the 2007 drought ran into the 2012 drought and when this report was written, it was still ongoing as water deliveries continue to communities that have no access to water. WY October 2017 through September 2018 is continuing the dry cycle, with precipitation to-date at 61 percent of historical average.[10] Since there is typically little additional precipitation from now through fall, it is highly likely that Tulare will finish the current water year substantially below "normal."

Tulare County's Drought Circumstance

Tulare County occupies 4,839 square miles in South San Joaquin Valley. It is bounded on the north by Fresno, to the west by Kings, and to the south by Kern. Tulare, Kern, Kings, and Fresno

10 Compiled from data downloaded from the National Centers for Environmental Information (NCEI, previously known as the National Climate Data Center, administered by the National Oceanic and Atmospheric Administration, U.S. Department of Commerce): https://www.ncei.noaa.gov/.

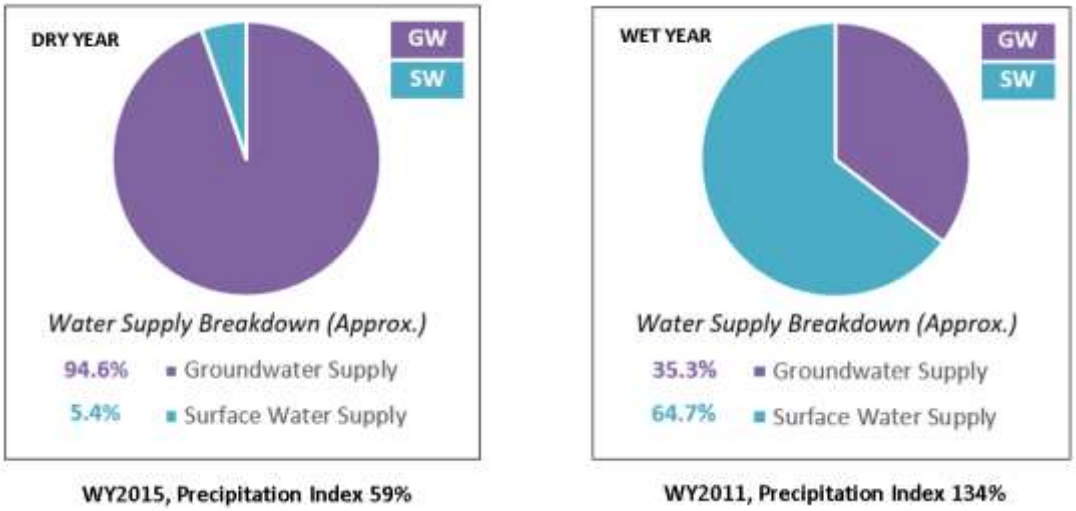
comprise 4 of the 5 counties referred to collectively as "South San Joaquin Valley." Madera, on the northern border of Fresno, is the fifth.

As of July 2017, Tulare County's population was 464,500.[11] The county's population density is relatively low, on average less than 100 people per square mile. The county is the largest agricultural producing county in California.

Water Resources

Tulare County has two primary water sources: surface water and groundwater. The specific mix of surface to groundwater used during any year depends on precipitation: much more surface water is used during wet years, and much more groundwater is used during dry years.

Figure 3: Groundwater versus Surface Water Supply Use in Dry versus Wet Year



Source: California Department of Water Resources Water Supply & Balance Data Interface Tool, LITE v.9.1.

During wet years (precipitation index greater than 100 percent), more surface water is used, reducing groundwater pumping and withdrawals from deep percolation.[12] During dry years, the inverse occurs.

The Critical Role of Groundwater

Tulare County is one of five counties at the southern end of the state's Central Valley region. These five counties, known collectively as "South San Joaquin Valley," have experienced substantial land subsidence,[13] primarily due to over pumping of groundwater aquifers that caused compaction of the aquifers. As a result, groundwater volumes decrease and depth to

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11 "QuickFacts." *U.S. Census Bureau.* July 1, 2017. https://www.census.gov/quickfacts/fact/table/tularecountycalifornia/PST045217.

12 "Deep percolation" refers to water that percolates the ground beyond the lower limit of the root zone of plants into groundwater. Source: Department of Water Resources (*DWR) Water Supply & Balance Data Interface Tool, LITE v.9.1.*

13 "Land subsidence is a gradual settling or sudden sinking of the Earth's surface owing to subsurface movement of earth materials." *Land Subsidence in California.* U.S. Geological Survey. July 8, 2018. https://ca.water.usgs.gov/land_subsidence/.

groundwater increases, making it more difficult, energy intensive, and costly to pump groundwater.

As shown in Figure 3, these five counties, with very high water demands in critically overdrafted groundwater basins, need to become drought resilient as soon as possible. All have experienced substantial land subsidence due to over-pumping of groundwater basins, are contending with significant water quality concerns due to decades of agricultural runoff carrying fertilizers and pesticides into groundwater basins and into natural waterways, and have had significant dry hydrology over the past ten years.

Of the five South San Joaquin Valley counties, Tulare experienced the most serious drought impacts. Tulare has little diversity in its water supply portfolio, meeting most of its urban water demand with groundwater. About 44 percent of the county's residential customers—205,000—are served by 41 small community water systems.[14] Ninety nine percent of the water provided to residents by community water systems is groundwater.[15] The State Water Resources Control Board (SWRCB) found that 40 percent of tested wells by community water systems exceeded the Maximum Contaminant Level (MCL) for nitrates. Tulare had a further daunting challenge: thousands of residents who relied upon a private well as their sole water resource had no drinking water when wells went dry.

These factors, combined with very low annual precipitation over the past ten years, created serious problems for the county and its residents. Residents in remote areas that historically provided their own water supplies had no groundwater to pump. The challenges to East Porterville, an unincorporated area of the county adjacent to the City of Porterville, were well publicized, both locally and nationally. The state Office of Emergency Services trucked water to residents left without enough water to meet critical needs for drinking, cooking, and sanitation. While the state has worked closely with local governments to expedite connection of residents to municipal water systems, water deliveries continue today to some communities.

Recycled Water

In 2015, the SWRCB conducted a municipal wastewater recycling survey in conjunction with CDWR. The purpose of this survey was to estimate the quantity of municipal recycled water produced and beneficially reused statewide.[16] Cities in Tulare County reported 18,537 acre-feet (AF) of recycled water used for agricultural irrigation, primarily secondary undisinfected wastewater effluent. The estimated potential for tertiary treated municipal recycled water is 33,500 AF per year.

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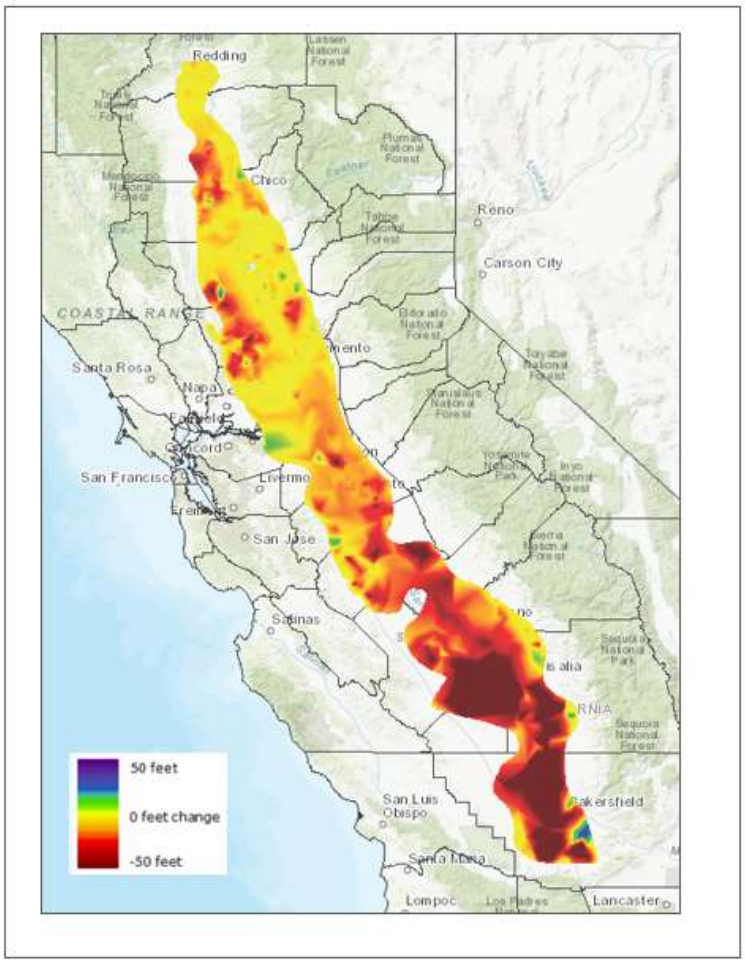
14 *California Health and Safety Code Section 116275(i)* defines a "community water system" as a public water system that serves at least 15 service connections used by yearlong residents or that regularly serves at least 25 yearlong residents of the area served by the system.

15 State Water Resources Control Board Report to the Legislature. *Communities that Rely on a Contaminated Groundwater Source for Drinking Water*. January 2013.

16 *Municipal Wastewater Recycling Survey*. State Water Resources Control Board's website: https://www.waterboards.ca.gov/water_issues/programs/grants_loans/water_recycling/munirec.shtml.

Figure 4: Changes in Groundwater Elevations (Water Years 2011-2016)



Note that except for a very small blue area in Kern County and several green areas in Tulare and Kern, groundwater elevations decreased considerably since water year 2011 (red areas).

Source: California Department of Water Resources. Groundwater Information Center Interactive Map Application, https://gis.water.ca.gov/app/gicima/.

For health reasons, undisinfected secondary effluent is used primarily for groundwater recharge or for agricultural irrigation.

California's Water Code limits application of undisinfected secondary effluent to non-food crops or crops in which the water has no direct contact with the edible portion of the plant. Undisinfected secondary effluent must be applied in a manner that does not allow people to come into direct contact with the effluent. For this reason, undisinfected secondary effluent cannot be used to displace many types of uses of potable water for nonpotable uses, such as for irrigating parks and playgrounds, school yards, residential landscaping, and unrestricted access golf courses.[17]

The four largest urban wastewater treatment plants (Cities of Visalia, Porterville, Tulare, and Dinuba) treat 80 percent of the county's wastewater, a combined volume of 13.4 billion gallons

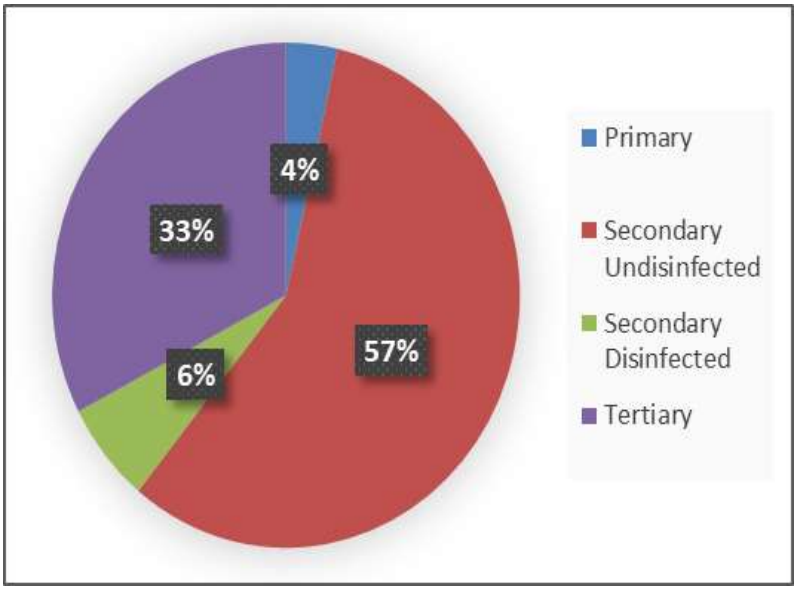
17 California Code of Regulations, Title 22, § 60304. *Use of Recycled Water for Irrigation.*

annually. Until recently, 90 percent of the wastewater was treated to secondary undisinfected quality.

Increased awareness of the need to build local supplies for drought resilience have resulted in many urban areas now treating their wastewater to tertiary standards, at a minimum, to enable using recycled water to displace use of valuable potable water supplies for non-potable purposes. Tertiary treated effluent can be used in urban areas with frequent human contact, such as to irrigate parks and golf courses. It can also be used for both food and non-food agricultural irrigation and groundwater injection.

In 2017, the City of Visalia completed the county's first tertiary wastewater treatment plant that now treats 33 percent of the county's wastewater effluent (see Figure 5). Secondary undisinfected effluent still accounts for the largest volume (57 percent), but the cities of Porterville and Tulare plan to upgrade their systems to tertiary. When those upgrades are complete, nearly 90 percent of the county's urban wastewater will be tertiary quality.

Figure 5: Wastewater Effluent Quality in Tulare County



Source: Water Energy Innovations, Inc.

Technological advances in water filtration and disinfection have led to a fourth "purification" stage with advanced filtration and ultraviolet disinfection of tertiary treated wastewater.[18] The SWRCB is considering new regulations that would allow this new "purified" water resource to directly augment potable water supplies. Please see the SWRCB water reuse definitions below for details.

18 Orange County Water District's Groundwater Replenishment System and the City of San Diego's Purewater System are examples of supplies that already apply advanced filtration and additional disinfection to tertiary treated wastewater. Sources: "GWRS—new water you can count on", Orange County Water District website: https://www.ocwd.com/gwrs/ and "Pure Water San Diego", City of San Diego website: https://www.sandiego.gov/water/purewater/purewatersd.

Water Reuse Definitions

Direct potable reuse (DPR) - There are two forms of DPR. In the first form, purified water from an advanced treatment facility is introduced into the raw water supply immediately upstream of a water treatment plant. In the second form, finished water is introduced directly into a potable water supply distribution system, downstream of a water treatment plant.

Indirect potable reuse (IPR) - In IPR, purified water from an advanced water treatment facility is introduced into an environmental buffer, such as a water body upstream from the intake to the drinking water facility, for a specified period of time before being withdrawn for potable purposes (see also de facto potable reuse).

De facto potable reuse - The downstream usage of surface waters as sources of drinking water that are subject to upstream wastewater discharges (for example, unplanned potable reuse).

Source: State Water Resources Control Board (SWRCB)

The Role of Technology in Building Drought Resilience

In its simplest terms, "drought resilience" is the ability to sustain extended periods of low precipitation without significant harm to people, the economy and the environment.

Successfully building "drought resilience", however, whether in Tulare County or anywhere else in the state, is a very complex issue—one that requires balancing competing interests and priorities among state, federal and local policies, rules, legislation and regulations governing public health and safety, the local and state economy, and the environment.

Clearly, Tulare County is not drought resilient: it was significantly impacted by multi-year periods of low precipitation, and the adverse impacts of the 2012-2016 (water years) drought continued in Tulare where water is still being delivered to residents that do not have water.

On a prospective basis, the outlook continues to be serious: while the state received above average precipitation during WY2017[19] (in some places, far too much precipitation, which changed the state's emergency focus from drought to flood), WY2018 is back to "dry." One wet year cannot replenish the groundwater supplies that Tulare and other counties in San Joaquin Valley have relied upon for decades.

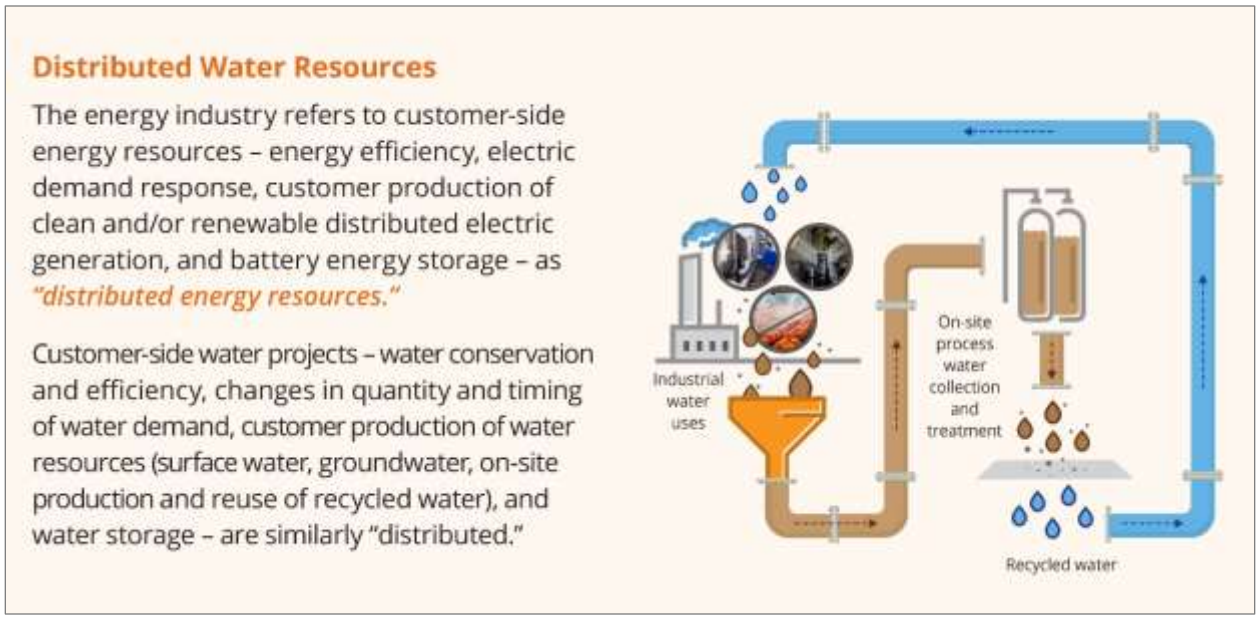
Technology Solutions can Accelerate Drought Resilience

Unlike strategies that require new or enhanced water and wastewater infrastructure that can take multiple years to implement, many customer-side strategies and technologies can be implemented by water customers within a fraction of the time and cost. Given the much shorter lead time to implement and potential to substantially increase efficient use of existing water

19 Water Year 2017 runs from October 2016 through September 2017.

supplies, California should fast-track "distributed water resources": water efficiency (also known as "demand side management") and customer-side wastewater treatment and recycled water production. Figure 6 defines the term "distributed water resources" and illustrates the process.

Figure 6: Districted Water Resources: On-Site Treatment, Recycle and Reuse



Source: Water Energy Innovations, Inc.

For purposes of "drought resilience", this project focused on identifying and qualifying potential technology solutions that can support the State Water Resources Control Board's broad scope as articulated in its mission statement; that is,

> "To preserve, enhance, and restore ***the quality of California's water resources and drinking water*** for the ***protection of the environment, public health, and all beneficial uses,*** and to ensure proper water resource allocation and efficient use, ***for the benefit of present and future generations***." [***emphasis added***]

That context is important, since merely assuring sufficient water to meet minimal human needs is not enough—water is also a vital resource for both economic stability (jobs) and for environmental protection. In fact, insofar as the quantity of water deemed appropriate to commit to protection of human health and safety, the state established a provisional standard of 55 gallons per capita per day (GPCD) for residential indoor water use by 2020. [Water Conservation Act of 2009, SB X7-7 20]

Market Facilitation

The California Energy Commission, which administers the Electric Program Investment Charge (EPIC) grant that funded this project, defines market facilitation as "… a range of activities, such as commercialization assistance, local government regulatory assistance and streamlining, market analysis, and program evaluation to support deployment and expand access to clean

energy technology and strategies."[20] This project was structured to achieve market facilitation by aligning the efforts of multiple diverse stakeholders along all segments of the technology adoption supply chain—from technology developers, to targeted adopters—under the unifying goal of increasing Tulare County's drought resilience.

In context of drought risk mitigation, there are two distinct types of strategies and technologies, differentiated primarily by the time needed to achieve targeted results:

- Near-term: strategies and technologies that can contribute significantly to drought resilience within 3 years.
- Long-term: strategies and technologies that will take more than 3 years to contribute significantly to drought resilience.

Both groups of strategies and technologies are essential, and ideally should proceed in parallel so that substantial near-term benefits can be achieved ("low hanging fruit") while concurrently building the path to long-term drought resilience.

Near-term strategies and technologies are those that can be achieved "today" or "tomorrow", such as those which:

- Have already been "proven":
    - Are past the research and development stage, and either pre-commercial or fully commercially available.
    - Have one or more successful full-scale installations at one or more facilities and for one or more applications.
- Do not require long-lead times for development and implementation:
    - Do not require California Environmental Quality Act (CEQA) or other types of permits and approvals that require multi-year studies and evaluations.
    - Do not require tremendous amounts of capital that require issuing public debt or some other long-lead time access to financing.
    - Are achievable within existing polices, laws, regulations, codes and standards.
- Can be readily assimilated into existing adopters' facilities, systems and operations:
    - The technology does not require acquisition of additional land or major reconfigurations of existing plant, equipment and/or people.
    - The strategy or technology can be readily integrated into existing facilities, systems and operations with minimal training of existing staff.

"Affordability" and "cost-effectiveness" will likely need to be determined on a case-by-case basis, since many high potential opportunities to save large quantities of water tend to be "customized" solutions (that is, need to be tailored for the specific site and application).

20 California Energy Commission, *EPIC Proposed 2018-2020 Triennial Investment Plan, April 2017*, Publication Number: CEC-500-2017-023-CMF.

Long-term strategies and technologies are those which will require several years for design and development, before implementation can even begin. These tend to have the following types of characteristics:

- The technology may have been "proven" in pilots but not yet adequately tested in full-scale applications.
- The types of applications for which a particular technology may be best suited have a lengthy development cycle, requiring one or more of the following:
    - CEQA or other types of permits and approvals that require multi-year studies and public hearings.
    - Large amounts of capital that require issuing public debt or other long-lead time financing.
    - Changes to state and/or local polices, laws, regulations, codes and standards.
    - Significant changes to existing facilities, systems and/or infrastructure (customer or utility-owned, some of which may require moving facilities, procuring additional land and/or rights-of-way, and so on).
- Require significant changes to the technology adopter's business and operations, including but not limited to:
    - Extensive hiring and training of new staff.
    - One or more fundamental changes to the technology adopter's historical business operations.
    - A substantial change in the organization's policies and corporate culture.

As for near-term strategies and technologies, "affordability" and "cost-effectiveness" will similarly need to be determined on a technology and application specific basis.

Summary of Findings

California Drought

- Drought is a condition of water scarcity accompanied by significant public health, safety, environmental, economic, and other impacts. It is not a scientific designation that can be made solely by counting the number of consecutive years during which precipitation has been less than "normal" (historical average).
- For that matter, historical average has limited usefulness in context of current and future expected water demand. It is a benchmark as to what has been observed during recorded hydrological history; but in California, "… hydrologic data cover a limited period of historical record—relatively few stream gauges have a period of record in excess of 100 years, and only a few precipitation records extend as much as 150 years."[21]

21 Department of Water Resources. *California's Most Significant Droughts: Comparing Historical and Current Conditions*. February 2015.

- Drought resilience must consider the amount of water supplies available to meet water demands over a certain amount of time, within a specific location. Tulare County's drought impacts highlighted the critical role of place in drought resilience—while most residents survived the drought with fairly minor inconveniences, some residents were left with no water at all.
- Building drought resilience requires re-examining both water supplies and water uses.
- A market and cultural change is underway. Where water users once believed that water should always be available upon demand, (1) state and local governments and water agencies are looking to water users to become proactive about reducing water use, and (2) water users within all sectors are becoming increasingly aware of their pivotal role in building drought resilience.

Tulare County's Drought Challenges

- The county has a dry climate, experiencing less annual precipitation than many other areas in California.[22]
- There is little diversity in the county's water resource portfolio, leaving residents and businesses vulnerable to shortages of surface water and groundwater. Groundwater supplies most of the county's urban water demand.[23]
    - During WY2015 (a dry year), nearly 95 percent of the water demand in Tulare County was served by groundwater.
    - All of the county's groundwater is pumped from aquifers identified by the California Department of Water Resources as critically overdrafted.
    - There has been considerable land subsidence throughout the county as a result of aquifer compaction due to groundwater depletion. Aquifer compaction makes it more difficult to store and retrieve groundwater supplies, and more energy intensive (because the groundwater elevations are lower).[24]
    - About 44 percent of the county's residential customers—205,000—are served by 41 small community water systems.[25] Ninety nine percent of the water provided to residents by community water systems is groundwater. [26]

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22 See *Appendix N: Tulare County's Water-Energy Nexus.*

23 See *Appendix N: Tulare County's Water-Energy Nexus, Table N-2. Water Supplies and Demand by Water Planning Year (TAF).*

24 "Land Subsidence: Cause and Effect." *U.S. Geological Survey*. https://ca.water.usgs.gov/land_subsidence/california-subsidence-cause-effect.html.

25 "'Community water system' means a public water system that serves at least 15 service connections used by yearlong residents or regularly serves at least 25 yearlong residents of the area served by the system." California Health and Safety Code, Division 104 Environmental Health, Part 12. Drinking Water, Chapter 4. California Safe Drinking Water Act, Article 1. Pure and Safe Drinking Water § 116275.

26 State Water Resources Control Board Report to Legislature. *Communities That Rely on a Contaminated Groundwater Source for Drinking Water*. January 2013.

- Residents that are wholly dependent on private groundwater wells are vulnerable to health and safety risks when wells fail. At the height of drought impacts, the Tulare County Office of Emergency Services reported 1,988 well failures.
- The State Water Resources Control Board (SWRCB) found that 40 percent of tested wells by community water systems exceeded the maximum contaminant level (MCL) for nitrates.[27]

Recycled Water

- The county's three largest municipal wastewater treatment facilities (the cities of Visalia, Porterville and Tulare) produce recycled water, primarily for agricultural irrigation and groundwater recharge.
    - In 2017, Visalia became the first city in Tulare County to produce tertiary recycled water at its wastewater treatment facility.
    - The cities of Porterville and Tulare currently discharge secondary undisinfected wastewater effluent to spreading basins for groundwater recharge and some agricultural irrigation. Both plan to produce tertiary treated recycled water in the future.
    - The primary constraint on beneficial use of tertiary treated recycled water is lack of recycled water distribution systems ("purple pipe") in Tulare County. Purple pipe infrastructure is a long-lead item that typically requires multiple years to design, finance, and construct. It is expensive to dig up existing streets and sidewalks to connect nonpotable water uses to recycled water.
- Some water users already recycle and reuse water multiple times. Since there is no requirement for customers to report this information, the quantity of water recycled and reused by water users is not known.

Building the Path to Drought Resilience

The 2012 drought[28] is not yet over for Tulare County—even though water year 2017 received more than "normal" precipitation, one wet year cannot make up for multiple dry years.[29]

In Tulare County, as in other areas throughout California, where residents rely upon a single water source and are not connected to municipal water systems, water demand side management (conservation and efficiency) can lessen the need for trucked or bottled water but will not solve the emergency. Atmospheric water generators (AWGs) that condense humidity

27 Ibid.

28 In terms of water years, what has been commonly referred to as the "2011-2016" drought, actually spanned water years 2012-2016 (October 2011 through September 2016).

29 See report *Figure 2. Groundwater vs. Surface Water in a Dry vs. Wet Year*; *Figure N-2. Historical Precipitation, Tulare Basin (Water Years 2001-2018)*; and *Figure N-3. Annual Precipitation in Visalia (Water Years 2006-2018).*

appear promising but are high energy consumers and low water producers, yielding small quantities of water at prices comparable to that of bottled water.

Pending future technology developments, residents served by a single groundwater well need at least one additional water supply to reduce risks to public health and safety. In the meantime, the state and county continue to deliver water to residents that have no other water supply options.

For purposes of this project, "drought resilience" is defined as increasing the ability to meet water demand and reducing vulnerability to adverse public health and safety, environmental, and economic impacts during periods of water supply shortage. Since the focus of this project is to increase drought resilience through technologies, traditional infrastructure approaches (for example, connecting residents to municipal water systems) were not addressed. Instead, the project focused on identifying technologies that could help to build drought resilience by reducing Tulare County's vulnerability to fluctuations in hydrology and short-term availability of traditional water supplies.

In this context, four primary water resource principles emerged:

1. The highest value water resource from the perspective of drought resilience is water use efficiency.
    a. Tulare County has two primary water resources: surface water and groundwater.
    b. There is little surface water storage capacity in Tulare County.
    c. Groundwater aquifers in Tulare County are critically overdrafted.
    d. Replenishment and potential restoration of the county's groundwater aquifers is a long-term strategy with uncertain results: one gallon of recharge does not equate to one gallon of groundwater supply.[30]

    The highest value water resource strategy is therefore to not use it at all—that is, to substantially reduce water use by increasing water conservation and efficiency, leaving as much groundwater in the ground as possible, and recharging aquifers whenever there is stormwater, urban water, unutilized recycled water, and other suitable water resources.

2. The second highest value water resource from a drought resilience perspective is recycled water production and use that reduces water demand, especially potable, both municipal and customer-side. Maximizing production and use/reuse of recycled water reduces both surface and groundwater withdrawals.
3. Runoff, whether urban or stormwater, should be collected and used, and treated if needed to reduce use of valuable potable water supplies for nonpotable uses.

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30 Bagnasco, Wendy and Kelly Bourque, Cristóbal Loyola Angosto, Lindsay McPhail, and Anna Schiller. "Multi-Benefit Approaches to Sustainable Groundwater Management A Framework for California's Groundwater Sustainability Agencies and Stakeholders." Bren School of Environmental Science & Management at the University of California, Santa Barbara. April 2018.

4. Groundwater recharge opportunities from natural flows (for example, stormwater runoff from precipitation events) should be maximized to the greatest possible extent.

These four principles guided the search for drought resilient technologies described in Chapter 2 and Appendix H, Drought Resilient Technologies.

CHAPTER 2:
Drought Resilient Technologies

A wide variety of technology solutions are available today that can quickly put the state on a path to drought resilience, as shown in Table 1. Retrofits or expansions of municipal water and wastewater infrastructure typically require multiple years to plan, finance, design and construct. On the other hand, many customer-side water-efficient technologies can be implemented within a fraction of the time and cost because they are much smaller in scale and complexity, and often do not require long lead time (multi-year) environmental permits.

Table 1: Examples of Distributed (Customer-Side) Water Resource Solutions

TECHNOLOGY SOLUTIONS	SECTOR			
	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	AGRICULTURAL
On-Site Recycle/Reuse of Stormwater, Wastewater, Greywater, Process water, Irrigation Runoff	Stormwater & Greywater		Process Water	Indoor Agricultural Irrigation
Efficient Plumbing Fixtures	Toilets, Faucets, Aerators, Showerheads			Drip & Other Types of Water-Efficient Irrigation Systems
Water & Energy Management Systems	"Smart" Meters with Climate or Weather-Based Controllers			

Source: Water Energy Innovations, Inc.

Given the much shorter lead time to implement and the potential to substantially increase beneficial use of existing water supplies, these types of customer-side strategies are critical in addressing drought issues.

To facilitate matching to potential applications, candidate technology goals are organized by type of technology solution.

Table 2: Types of Drought Resilient Technology Solutions

Technology Solution	Technology Goal
Water Use Efficiency	Reduce Quantity of Water Needed to "Do the Same Work"
Reduce Use of Potable Water for Non-Potable Uses	Reduce Use of Potable Water for Non-Potable Purposes
Increase Local Water Supplies	"Make" Additional Water Supplies by Treating Otherwise Unusable Water Resources to Levels Suitable for Beneficial Use/Reuse
Water Management Tools	Provide Monitoring and Analytical Tools for Enhanced Decision-making about Water Use

Source: Water Energy Innovations, Inc.

The drought resilient solutions described herein were identified with the assistance of both technology developers and technology adopters (water users). Recommended technology solutions listed in Table 3 are described below, along with examples of some candidate technologies that appear to offer substantial benefits for the county and its constituents.

Water Use Efficiency

Like energy, the lowest cost and fastest approach to addressing water supply challenges is often to reduce consumption through a combination of conservation and efficiency.

- "Conservation" implies conscious behavioral changes by water users, such as choosing to take shorter showers.
- "Efficiency" typically requires some type of hardware change to achieve permanent reductions in water use.

This project focused on identifying hardware solutions that could be implemented by water users in Tulare County to advance drought resilience by reducing their water consumption. Table 3 groups candidate technology solutions by sector and type of application. Recycled water opportunities were also considered for each sector.

Table 3: Drought Resilient Technology Solutions by Sector

Sector(s)	Types of Technology Applications
Agricultural	Increase Crop Yield per Unit of Water Applied
Commercial and Industrial	Waterless and/or Water-Efficient Cleaning Equipment and Facilities
Residential, Commercial and Institutional	Indoor: Above Code Plumbing Fixtures and Water Efficient Appliances
	Outdoor: Efficient Landscape Irrigation

Agricultural Water Use Efficiency

Excluding water used for environmental purposes, agricultural uses during "normal" (historical average) hydrology years account for about 45 percent of all water used within the state.[31] In Tulare County, agriculture accounted for 95 percent of net water use during WY2015 (very dry) and 86 percent during WY2002 (close to "normal", historical average). The very high percentage of agricultural use in Tulare County is attributable to low urban water use due to low population density, and relatively few environmental flows[32] (10 percent in WY2002 and 2.4 percent in WY2015).

31 The California Department of Water Resources Water Portfolio Tool estimated total water use in California during very dry water year 2015 at 64,129 million acre-feet, with urban water use accounting for 10.9 percent, agricultural 50.5 percent, and environment 38.6 percent. During an average water year (2002), the relationships were 11.4 percent urban, 45 percent agricultural, and 43.6 percent environmental. ("Water Supply & Balance Data Interface, 'Lite' ver. 9.1." Downloadable from California Department of Water Resources' website: https://water.ca.gov/Programs/California-Water-Plan/Water-Portfolios).

32 Environmental flows are water uses that sustain natural waterways and ecosystems. Environmental flows may occur naturally—for example, due to precipitation and runoff. They may also be stipulated by laws or regulation when needed

During calendar year 2015, agriculture accounted for 42.6 percent of non-residential electric energy (kWh) and 49.3 percent of non-residential electric demand (kW).[33]

The magnitude of both water and electric resource requirements makes agriculture a very high priority for technology investment in Tulare County, since even modest efficiency gains can yield tremendous resource benefits. Considerable environmental and economic benefits associated with saving water and electricity are also achievable.

A 5 percent reduction in agricultural water use could have saved 136 thousand acre-feet (TAF) during WY2002, more than the total annual urban water demand of 133 TAF.

During very dry WY2015, a 5 percent reduction in agricultural water use could have saved 139 TAF—74 percent more water than was needed to meet countywide urban demand of 80 TAF that year,[34] and still more than total urban water use during WY2002, a "normal" water year.

California is not alone. Global water supply and quality pressures have spurred worldwide research in agricultural water use efficiency. The scope of explorations has spanned studies aimed at understanding the differences among various crops as to the quantity, quality and timing of water needed to optimize yields, and improved irrigation technologies that increase precision of applied water. Meanwhile, California's unpredictable hydrological cycles and events, policy goals, increasingly stringent regulations, and public health concerns (for example, with water quality) have created sophisticated farmers, equally knowledgeable about both business and science, that continually assess and reassess the crops that they plant and the efficacy of strategies and technologies for reducing regulatory, resource, environmental, and economic risks.

Examples of Water-efficient Technologies

In this dynamic market, substantial technological advances have been made in agricultural water use efficiency over the past several decades, with new technologies coming into the market every year.

- Some technologies focus on continually improving the efficiency of water delivery to crops through enhanced research and understanding about various crops' responses to different irrigation methods.
- Some technologies focus on enhancing real-time water management by merging telemetry with drones and decision-making software to create tools that enable farmers to make water use decisions from their phones.

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to sustain fresh water systems for species, and ecosystems, especially when natural water flows have been diverted or may be impeded by manmade dams, surface water storage systems, and other types of manmade barriers that divert or interrupt natural water flows.

33 Southern California Edison. See Appendix N: Tulare County's Water-Energy Nexus, Table N-8. Largest Electric Consumers by NAICS Code (Calendar Year 2015).

34 Urban demand during water year 2015 was low due to a combination of water supply shortages and mandatory water use reductions.

- Others are bringing both biological and physical solutions that increase the efficiency of water uptake by crops to increase crop yields per unit of water applied.

Stakeholder Recommendations

These types of technology solutions have significant value for Tulare, the largest agricultural producing county in California. Dairy farming and milk production is the largest agricultural activity in Tulare County, using about 52.8 TAF of water per year (17 billion gallons) and 38.2 percent of annual agricultural electricity. Through meetings with a wide variety of agricultural stakeholders (farmers and technical services providers), one technology need that emerged as a very high priority for Tulare was the ability to use manure effluent via drip irrigation.

One of the biggest challenges that dairy farmers face is efficient reuse of manure effluent. Conventional manure sludge dewatering processes leave solids that are too large for drip nozzles, causing lines to clog. For this reason, alfalfa and other fodder crops are flood irrigated with the manure effluent. However, flood irrigation is vastly inefficient compared to other irrigation methods. One dairy farmer estimated that enabling use of manure effluent for drip would reduce applied water by 20 percent while concurrently increasing yield by 33 percent, a net water efficiency gain of 41 percent. This estimate is consistent with a research project conducted by Sustainable Conservation, De Jager Farms in Madera County, and Netafirm USA that delivers liquid manure to fodder crop roots via subsurface drip irrigation (SDI) that determined, "A 2015 pilot of the system on a 40-acre (16.2-hectare) field of silage corn at De Jager Farms produced stellar results. Water use efficiency increased by 38 percent, nitrogen use efficiency by 52 percent, and corn yield by 15 percent."[35]

Commercial and Industrial Water Use Efficiency

Statewide commercial and industrial water use during WY2002, a "normal" hydrology year, was 1,700 TAF, 13.2 percent of total urban water demand. During WY2015, a very dry year, total urban water use fell 24 percent. Of that amount, 19 percent was used by the commercial and industrial sectors.[36]

In Tulare County, commercial and industrial water use accounted for 17 percent of total urban water demand during WY2015, close to the same percentage of total applied water during WY2002. In actual water volumes, however, commercial and industrial water use fell substantially during WY2015, both statewide and in Tulare County.[37]

Although commercial and industrial sector water use appears small relative to that of the residential sector, there are still many opportunities for water efficiency. When asked about the single largest use of potable water for nonpotable uses, many stakeholders identified cleaning and washing of facilities, equipment, and vehicles. Several stakeholders including municipal

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35 Postel, Sandra. "*California Dairies Join Forces with Conservationists and an Irrigation Supplier to Save Water and Reduce Groundwater Pollution.*" National Geographic Changing Planet. August 10, 2017.

36 California Department of Water Resources Water Portfolio Tool, "Water Supply & Balance Data Interface, 'Lite' ver. 9.1." for Water Years 2002 and 2015.

37 Ibid.

water agencies and food processors noted that a significant portion of Tulare County's valuable groundwater is used to wash large vehicles (flatbeds, box trucks, and tank trucks) that transport crops and food products. For this sector, the most significant opportunity to save water is to reduce use of potable water for non-potable purposes. That broad objective encompasses waterless or highly water-efficient equipment, systems, and processes, and recycle/reuse of water.

Within the commercial sector, the amount of water that can be saved depends on the water use profiles of specific business segments. For example, restaurants use water to clean dishes and kitchens; commercial laundries use water to clean linens, uniforms and other clothing; lodging (hotels and motels) use water to clean bedding, linens, and uniforms; and lodging, institutional facilities, and commercial buildings provide water for use by guests, tenants, and residents.

Water use for cleaning of facilities and equipment is significantly larger as a percentage of total water use within the industrial sector. It is particularly high in food and beverage (F&B) processing where 60 percent or more of process (non-food) water is used for cleaning:[38]

- "Clean in place" (CIP) systems clean the interior surfaces of process equipment without the need to disassemble the system.
- "Clean out of place" (COP) systems clean equipment that cannot be cleaned "in place", such as areas where process equipment may need to be disassembled, and/or items that are small, complex, sensitive, or difficult to clean.
- Floors and exterior equipment.
- Lubricating and cleaning conveyors.

Table 4 provides examples of water-efficient cleaning and disinfection technologies.

Other avoidable uses of water include cleaning bottles and cans with waterless technologies ("air-rinsing"). In addition, technologies are being developed that displace use of water for conveyance of fruit, nuts, vegetables, and other fresh food products throughout a processing plant.

Stakeholder Recommendations

Food and Beverage On-Site Process Water Effluent Treatment, Recycling, and Reuse

One California manufacturer of specialty ice creams stated that most of the water use in ice cream plants is for cleaning ice cream vats between flavor changes, equipment surfaces (both "CIP and "COP"), and facility floors. This manufacturer is considering an on-site primary treatment system with advanced filtration and disinfection that will produce a high quality recycled water that can be used for all non-food purposes. The amount of water estimated to be recycled and reused by that one ice cream manufacturer is 80 percent. In addition to reducing the manufacturer's water and wastewater costs and decreasing vulnerability to water supply

38 Blake Schomas, Director of Marketing for Nalco Water, an Ecolab company, in an interview with Debra Schug, Food Engineering, *Reducing water usage in food and beverage processing*, April 18, 2016.

shortages, this strategy helps build drought resilience for the community. Additional anticipated benefits are:

- Minimal discharges to the municipal wastewater treatment plant that is experiencing a relatively high frequency of permit violations due to deferred maintenance.
- Very low energy use (the primary treatment portion of the process uses a 3 horsepower pump for only 10-15 minutes per hour for a 15,000 gallon-per-day system).

Table 4: Water-Efficient or Waterless Cleaning and Disinfection Technologies

Technology Name	Description	Benefits
Dry Ice Blasting (also known as Cryoblasting)	Blasts surfaces with small pellets of solid CO2 that evaporate and freeze substrates on surfaces	• No residual cleaning chemical • No drying time delay • Good for sensitive electronics where water and chemicals could cause damage
Biomist Disinfection	A misted alcohol for disinfection of food and food processing surfaces	• Kills germs on contact and evaporates; surfaces and equipment left dry • Non-corrosive; can sanitize non-washable equipment, electronics, control panels, etc.
Electrochemically Activated Solutions (ECA)	Uses water, table salt and electricity to create 2 solutions: one for cleaning and one for sanitizing	• No additional chemicals or hot water • Low operational costs • Skin-safe; little danger to workers • Can be applied to food products; does not affect appearance, taste, or smell
Ultrasound	Antimicrobial agent using soundwaves at high power and low frequencies	• Generally considered safe, non-toxic, and environmentally friendly • Barrier: Lack of case study data
Cold Plasma	Applies electricity to a gas, creating ions, radiation and excited molecules that eliminate pathogens	• Utilizes non-reactive, non-polluting gases and minimal electricity • No water use, liquid waste, sewage disposal • Non-toxic, can be used with food products

Source: Water Energy Innovations, Inc.

In addition, some non-biological wastewater treatment processes, such as the one being contemplated for this application, increase production of biogas, a renewable energy resource, by as much as 3-5 times that of conventional biological municipal wastewater treatment systems by separating biosolids during primary treatment instead of at the end of the process. Conventional municipal wastewater treatment collects biogas at the end of the process, by which time significant quantities of biogas have escaped.[39]

Vehicle Washing with Recycled Water

One local government official stated that the single largest use of potable water for nonpotable purposes was using groundwater to wash large commercial vehicles that transport crops and

39 Interview with Alex Wright, Clear Cove Systems.

food products. Several technology companies provide packaged recycled water vehicle washing systems for both passenger and commercial vehicles. Existing facilities would need to purchase and install these systems, or install other types of retrofits to recycle vehicle wash water, incurring incremental costs.

Estimating the Potential for Water Use Efficiency in Commercial and Industrial Sectors

The project team was unable to obtain water use data by specific customer segments or end uses. However, total water savings potential is likely to be greater than 10 percent for these sectors on an average basis, since F&B manufacturers and vehicle washing facilities are very large water users and can reduce their water use by 60-80+ percent through on-site production and use of recycled water. Since most of the water used in Tulare County for these purposes is pumped from groundwater wells, electric consumption would also decrease through avoided water pumping.

Indoor Water Use Efficiency

California has some of the most aggressive codes and standards for water efficient plumbing fixtures and appliances in the nation. California's Title 20 Appliance Efficiency Regulations apply to sellers, not to water users.[40] Specifically, Title 20 applies to fixtures and appliances that are "sold or offered for sale" in California. In this manner, the state assures that new fixtures and appliances purchased in California will meet or exceed current code. Until recently, there was no requirement for water users to upgrade fixtures and appliances before the end of their "useful life".

In 2009, Senate Bill 407 [Padilla, 2009] required that single family residences offered for sale on or after January 1, 2017 be equipped with water efficient plumbing fixtures that are compliant with then-current California codes. The law requires sellers or transferors of single family residences to sign a disclosure attesting to such compliance, or disclosing non-compliance. Effective January 1, 2019, sellers or transferors of multi-family residential properties and commercial properties must similarly comply. In addition, multi-family and commercial properties that require building permits and meet certain criteria (sum of concurrent permits by same applicant that increase floor space in a building by more than 10 percent, and/or total construction costs estimated in the building permit exceed $150,000) are required to bring all plumbing fixtures up to code.

Energy Commission staff estimated that annual water savings from 2015 and 2016 code changes to indoor water fixtures (toilets, urinals, faucets and faucet aerators, and showerheads) would save about 12.2 billion gallons per year[41]. The associated annual savings of electricity and gas attributable to reduced hot water consumption from increased water fixture efficiencies

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40 California Energy Commission. *2015 Appliance Efficiency Regulations*. Publication Number CEC–400–2015–021.

41 Compiled from [1] California Energy Commission. Staff Analysis of Water Efficiency Standards for Toilets, Urinals and Faucets. Publication Number CEC–400–2015–021; [2] California Energy Commission. Staff Analysis of Water Efficiency Standards for Showerheads. Publication Number CEC-400-2015-027.

were estimated at 303 gigawatt-hours (GWh) and 46 million therms (Mtherm) respectively, with estimated annual reductions of energy-related greenhouse gas emissions of 3.5 million tons.

Annual savings are projected to be much higher—by nearly a factor of 10—when the existing stock of noncompliant plumbing fixtures are projected to be exhausted (referred to as "full turnover") around 2038-2039. Presuming no other changes to California's water efficiency standards occur prior to full turnover, annual savings of 127.4 billion gallons of water, 2,999 GWh of electricity, and 425 million therms of natural gas are expected, with estimated annual reductions of energy-related greenhouse gas emissions of 36.1 million tons of carbon dioxide (CO_2) equivalents.

Table 5: Incremental Annual Statewide Value of Early Title 20 Water Fixtures Change-outs

California Title 20 Changes to Water Efficiency Standards	Estimated Annual Savings at Inception vs. "Full Turnover"				
	Projected Year	Water (MG)	Electricity (GWh)	Gas (Mtherm)	GHGs (tons eCO_2)
First Full Year	2018	12,250	303	45	3,511,151
At "Full Turnover"	2038	127,392	2,999	425	36,099,844
Incremental *Annual Value* of Early Changeouts		**115,142**	**2,696**	**380**	**32,588,693**

Sources: Compiled from [1] California Energy Commission. *Staff Analysis of Water Efficiency Standards for Toilets, Urinals and Faucets*. Publication Number CEC–400–2015–021; [2] California Energy Commission. *Staff Analysis of Water Efficiency Standards for Showerheads*. Publication Number CEC-400-2015-027.

Key Findings

1. Annual savings of water, electricity and natural gas, and associated greenhouse gas reductions increase by a factor of about ten, once the existing inventory of noncompliant plumbing fixtures is fully exhausted (that is, all noncompliance plumbing fixtures are replaced with fixtures that comply with codes effective as of 2018).
2. Substantial incremental water, electric, gas, and greenhouse gas emissions benefits are achievable by accelerating the changeout of California's existing water fixtures (toilets, urinals, faucet aerators, and showerheads) as quickly as possible.

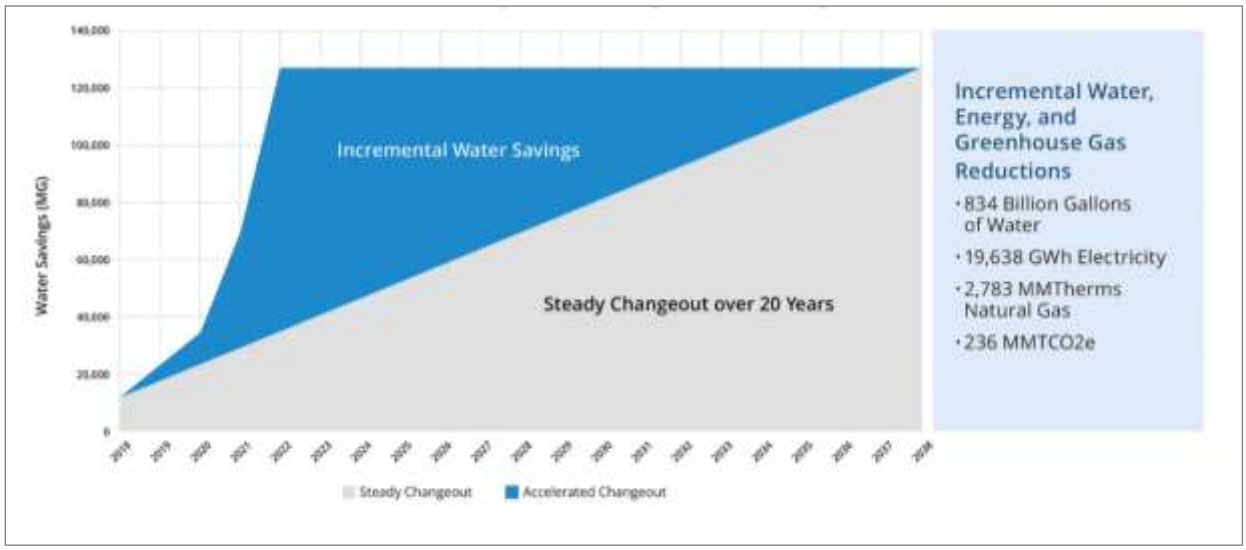
Recommendations

1. Substantially enhance financial and technical assistance to encourage residential and non-residential water users to upgrade their plumbing fixtures to current or future code prior to the end of the fixtures' useful lives (that is, encourage early retirements of existing plumbing fixtures that are not yet in compliance with 2018 codes or their successors).
2. Provide incentives to manufacturers and distributors to bring above code choices to Californians.

Since the cost of purchasing and installing water fixtures is relatively inexpensive, these types of measures should be expedited. If the changeout period could be shortened from 20 years to 5 years—thereby accelerating the annual benefits projected to occur in 2038 by 15 years to

enable achieving the full annual benefits by 2023—substantial incremental water, electric, gas, and greenhouse gas benefits would be earned.

Figure 7: Incremental Annual Statewide Benefits by Accelerating Title 20 Changeouts



Source: Water Energy Innovations, Inc.

Many 1.5 gallon per minute (gpm) showerheads are available today, both online and in retail stores, some with flow restrictors that can dial back flows to as low as 0.5 gpm. Project staff obtained prototypes of 1.0 gpm units that are under development, and some that are commercially available today. Although California does not yet require residential lavatory faucets to use 0.5 gpm aerators, retailers sell these fixtures that receive generally positive reviews, especially from parents that stated these aerators substantially reduce water waste by their children.[42]

Outdoor Urban Water Use Efficiency

The most significant opportunity to reduce use of potable water for nonpotable purposes in the urban sector is landscape irrigation: 44 percent of all urban water is used outdoors, primarily for landscape irrigation.[43] Most of the water used for landscape irrigation is drinking water.[44]

On April 1, 2015, Governor Edmund G. Brown, Jr. issued an Executive Order directing, among other things, mandatory statewide water use reductions. The stipulated goal was to reduce urban water use by 25 percent, an estimated savings of 1.5 million acre-feet.[45] The order included a directive to replace 50 million square feet of lawns statewide with drought tolerant

42 Customer reviews of 0.5 low flow faucet aerators on amazon.com and other purchasing sites. One manufacturer received an average score of 4.4 out of 338 reviews that praised the water savings and reduced water waste. One package of six 0.5 aerators cost less than $10 including shipping.

43 *Urban Water Use Efficiency*. Department of Water Resources. https://water.ca.gov/Programs/Water-Use-And-Efficiency/Urban-Water-Use-Efficiency.

44 Ibid.

45 Governor Brown. *Executive Order B-29-2015*. April 1, 2015.

landscaping in partnership with local governments. To implement the Governor's directive, CDWR established a turf replacement rebate program that provided $24 million in grant funds to help single family residences replace their lawns. Incentives were paid in the amount of $2 per square foot with the goal of replacing 10 million square feet of turf to save 300,000 acre-feet of water each year, which is 20 percent of the Governor's goal.

Many of the larger water agencies offered their own rebates, some with assistance from the U.S. Bureau of Reclamation's WaterSmart grant program.

The emphasis on turf replacements was a simple choice: in its 2013 Water Plan Update, CDWR estimated that 34 percent of all residential water use is poured onto lawns and gardens every year. Another 10 percent is used for large landscapes by commercial and industrial customers, bringing the total amount of water used for urban landscapes to 44 percent (this estimate was down from the 50 percent estimated in the 2009 Water Plan). At an estimated annual urban water demand of 8 million acre-feet, 3.52 million acre-feet—1.15 trillion gallons per year—is poured onto lawns and gardens every year, and most of that water is drinking water. Through a combination of climate-appropriate (drought tolerant) plantings and water-efficient irrigation, savings of up to 50 percent of water used for urban landscape irrigation have been documented by some customers that took advantage of the turf incentives. Half of the amount of water used for urban irrigation is approximately 1.76 million acre-feet—88 percent of the targeted 25 percent urban water use reduction targeted by the Governor's Executive Order B-29-15.

To assure that California continues diligence about saving water outdoors, the California Water Commission approved a revised Model Water Efficient Landscape Ordinance (MWELO) on July 15, 2015.[46] Local agencies (cities and counties) are responsible for either adopting the state's MWELO or adopting their own ordinance that must adhere to certain MWELO principles. Of particular note is the provision for a "maximum applied water allowance" (MAWA) that reduced the percentage of landscape area that can be planted with high water use plants (including turf) from 33 percent to 25 percent. Local agencies are responsible for annual compliance reporting to CDWR.

Key Findings

1. Water agencies, customers, landscape contractors, and irrigation equipment providers have become knowledgeable about climate-appropriate plantings and water efficient irrigation methods.
2. Technology developers continue to seek ways to increase irrigation efficiency.
3. The state's MWELO is playing an important role in (a) increasing awareness about the need to substantially reduce use of potable water for urban landscapes, and (b) keeping this issue top of mind among local agencies by requiring annual reports confirming compliance and enforcement.

46 California Water Commission. *The 2015 Updated Model Water Efficient Landscape Ordinance, Guidance for Local Agencies.* June 19, 2015.

4. Concurrently, water agencies, local governments, state agencies and others provide education for water customers.
5. Water-smart landscaping requires a statewide culture-change.
6. The quantity of water that can be saved by fairly simple and cost-effective means are too important to ignore.

Recommendations

1. The portfolio of policies and programs already in place are effective and do not need much technical assistance from the state.
2. Continued financial assistance remains important, however, water agencies do not have access to comparable public purpose financial funds as do energy utilities.

Reduce Use of Potable Water for Non-Potable Uses

Throughout California, potable water is routinely used for nonpotable purposes.

Table 6: Routine Uses of Potable Water for Non-Potable Uses

Sectors	Non-Potable End Uses Routinely Met by Potable Water
Residential, Commercial & Institutional	Indoors: Flushing Toilets Outdoors: Landscape Irrigation (including parks and golf courses)
Commercial, Industrial	Cleaning: Equipment, Systems, Facilities, Surfaces, Vehicles
Agricultural	Irrigation: Non-food and non-edible portions of crops Cleaning: Livestock, livestock pens and stalls,

Source: Water Energy Innovations, Inc.

Where potable water supplies are critically low, potable water should be allocated first to critical public health needs: drinking, cooking, hygiene, and sanitation.

Examples of candidate technologies for recycling and reusing water have been provided in previous sections in this chapter by sector. In addition, gray water (relatively clean wastewater from kitchens, bathrooms and laundry rooms) can be reused for nonpotable purposes such as flushing toilets and landscape irrigation with little or no filtration or disinfection.

Increase Local Supplies through Groundwater Remediation

In addition to increased local water storage and recharging depleted groundwater basins, water reuse, both gray and recycled, are high priority strategies for increasing local water supplies. Within agricultural communities, however, both in California and throughout the world, there is an urgent need to remediate contaminated groundwater.

Nitrate concentrations in many domestic wells in Tulare County exceed safe drinking water standards. Nitrates in drinking water are known to cause reproductive issues such as

methemoglobinemia, or "blue baby disease."[47,48] In response to nitrate concerns, the State Water Board contracted with the University of California, Davis (UC Davis) in 2010 to conduct an independent study on nitrates in the Tulare Lake Basin and the Salinas Valley. The 5-year field study, called Nitrogen Fertilizer Loading to Groundwater in the Central Valley, identified the anthropogenic sources[49] that contribute to nitrate accumulation in groundwater in the Tulare Lake Basin and Salinas Valley.[50] The study found the following sources of nitrates:[51]

- Cropland (96 percent of total), where nitrogen applied to crops, but not removed by harvest, air emissions, or runoff is leached from the root zone to groundwater. Nitrogen intentionally or incidentally applied to cropland includes:
    - Synthetic fertilizer (54 percent).
    - Animal manure (33 percent).
    - Irrigation source water (8 percent).
    - Atmospheric deposition (3 percent).
    - Municipal effluent and biosolids (2 percent).
- Percolation of wastewater treatment plant (WWTP) and food processing (FP) wastes (1.5 percent of total).
- Recharge from animal corrals and manure storage lagoons (1 percent of total),
- Leachate from septic system drainfields (1 percent of total).
- Urban parks, lawns, golf courses, and leaky sewer systems (less than 1 percent of total).
- Downward migration of nitrate-contaminated water via wells (less than 1 percent of total).

A Central Valley-wide Salt and Nitrate Management Plan (SNMP)[52] was adopted by the Central Valley Regional Water Quality Control Board (RWQCB) on June 1, 2018 and will be implemented over the next four years. The Nitrate Control Program within the SNMP will require all dischargers to evaluate their nitrate contributions and address them either individually or in cooperation with other dischargers in a specialized management zone. The SNMP includes a

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47 "Nitrate poisoning, called methemoglobinemia ("blue baby" syndrome). Toxic effects occur when bacteria in the infant's stomach convert nitrate to more toxic nitrite. When nitrite enters the bloodstream, it interferes with the body's ability to carry oxygen to body tissues. Symptoms include shortness of breath and blueness of the skin around the eyes and mouth. Infants with these symptoms need immediate medical care since the condition can lead to coma and eventually death." Source: SWRCB Groundwater Information Sheet: Nitrate. Revised November 2017. Retrieved from SWRCB website: https://www.waterboards.ca.gov/gama/docs/coc_nitrate.pdf.

48 Fan, A. M., & Steinberg, V. E. (1996). *Health Implications of Nitrate and Nitrite in Drinking Water: An Update on Methemoglobinemia Occurrence and Reproductive and Developmental Toxicity.* Regulatory Toxicology and Pharmacology. 23:1.

49 Caused or influenced by human activity.

50 University of California, Davis (2012). *Technical Report 2: Nitrogen Sources and Loading to Groundwater With a Focus on Tulare Lake Basin and Salinas Valley Groundwater.*

51 "Nitrate Project." State Water Resources Control Board. https://www.waterboards.ca.gov/water_issues/programs/nitrate_project/index.html.

52 Final SNMP adopted on June 1st, 2018. "FINAL SNMP for Central Valley Water Board Consideration, CV-SALTS website: https://www.cvsalinity.org/docs/central-valley-snmp/final-snmp.html.

conditional prohibition in which permittees discharging nitrate will be prohibited from discharging upon receiving a notice to comply unless they are implementing the requirements of the Nitrate Control Program. This will lead to increased effort among all dischargers in the region to adopt new technologies and strategies for managing their nitrate contributions. Table 7 lists some of the many technologies that can contribute to this regional effort to remediate water quality within California's agricultural communities.[53]

Table 7: Water Quality Technologies

Technology	Components Managed	Suitable Applications
Algae Production	• Nitrogen • Phosphorous	High-rate algae ponds require a large footprint, but use little energy, while photobioreactors have a smaller footprint but use more energy. Both are useful for municipal or industrial wastewater treatment, and algae ponds can be used for animal wastewater treatment. Treated water can be used for municipal application, agricultural irrigation, or groundwater recharge in most cases. Produces algae by-product as an additional revenue stream.
Anammox	• Nitrogen	Ideal for municipal treatment facilities that lack land to treat nutrients and need a low-energy solution. Water needs further treatment before being reused. Produces a little sludge.
Biocatalyst Nitrate Removal	• Nitrogen	Useful for direct groundwater remediation or, treating drinking water from wells, or for nitrate removal from wastewater without removing organics. Treated water is potable.
Biochar	• Nitrogen • Phosphorous • Heavy Metals • Pesticides • Soil Acidity	Biochar is most effective in soils that have been highly degraded due to acidity, heavy metals, compaction, or pesticides. Because restorative agriculture management practices can take many years to rebuild soil carbon, biochar application can be used as a shortcut. Reduces application of synthetic fertilizer.
Cover Crops	• Nitrogen • Phosphorous	Useful for any crop that doesn't need surface soil to be cleared annually. Reduces application of synthetic fertilizer.
Forward Osmosis	• Nitrogen • Phosphorous • Heavy Metals • Dissolved Solids • Salinity • Pathogens	Forward osmosis is most effective for industrial users that have two solutions: one that must be concentrated and one that must be diluted. It can be used for just one solution, but requires additional treatment. Food and beverage processors such as fruit juice or dairy processing are examples. Treated water can be used for municipal application, agricultural irrigation, or groundwater recharge Sometimes produces brine, depending on the setup, which is difficult to dispose of.

53 See *Appendix F: Technology Solutions for Nitrates* for more information about these technologies.

Technology	Components Managed	Suitable Applications
Membrane Bioreactor	• Nitrogen • Phosphorous • Dissolved Solids • Salinity • Pathogens	Typically used for large municipal wastewater treatment facilities. Treated water can be used for municipal application, agricultural irrigation, or groundwater recharge.
Nitrification/ Denitrification Basins	• Nitrogen	Common for municipal wastewater treatment facilities that need a simple way to meet nutrient discharge TMDLs. Water needs further treatment before being reused. Produces sludge.
No-Till Farming	• Nitrogen • Phosphorous	Useful for agricultural production that has not yet been mechanized, and that does not require raised rows of soil, such as fresh fruits. Requires 3-7 years to see many of the benefits. Reduces application of synthetic fertilizer.
Reactive Filtration	• Nitrogen • Phosphorous • Dissolved Solids • Salinity • Pathogens	Can be used to treat water from agricultural drainage canals, stormwater, or municipal wastewater. Treated water can be used for direct potable reuse, municipal application, agricultural irrigation, or groundwater recharge.
Reverse Osmosis	• Nitrogen • Phosphorous • Heavy Metals • Dissolved Solids • Salinity • Pathogens	Reverse osmosis is most effective for water with high salinity concentrations, or for water that needs to be pure, such as for use within laboratories. Treated water can be used for offsetting water for direct potable reuse, municipal application, agricultural irrigation, or groundwater recharge. Produces brine, which is difficult to dispose of.
Struvite Beads	• Phosphorous • Nitrogen • Magnesium	Struvite replaces traditional fertilizers and lasts for an entire growing season. It is most effective in crops that release organic acid anions from their root systems. Reduces application of synthetic fertilizer.
Struvite Removal	• Phosphorous • Nitrogen • Magnesium	Useful for large municipal facilities with anaerobic digesters and struvite problems. Produces struvite beads which can be sold as an additional revenue stream.
Vermifiltration	• Nitrogen • Phosphorous	Can be scaled to almost any wastewater application. Great for remote areas and small communities. Industries include dairies, food and beverage processors, and municipal wastewater. Treated water can be used for agricultural irrigation. Produces worm castings, a high-value soil supplement, and vermicompost which can also be applied to agricultural land.

Source: Water Energy Innovations, Inc.

Water Management Tools

Technologies are advancing at a rapid pace for customer-side water use management. These types of real-time monitoring and decision-making tools are being bundled with energy management systems and home security systems, and are now being widely offered by telecom service providers.

Advances are also being made in water management tools that enhance real-time decision making by water and wastewater agencies. These tools are not directly related to drought resilience but can increase efficiencies within centralized water and wastewater treatment systems, reducing use and costs of energy and chemicals.

The actual amount of water that can be saved with the assistance of water management tools varies significantly by type of technology and application.

Summary of Findings

1. Water and wastewater technologies are developing at an incredibly rapid pace. Potential technologies were identified nearly daily through industry e-newsletters and journals, or conversations with technology developers and key stakeholders.
2. Many technically viable distributed water and wastewater technologies exist today that could be rapidly deployed to substantially increase near-term drought resilience. Some may already be cost-effective without need for subsidies or incentives, others may need some financial and/or technical assistance to implement.

   Detailed discussions with technology solutions providers identified many candidate technologies for building drought resilience in Tulare County. Importantly, many of those can produce substantial water, electric, and greenhouse gas benefits within three years.
3. The primary challenge is that water savings require distributed (customer-side) technology solutions. Consequently, water customers must take the actions needed to achieve the targeted benefits, but water agencies do not have sufficient programs, funding, or staff resources to help their customers adopt drought resilient technologies.[54]
4. The following relationships are informative with respect to targeted public investments in distributed water resources.
   a. An increase in agricultural water use efficiency of 5 percent would save enough water to meet 100 percent of Tulare County's urban water demands.
   b. Within the urban sector, outdoor water uses of mostly potable water for nonpotable purposes (primarily landscape irrigation) continue to be significant. During Water Year 2015 (WY2015), outdoor water uses in Tulare County totaled 42 thousand acre-feet (TAF) (44 percent of total urban water demand).

[54] See Chapter 4.

c. Residential water uses account for 80 percent of Tulare County's urban water use. Commercial (7 percent) and industrial (10 percent) uses are relatively small, collectively accounting for 17 percent of total urban water demand during WY 2015. (Commercial and industrial uses were only 4 percent higher during WY2011, a wet year.) The remaining 3 percent is used for large commercial landscapes.

d. Dairies accounted for 38 percent of CY2015 agricultural electric use, and dairy-related manufacturing (milk products, cheese, ice cream) accounted for 87 percent of food and beverage manufacturing (excluding pet food).

e. There is significant potential to reduce use of potable water for nonpotable uses in every sector.

In short, every sector has high potential opportunities for drought resilient solutions that can begin saving substantial quantities of water within three years or less. Some of these technologies also have potential to produce distributed energy resources and to reduce greenhouse gas emissions.

5. Sector-Specific Opportunities

a. Agricultural Sector.

i. Tulare is the largest agricultural producing county in the state and the largest dairy producing county in the nation. In 2017, Tulare County had 258 dairy farms with a total of 471,081 milk cows –27.15 percent of the total number of milk cows in California:

ii. There are more cows than people in the county. Increasing agricultural water use efficiency just 5 percent would be enough to supply 100+ percent of Tulare County's urban water demand.

b. Residential Sector. Residential water use efficiency measures are mature and well understood. Technology developments in indoor water efficient fixtures and appliances are largely driven by California policy, regulations (Titles 20 and 24), and public investment. California's influence on technology innovation can be clearly seen in the implementation of 2015 changes to Title 20 Appliance Efficiency Regulations: for months, manufacturers and distributors have been preparing for the new 1.8 gpm showerhead code that became effective on July 1, 2018. Some manufacturers have gone further, offering above-code showerheads of 1.5 gpm or less. Substantial incremental water, energy, and greenhouse gas emissions benefits are achievable by changing out water fixtures sooner than later.

c. Commercial and Industrial Opportunities. Commercial and industrial water users typically weigh water availability and costs in context of business risk; residential water users view water through the lens of health and safety.

i. Within the commercial sector, several types of water use reduction opportunities are apparent:

- Large landscape, typically associated with commercial facilities, account for 2.3 TAF per year.[55]
- Indoors, many opportunities remain for adopting best-in-class above code plumbing fixtures and appliances.

ii. In addition, however, there are unique opportunities to reduce use of potable water for non-potable purposes. Several stakeholders stated that the largest avoidable use of potable water for nonpotable purposes is vehicle washing—not just passenger vehicles, but large commercial vehicles (trucks, tractor trailers, and tankers) that are used to transport crops and food products.

iii. Within the industrial sector, the largest users of water and electricity are food and beverage processors and related manufacturing. During CY2015, dairy-related manufacturing (milk products, cheese, ice cream) account for 87 percent of electric use for food and beverage manufacturing (excluding pet food).

6. Investments in distributed water resources are made by customers, reducing the amount of capital needed by municipal water and wastewater facilities for repairs, replacements, and expansions. Reduced capital and operating costs attributable to these types of increased customer-side strategies eventually accrue to water and wastewater customers in the form of reduced rates.

   Customer-side programs are most effective when the water or energy utilities work closely with their customers to encourage and support adoption. Transitional strategies similar to the Competition Transition Charge (CTC) established by Assembly Bill 1890 to support the electric utilities' transition to competitive electric markets are needed to protect water and wastewater agencies from revenue shock and stranded investments as they help their customers build customer-side water resources. It would be reasonable for the state to provide financial assistance to water and wastewater agencies that encourage their customers to make investments in drought resilient technologies that ultimately benefit all Californians.

7. Risk Mitigation
   a. Diversification is a widely recognized strategy for mitigating risk. In fact, both water and energy utilities already seek to diversify their portfolios as much as possible to manage supply and delivery risks.
   b. Distributed energy resources already play a major role in building energy reliability for the state. The water equivalent is customer-side water use conservation and efficiency, and on-site recycled water production and reuse.

Distributed water resources—water demand-side management (DSM) and on-site ("distributed") wastewater treatment and recycled water production—create valuable

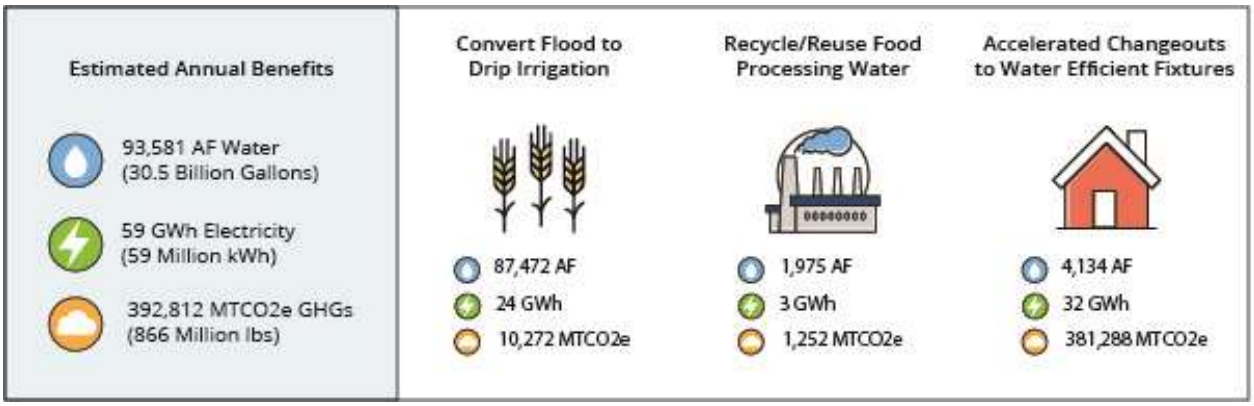
55 Department of Water Resources (DWR) Water Supply & Balance Data Interface Tool, LITE v.9.1.

local water resources. The distributed nature of customer-side actions also reduces risks of interruptions to water deliveries due to infrastructure failures.

Benefits Achievable through Drought Resilient Technologies

The potential water, energy and greenhouse gas benefits that can be achieved by implementing these recommendations are substantial. Figure 7 summarizes annual benefits that could be achieved in Tulare County alone by implementing just three of the high potential technologies and strategies identified through this project.

Figure 8: Estimated Annual Benefits to Tulare County from Three Drought Resilient Strategies



Source: Water Energy Innovations, Inc. Water savings from the above technology solutions exceed Tulare County's annual urban water demand. Converting flood irrigation to drip statewide could save 1 million acre-feet each year (326 billion gallons, about 12-1/2 percent of the state's annual urban water demand).

The above conservative estimates of electric and greenhouse gas emissions benefits are based on the following drought resilient technology strategies:

- Convert flood irrigation with manure effluent for alfalfa and other fodder crops to drip.
- Implement customer-side recycle/reuse of processing water used by food and beverage manufacturers.
- Accelerate Title 20 code changeouts for water efficient fixtures and appliances.

These estimates are conservative:

- Estimated electric and greenhouse gas emissions savings for the first two examples—converting flood irrigation to drip and recycle/reuse of food processing water—only consider the estimated amount of electricity embedded in water, and the greenhouse gas emissions associated with embedded electricity, that could be reduced by saving water.56

56 Electric savings attributable to converting flood irrigation to drip was calculated at a conservative 275 kWh/acre-foot (AF) for avoided agricultural water pumping. Electric savings attributable to onsite treatment, recycle and reuse of food processing wastewater was calculated at an average electric intensity of 1,484 kWh/AF (this amount includes avoided electric inputs to municipal water supplies and municipal wastewater treatment attributable to the saved and recycled food processing water).

- The third example—benefits of accelerated changeouts to water efficient fixtures—shows high electric and greenhouse gas emissions savings relative to the quantity of water saved because it includes estimated energy inputs and related greenhouse gas emissions that would be avoided (saved) by reducing use of hot water. These estimates were computed by Energy Commission staff in support of the 2015 updates to California's Title 20 Article 4. Appliance Efficiency Regulations that includes codes and standards for water fixtures.[57]

The assumptions and computations underlying these estimates are provided in Appendix P.

57 Compiled from [1] California Energy Commission. Staff Analysis of Water Efficiency Standards for Toilets, Urinals and Faucets. Publication Number CEC–400–2015–021; [2] California Energy Commission. Staff Analysis of Water Efficiency Standards for Showerheads. Publication Number CEC-400-2015-027.

CHAPTER 3:
Government Plans and Policies

Beginning in 2014, California experienced severe drought conditions that threatened water supplies throughout the state. The Governor and Legislature responded by adopting state laws and regulations that directed local water suppliers and local governments to eliminate water waste and increase water conservation. Several state agencies were directed to help local water suppliers, local governments and other water users become drought resilient. Since that time, the CDWR, SWRCB, the California Public Utilities Commission (CPUC), the California Department of Food and Agriculture (CDFA), and the Energy Commission have worked with local water entities to reduce water waste, increase the wise use of water, and more efficiently manage water use throughout California. Initially, state rules and regulations focused on basic uses but have expanded over the past four years to require stronger and more comprehensive water conservation actions by local water entities.

On May 31, 2018, Governor Edmund G. Brown, Jr. signed two bills that, among other things, codified a statewide indoor water use efficiency standard of 55 gallons per capita per day:[58] Senate Bill 606 Water Management Planning (Hertzberg, 2018) and Assembly Bill 1668 Water Management Planning (Friedman 2018). These two bills are designed to work in concert to establish urban water conservation and efficiency objectives by November 1, 2023. Urban water suppliers will be required to achieve the objectives that they establish, and report progress to the SWRCB. The SWRCB has been charged with adopting regulations implementing these bills and enforcing compliance. Primary changes to state water policy made by these bills include the following:

- Implement a statewide indoor urban water use standard of 55 gallons per person per day (gallons per capita daily, or GPCD) until January 2025 and decrease over time.
- Establish an outdoor water use standard based on land cover, climate, and other factors determined by DWR and SWRCB, to be adopted by SWRCB by June 2022.
- Establish and adopt a water leaks standard by July 2020 pursuant to prior legislation (Senate Bill 555 Urban Retail Water Suppliers: Water Loss Management [Wolk 2015]).

SB606 and AB1668 also require that agricultural water suppliers update and submit to DWR annual water budgets, on or before April 1, 2021 and every five years thereafter, for review.

58 "California Statutes on Making Conservation a California Way of Life." *State Water Resources Control Board.* https://www.waterboards.ca.gov/water_issues/programs/conservation_portal/california_statutes.html.

Tulare County Water Efficiency Goals, Plans and Policies

Tulare County, its unincorporated areas, and the county's incorporated cities updated their respective General Plan goals, policies, ordinances and processes to comply with state-mandated water conservation requirements. The new policy enacted on May 31, 2018 will require additional changes.

The county's urban water suppliers already prepare Urban Water Management Plans that require increasing recycled water supplies and preparing water shortage contingency plans.[59] Since all of Tulare County's groundwater basins and sub-basins have been designated "critically overdrafted" by CDWR, local water suppliers must also establish and/or participate in Groundwater Sustainability Agencies (GSAs) and prepare Groundwater Sustainability Plans (GSPs) that reduce use of limited groundwater supplies and participate in groundwater recharge.[60]

The Urban Water Management Planning Act requires every public and private urban water supplier to prepare and adopt an Urban Water Management Plan (UWMP) that:

- Assesses the reliability of water sources over a 20-year planning time frame.
- Describes water demand management measures and water shortage contingency plans.
- Reports progress toward meeting a targeted 20 percent reduction in per-capita (per-person) urban water consumption by the year 2020.
- Discusses the use and planned use of recycled water.

Source: "Urban Water Management Plans", Department of Water Resources website: https://water.ca.gov/Programs/Water-Use-And-Efficiency/Urban-Water-Use-Efficiency/Urban-Water-Management-Plans

State Laws and Regulations for Efficient Water Use and Drought Resilience

With the onset of the state's drought, the Governor and Legislature directed state agencies to work with local water suppliers and local governments to 1) save more water; 2) increase enforcement of water conservation; 3) streamline government response; and 4) invest in new technologies. Local cities and counties were required to reduce urban water use by 25 percent from 2013 usage levels. Other key directives required local water suppliers to:

- Direct commercial, industrial, and institutional properties, such as campuses, golf courses, and cemeteries, to implement water efficiency measures to reduce potable water usage.

59 *Urban Water Management Plans.* California Department of Water Resources. https://water.ca.gov/Programs/Water-Use-And-Efficiency/Urban-Water-Use-Efficiency/Urban-Water-Management-Plans.

60 SGMA Groundwater Management. California Department of Water Resources. https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management.

- Prohibit irrigation with potable water for ornamental turf in public street medians and potable water for landscape irrigation for new developments that are not delivered by drip or micro-spray systems.
- Consider the development of local rate structures and other pricing mechanisms, including but not limited to surcharges, fees, and penalties, to maximize water conservation consistent with statewide water restrictions.

State agencies were required to:

- Identify local water agencies in high and medium priority groundwater basins and require them to implement all requirements of the California Statewide Groundwater Elevation Monitoring Program.
- Provide technical assistance and give priority in grant funding to public agencies for actions necessary to comply with local ordinances.
- Help agricultural water suppliers that supply water to 10,000 to 25,000 acres of irrigated lands develop Agricultural Water Management Plans with a detailed drought management process to manage water demand during a drought.
- Give priority in grant funding to agricultural water suppliers that supply water to 10,000 to 25,000 acres of land for development and implementation of Agricultural Water Management Plans.
- Update the State Model Water Efficient Landscape Ordinance for use by local water suppliers to increase water efficiency standards for new and existing landscapes, for example more efficient irrigation systems, gray water usage, onsite storm water capture, and limiting landscape areas that can be covered in turf.
- Provide funding for lawn replacement programs in underserved communities, which will complement local programs already underway across the state.
- Implement a statewide appliance rebate program to provide monetary incentives for the replacement of inefficient household devices.
- Establish standards that improve the efficiency of water appliances, including toilets, urinals, and faucets available for sale and installation in new and existing buildings.
- Implement a Water Energy Technology (WET) program to deploy innovative water management technologies for businesses, residents, industries, and agriculture to accelerating use of cutting-edge technologies such as renewable energy-powered desalination, integrated onsite reuse systems, water-use monitoring software, irrigation system timing and precision technology, and on-farm precision technology.[61]

In 2016, state agencies were charged with developing additional and stronger water conservation directives for local water suppliers and local governments: 1) use water more wisely; 2) eliminate water waste; 3) strengthen local drought resilience; and 4) improve agricultural water use efficiency and drought planning. Major directives include:

61 California Office of the Governor. *Executive Order B-29-15*. 2015.

- Use water more wisely
  - Develop new water targets to achieve a 20 percent reduction in urban water usage by 2020 based upon strengthened standards for: 1) indoor residential per capita water use; 2) outdoor irrigation, that includes landscape area, local climate; 3) commercial, industrial and institutional water use; and 4) water lost through leaks.
  - Permanently require urban water suppliers to report on their water usage, conservation achieved, and enforcement efforts.
- Eliminate water waste
  - Permanently prohibit practices that waste potable water, such as hosing off sidewalks, driveways and other hardscapes; washing automobiles with hoses not equipped with shut-off valve; etc.
  - Minimize water system leaks that waste large amounts of water.
  - Direct urban and agricultural water suppliers to accelerate data collection.
  - Require state-certification of innovative water conservation and water loss detection and control technologies that also increase energy efficiency.
- Strengthen local drought resilience
  - Strengthen requirements for Urban Water Shortage Contingency Plans for urban water suppliers and local agencies.
- Improve agricultural water use efficiency and drought planning
  - Update Agricultural Water Management Plan requirements to identify and measure increased water efficiency.
  - Permanently require Agricultural Water Management Plans by water suppliers with over 10,000 irrigated acres of land.[62]

In 2017, Governor Brown lifted the state's drought emergency order, except for the counties of Fresno, Kings, Tulare, and Kern, and ended mandatory water conservation levels. State agencies were directed to work with local water entities to increase permanent water conservation, improve water use efficiency within local communities and agricultural production, and strengthen local and regional drought planning for California's resilience to drought and climate change. Executive Order B-37-16 "Making Water Conservation a California Way of Life " was retained and the state agencies and water suppliers and local governments were directed to:

- Continue the development of permanent prohibitions on wasteful water use and requirements for reporting water use by urban water agencies.
- Set new urban water use targets that include indoor use, outdoor use, and leaks.
- Establish performance measures for commercial, industrial and institutional water use.

62 California Office of the Governor. *Executive Order B-37-2016: Making Conservation a California Way of Life*. 2016.

- Provide technical assistance and urban landscape area data for determining efficient outdoor water use.
- Accelerate data collection by urban and agricultural water suppliers, improve water system management practices.
- Identify mechanisms that encourage adoption of rate structures and other pricing mechanisms to promote water conservation.[63]

The Sustainable Groundwater Management Act (SGMA) became law in 2014 and created a framework to manage California's groundwater, which was severely overdrawn due to extended drought conditions. Recognizing that groundwater management is best accomplished locally, state regulations directed local water suppliers to establish new Groundwater Sustainability Agencies (GSAs) to assess the conditions of their local groundwater basins and take steps to reduce overdrafts. Each GSA is required to develop a Groundwater Sustainability Plan (GSP) by 2020 that would have to attain water sustainability by 2040. Once established, Groundwater Sustainability Plans could be another tool for implementing water technologies that reduce groundwater usage. SGMA also required local water agencies to collect water data and report groundwater conditions to the state, provide descriptions of current and historical groundwater conditions, and "water budget" elements, among other things.[64]

Local Policies, Plans, and Ordinances

Tulare County has two major water sources: surface and groundwater. The county is responsible for several unincorporated communities and hamlets throughout the county and works closely with its eight independent incorporated cities.

The county and incorporated cities manage water usage through adopted General Plan goals and policies, local ordinances, rules and processes. Once developed, GSPs will be another tool for managing water use.

The county and its incorporated cities have adopted basic policies and ordinances that conform to the state's mandatory-water conservation requirements as they existed prior to the new law enacted on May 31, 2018. Adopted Water Conservation Plans minimize outdoor water use during severe drought conditions. Water restrictions apply in escalating stages based upon the severity of drought conditions.[65] Water efficient landscape irrigation and water efficient building requirements were adopted through General Plans, policies, ordinances and rules.[66]

Local jurisdictions' water conservation requirements vary because they are tailored to each jurisdiction's unique, local circumstances. Variations include building types; zoning

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63 California Office of the Governor. *Executive Order B-40-2017 Drought Emergency Lifted and Retain Prohibitions on Wasteful Water Practices*. 2017.

64 Sustainable Groundwater Management Act, Chapters 346-348, Statues of 2014.

65 Tulare County Ordinance, Code Sections 8-07-1000 *et. seq.*; City of Tulare Ordinance Code Sections 7.32.010 *et.seq.*, Visalia Municipal Code Sections 13.20.010 *et.seq.*, Dinuba Municipal Code Sections 13.05.010 *et. seq.*, Porterville Water Conservation Plan, Adopted August 19, 2014.

66 *Tulare County Water Efficient Landscaping Ordinance*, Sections 7-1-1000 *et.seq.*, other incorporated cities require the use of the Department of Water Resources *Municipal Water Efficient Landscape Ordinance*.

classifications, such as residential, commercial, industrial; building or landscape area sizes; types of water conservation devices required in new and/or retrofitted buildings. Many jurisdictions' ordinances require local developers to adhere to current California State Building Standards, the California State Plumbing Code, and/or LEED Building Design Standards.

Examples of General Plan goals, policies, and implementation measures for conserving water are included in Tulare County's General Plan 2030 Update.[67] The county's five largest incorporated cities have adopted similar water conservation goals and policies to ensure compliance with state-mandated water conservation requirements: 1) water conservation plans that limit water use in stages during drought conditions; 2) water efficient landscape requirements; 3) water conservation measures for certain development types, for example low-flow toilets, landscape water meters for certain residential buildings. Some cities have adopted stronger policies, such as the capture and reuse rainwater and use of gray water systems. These technologies are encouraged but not required.

Almost all local governments' General Plans and policies focus on ensuring adequate water supplies and recharging groundwater. Some General Plans "encourage" the use of water conservation technologies, but there are few implementation measures, requirements, or enforcement efforts to ensure that these types of technologies are included in development projects.

The state's recycled water policy[68] targets increasing recycled water in California to 1 million acre-feet per year (AFY) by 2020 and 2 million AFY by 2030 over 2002 levels. Several jurisdictions list goals, policies and steps to ensure treatment of wastewater. In fact, several incorporated cities will increase the amount of treated wastewater; however, since most of the municipal recycled water in Tulare County is secondary undisinfected effluent, these policies limit use to agricultural lands, landscape irrigation or recharge basins, rather than the reduction of potable water use for non-potable purposes.

SGMA identifies Tulare County as a high-priority area because of its critically over-drafted groundwater basins. Fifteen GSAs were established in Tulare County to implement SGMA.[69] The county participates on four GSAs and monitors the rest. GSAs with critically overdrafted basins are required to prepare GSPs. Failure by a GSA to complete or implement a GSP could result in CDWR assuming control over local groundwater operations.

Many GSAs are discussing the advantages of water recycling and reuse. The GSPs could be a vehicle to include more water conservation measures and technologies to reduce the use of groundwater.

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67 See *Appendix A: California's Drought Policies, Summary of Tulare County's Major Water Goals taken from its General Plan 2030 Update, Goals and Policy Report*.

68 State Water Resources Control Board. *Recycled Water Policy*. As modified by State Water Board Resolution 2013-0003 (January 22, 2013). https://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/2013/rs2013_0003.pdf.

69 See *Appendix D: Groundwater Management, Sustainable Groundwater Management Act*.

Local Policy Opportunities

There are many opportunities for strengthening local government policies, plans, codes, ordinances, and other local government policy tools to build drought resilience in Tulare County, such as the following:

- There is no single drought plan or vision for the entire county.
- Even though the county and its largest five cities encourage water recycling, until recently, few planned to increase treatment levels to tertiary to enable reducing use of potable water for nonpotable uses.
- Most jurisdictions' water rules focus on conventional residential strategies such as water efficient landscaping and some indoor water efficient fixtures such as low-flow toilets. Few existing programs provide incentives or mandates for incorporating water efficient technologies into commercial or industrial facilities.[70]
- The county's wastewater treatment facilities lack recycled water distribution systems ("purple pipe") to deliver treated wastewater effluent to urban water users.
- Local governments competing for economic development opportunities are generally reluctant to require potential new businesses to incur additional costs to site within their respective jurisdictions, even when doing so could help to build drought resilience for all residents and businesses.
- Many local government policies call for increased education about recycled water and water efficient technologies, but few have resources to fund education.
- The county has many unincorporated communities with scattered customers on wells and septic tanks. Requiring water recycling could damage septic tanks.
- Most of the populated areas of Tulare County on the western side are comprised of disadvantaged communities (DACs). DACs tend to have limited financial resources. Of necessity, DACs prioritize repairs to critical water infrastructure over investments in new technologies.
- Enforcement of Tulare County water ordinances is more costly and time-consuming than in other California counties because of low population densities throughout the county.

Summary of Findings

1. The Governor and the Legislature directed state agencies to work with local water suppliers and local governments to: i) save more water; ii) increase enforcement of water conservation; iii) streamline government response; and iv) invest in new technologies. Commencing 2015, cities and counties were required to reduce urban water usage by 25 percent from 2013 usage levels. On May 31, 2018, Governor Brown signed Senate Bill 606 [Hertzberg] and Assembly Bill 1668 [Friedman] that:

70 Most agricultural water is provided by wholesale water purveyors or irrigation districts; consequently, few urban water agencies have specific agricultural water use efficiency programs.

a. Establishes a goal of 55 gallons per day (gpd) per person for indoor water use by 2022, decreasing to 52.5 gpd in 2025, and decreasing again to 50 gpd in 2030.

b. Creates incentives for water suppliers to recycle water.

c. Requires both urban and agricultural water suppliers to establish annual water budgets and prepare for drought.

2. There is no single drought plan or vision for the county. Instead, many drought mitigation and resilience activities are being separately conducted by multiple stakeholders to comply with rapidly evolving state and regional water policies, rules, and regulations. Groundwater is one of Tulare County's two major water resources, with surface water serving most of the county's agricultural and environmental water demand during wet years, and groundwater serving most of all water demand during dry years. All three of the groundwater sub-basins serving Tulare County (Kings, Tule, and Kaweah) are deemed "critically overdrafted". Consequently, the county's water stakeholders are presently focused on implementing the state's Sustainable Groundwater Management Act (SGMA).[71]

3. The level of staff and consultant resources dedicated to SGMA is unprecedented, complicated by establishment of fifteen Groundwater Sustainability Agencies (GSAs) for the county's three sub-basins. Many water stakeholders stated that although they feel a need to participate in multiple GSAs, they have neither the time nor staff resources to cover them all. They therefore pick and choose which meetings appear most important, leaving gaps in both their opportunity to provide input and their knowledge about what each GSA is planning.

4. Multiple state grants have been established to help GSAs, farmers, dairies, and other affected stakeholders implement the plans and actions that are needed to comply with new state water regulations. Still, the portfolio of actions that affected stakeholders will need to implement is daunting, and the process of applying for and obtaining state financial assistance is not simple, and not guaranteed. In addition, while grants are being made available to water and wastewater utilities, and agricultural water suppliers, there is no state grant program to encourage and help their customers—water users—adopt high potential drought resilient technologies.

5. Most of the populated areas of Tulare County are classified as "disadvantaged" by the state's CalEnviroScreen[72] tool that computes numeric scores by census tract to determine eligibility for DAC assistance. Local government officials observed that many

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71 A three-bill legislative package, composed of AB 1739 (Dickinson), SB 1168 (Pavley), and SB 1319 (Pavley), collectively known as the Sustainable Groundwater Management Act (SGMA), signed into law by Governor Brown on September 16, 2014 [California Water Code § 10720]. Source: Department of Water Resources website, https://www.water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management.

72 CalEnviroScreen is a mapping tool that helps identify California communities that are most affected by many sources of pollution, and where people are often especially vulnerable to pollution's effects. CalEnviroScreen uses environmental, health, and socioeconomic information to produce scores for every census tract in the state." Communities with scores in the top quartile (> 75%) are considered "disadvantaged." "About CalEnviroScreen." Office of Environmental Health Hazard Assessment (OEHHA) website: https://oehha.ca.gov/calenviroscreen.

of the impacts DAC programs are designed to address, such as water quality and air pollution, do not observe census tract boundaries.[73]

Recommendations for Reducing Potable Water Use

The lack of new water supplies, increased population growth, and higher potable water demand requires more comprehensive water conservation and management actions by Tulare County and its largest cities.

1. Incorporated cities should evaluate their largest water users for appropriate on-site water recycling technologies that reduce potable water demand.
    a. The highest urban water use for these cities are single family residences, which is expected to grow to 57,115 acre-feet in 2025. Mandatory water recycling and gray water technologies in new residential development would help reduce the use of potable water.
    b. The City of Tulare also has large truck transport companies that wash tanker trucks and 18-wheeler trucks. Retrofitting these and future vehicle washing facilities would reduce groundwater use.
2. Expand the use of treated wastewater to include offsetting limited potable water. More than 1 million gallons a day of water—87 percent of the total municipal wastewater treated in Tulare County—are treated by the Cities of Visalia, Tulare, Porterville, Dinuba, Cutler-Orosi, and Exeter. Visalia recently implemented tertiary treatment. All other existing municipal wastewater facilities treat wastewater to secondary undisinfected quality. Due to health and safety regulations, secondary undisinfected effluent is restricted to irrigation of non-food crops. Further, secondary undisinfected effluent cannot be used for any purposes that might create direct contact with humans. Consequently, it cannot be used for many of the nonpotable purposes that currently use potable water, such as irrigating parks and playgrounds.

    The cities of Porterville and Tulare plan to implement tertiary treatment in the future. Smaller cities and communities need new technologies to cost-effectively upgrade their systems to tertiary.
3. Establish a county-wide Drought Resilience Committee that includes the county's water purveyors, electric utilities, community and business leaders, and other key water stakeholders to collaborate and coordinate on development and implementation of a plan to reduce use of potable water for non-potable uses.
4. Revise General Plan goals, priorities, rules, regulations, processes, for example construction requirements, building permit processes to increase water efficiency and recycled water production and use.

73 These and other issues associated with DAC program implementation are provided in Appendix L: Disadvantaged Communities, along with some recommendations for improving delivery of DAC benefits to the intended beneficiaries.

5. Provide developer incentives such as reduced or waived permit fees, storm water fee reductions, expedited permits and approvals, and other local government services that have monetary value to developers. State grants and/or rebate programs may be available to support these types of programs. Partnerships with water agencies and energy utilities (electric and gas) may also be leveraged to provide incentives to residents and businesses to adopt drought resilient technologies.

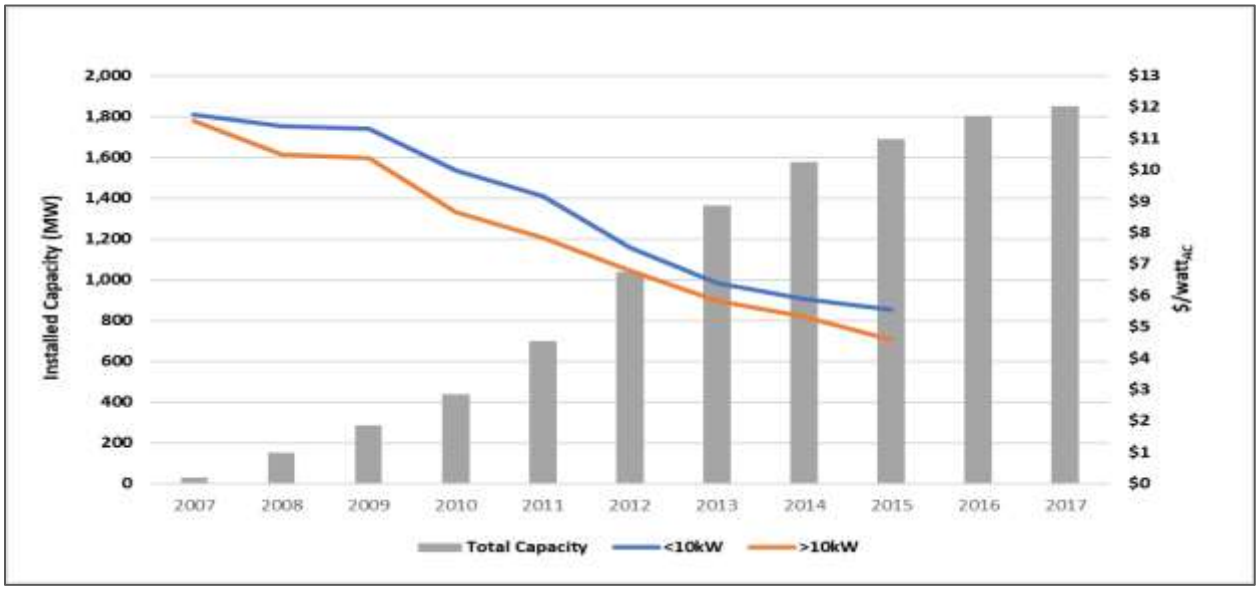
CHAPTER 4: Accelerating Development of Distributed Water Resources

California Leadership in Technology Innovation

As the 5th largest economy in the world,[74] California has enormous influence in virtually every market. With more than 12 percent of the nation's population, California has tremendous buying power, assuring that California's market leading resource and environmental policies will spark interest and enthusiasm from a wide range of entities that envision playing a significant role in bringing new products and services that help to meet California's visionary goals.

California's ambitious clean energy goals combined with the heft of California's buying power was the single largest factor in establishing the national (and international) solar photovoltaic (PV) markets which, prior to the 2007 California Solar Initiative, had been faltering. Figure 8 shows how California's commitments to solar drove market prices down at a much more rapid pace than "business as usual" could ever accomplish.

Figure 9: Inverse Relationship of Average Solar Photovoltaic Prices and California Installations



Source: Compiled from California Distributed Generation Statistics website: https://www.californiadgstats.ca.gov/charts/csi

The above chart shows the significant decrease of solar PV costs (the blue and orange lines) driven in large part by California's $3.3 billion commitment to the California Solar Initiative and the New Solar Homes Partnership Program.[75]

74 Bureau of Economic Analysis. *Gross Domestic Product by State: Fourth Quarter and Annual 2017*. May 4, 2018.

75 "About Go Solar California." *Go Solar California*. http://www.gosolarcalifornia.ca.gov/about/index.php.

Similarly, California's call for battery energy storage to support its growing portfolio of solar and wind resources under its aggressive Renewable Portfolio Standard[76] is driving the global energy storage market.[77] California also accounts for nearly 50 percent of the national market for plug-in electric vehicles.[78]

In fact, California has been driving technology innovation for many years through its visionary energy and environmental policies and aggressive codes and standards. On the horizon:

- On January 1, 2018, California's new Title 20 Appliance Efficiency regulations stipulating performance requirements for lighting became effective. The new regulation (adopted in January 2016) created "first-in-the-nation energy standards for the next generation of light bulbs."[79] Energy Commission staff estimated electric savings from these new standards of 3,000 GWh per year at full turnover of existing lightbulb inventories, projected to occur by 2029. This new regulation is also estimated to avoid 10.3 million metric tons of CO2 equivalents between 2017 and 2029.[80]
- On May 9, 2018, the Energy Commission adopted building standards that will require, among other things, that all new homes built on or after January 1, 2020 have solar PV systems.[81]
- On July 1, 2018, water efficiency standards adopted in 2015 became effective. Under this regulation, showerheads sold in California cannot exceed 1.8 gpm.[82]

Attesting to California's market leadership is the fact that suppliers along all segments of these supply chains rush to provide the new products and services needed to meet California's new efficiency codes. More than that, many suppliers also seek to be among the first that offer above-code fixtures that exceed California codes and standards. Many suppliers had 1.5 to 1.8 gpm showerheads available for purchase long before the Title 20 effective date of July 1, 2018. Some, anticipating niche markets for the ultra-committed customers, are marketing showerheads that can be dialed down to even lower flows—some as low as 0.5 gpm.

California doesn't disappoint, with billions of dollars made available every year to support adoption of efficient measures and strategies. During calendar year (CY) 2017, ratepayer investments in regulated energy utilities' demand side management programs exceeded $1.66 billion.[83]

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76 Senate Bill 350, De León. *Clean Energy and Pollution Reduction Act of 2015, 50% renewable energy by 2030.*

77 The Climate Group. *How California is Driving the Energy Storage Market Through State Legislation.* April 27, 2017.

78 The International Council on Clean Transportation (ICCT). *Update: California's electric vehicle market.* May 2017.

79 California Energy Commission Press Release. *Energy Commission Adopts Lighting Standards to Save More Than $4 Billion in Electricity Costs.* January 27, 2016.

80 California Energy Commission. *Energy Efficiency Standards for Lighting, Frequently Asked Questions.* Publication Number CEC-400-2015-041-FS.

81 California Energy Commission. *2019 Building Energy Efficiency Standards, Frequently Asked Questions.*

82 California Energy Commission Press Release. *Energy Commission Approves New Standards to Save 38 Billion Gallons of Water.* August 12, 2015.

83 Zelazo, Michael, Bridget Sieren-Smith, Amardeep Assar. *California Electric and Gas Utility Cost Report, Public Utilities Code Section 913, Annual Report to the Governor and the Legislature, Table 5.1: 2017 Demand Side Management and Customer Programs Costs ($000).* California Public Utilities Commission. April 2018.

Public Investments in Customer Demand Side Management

The electric sector invests billions of dollars in customer demand side management and related customer programs (for example, demand response, clean/renewable distributed generation, and battery energy storage). When investments by publicly owned energy utilities are included, public investments in energy customers' demand side management (DSM) during CY2017 totaled $1.9 billion.[84] Of that amount, $1 billion funded electric conservation and efficiency; another $184 million funded the EPIC program.[85]

California also invests billions of dollars in greenhouse gas reductions. During fiscal year (FY) 2016/17, the Governor and the Legislature appropriated over $1.1 billion from the Greenhouse Gas Reduction Fund (GGRF) for programs and projects designed to achieve the state's Climate Action Plan.[86] The investment increased to $2.7 billion during FY2017/18.[87]

Demand Side Management

Actions taken by customers to manage their use of energy, water, and other resources.

California's success in continuing to reduce energy consumption is attributable to aggressive efficiency goals that are supported with substantial investments in education, technical support, and incentives for customers that reduce their energy use, as well as continual changes to codes and standards that encourage technology developers and manufacturers to develop and produce increasingly efficient fixtures and appliances.

There is no comparable statewide program for customer-side water programs. While the actual amount of water sector investment is not known, the largest urban water agency in the state, the Metropolitan Water District of Southern California (MWD), provides some useful benchmarks. Specifically, MWD collects and administers a Conservation Credits program that provides funding for water demand side management to its member agencies that collectively serve about 19 million residents in southern California.[88]

During FY2017,[89] MWD's Conservation Credits program expenditures, including salaries and other operating expenses, totaled $41 million. Member agencies expended an additional $11 million, and MWD expended $4 million on outreach and education, bringing the total

84 Publicly owned energy utilities invested $226 million in energy efficiency program expenditures during the fiscal year ended June 30, 2017.

85 Changus, Jonathan and Byron Cope. *Energy Efficiency in California's Public Power Sector, 12th Edition—2018*. Northern California Power Agency and Southern California Public Power Authority. 2018.

86 *California's Climate Action Plan*, Air Resources Board website: https://www.arb.ca.gov/cc/cleanenergy/clean_fs2.htm.

87 *About California Climate Investments*, California Climate Investments website: http://www.caclimateinvestments.ca.gov/about-cci/.

88 The Metropolitan Water District of Southern California delivers wholesale water to 26 member public agencies—14 cities, 11 municipal water districts, and one county water authority—that provide water to 19 million people in Los Angeles, Orange, Riverside, San Bernardino, San Diego and Ventura counties. *Overview and Mission*, MWD website: http://mwdh2o.com/WhoWeAre/Mission/Pages/default.aspx.

89 MWD's fiscal year runs from July through June (same as the State of California).

Conservation Credits program expenditures for MWD and its member agencies to $56 million during FY2017.[90]

At the height of the drought, conservation, outreach and education totaled $289 million (FY2016) and $175.5 million (FY2015) for MWD and its member agencies. Annual MWD and member agencies' investments during the prior five years (FY2010-2014) ranged from $22 million to $45.5 million—averaging $31 million per year.

MWD's level of investments during the height of the drought were clearly unusual, primarily to fund removal of 160 million square feet of turf.[91] For that reason, MWD's FY2017 investment of $56 million was used to estimate "typical" annual water customer-side financial support from MWD and its member agencies.

MWD and its member agencies serve about 50 percent of the state's residents.[92] If other water agencies invest comparable amounts in customer-side water efficiency programs, statewide water sector investments would be about $112 million per year or 9.5 percent of the level of investments made by electric utilities for comparable customer-side DSM programs during CY2017.[93]Water Sector Programs

Since 2002, California authorized more than $17 billion in general obligation bonds to fund water-related projects.[94] That amount does not include the $4 billion for The Disaster Preparedness and Flood Protection Bond Act of 2006 (Proposition 1E) that provides some water supply benefits through plans and structures that divert flood waters to groundwater recharge basins.

Approved uses of these funds encompassed a diversity of water-related concerns: public water system improvements, surface and groundwater storage, drinking water protection, water recycling and advanced water treatment, water supply management and conveyance, stormwater management, wastewater treatment, ecosystem and watershed protection and restoration, and drought emergency relief.

Although California has invested considerable funds in protecting water resources, systems, infrastructure, and ecosystems, there is not yet a water equivalent of the energy sector's customer DSM funding programs. While the state provides billions of dollars in financial

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90 *Achievements in Conservation, Recycling and Groundwater Recharge, Water Tomorrow Annual Report to the California State Legislature Covering the fiscal year of July 2016—June 2017*, Metropolitan Water District of Southern California, February 2018.

91 *Changing the landscape of Southern California: A conservation success story*, Metropolitan Water District of Southern California brochure (January 2017): http://mwdh2o.com/PDF_Newsroom/Turf_Removal_Program.pdf.

92 California Department of Finance press release May 1, 2018 announced that California's population was 39,810,000 as of January 1, 2018. *New Demographic Report Shows California Population Nearing 40 Million Mark with Growth of 309,000 in 2017*, California Department of Finance press release retrieved from http://www.dof.ca.gov/Forecasting/Demographics/Estimates/E-1/.

93 Electric utilities investments in customer energy efficiency and efficient new electric technologies totaled $1.184 billion during calendar year 2017. Using MWD's 2017 budget for water conservation and efficiency as a proxy for the level of water sector investments statewide, water investments were about 9.5% of the amount invested by electric utilities.

94 See *Appendix A: California's Drought Policies.*

assistance to public water and wastewater agencies to address a multitude of water supply and quality challenges, none of these programs yet consider the substantial contribution that could be made by water customers to California's drought resilience.[95]

California's Future is "Distributed"

The water sector can benefit from the electric sector's experiences during the arduous journey from "deregulation" in 1995, to today with recognition that the key to California's reliable energy future is "distributed:" distributed resources, distributed infrastructure, and distributed decision making. In this distributed future, customer-side technologies are key.

Drought has highlighted the state's need for new technologies and new business models. As the state looks to water users to make "water conservation as a way of life,"[96] it has become abundantly clear that building drought resilience cannot be done by the state and the water sector alone—every water user in the state, in every sector, has an important role.

The primary barrier to implementing high potential, near-term, cost-effective drought resilient technologies is that California's water sector does not have the ability to fund customer-side programs that advance distributed water resources at a level anywhere nearly comparable to that of the state's electric sector or its climate action (greenhouse gas reduction) programs.

Statewide Distributed Water Resources Program is Needed

When California sought to identify new technologies that could help build drought resilience, it did not go to the water sector for funding. Instead, it went to energy (in the case of this project, to EPIC which is funding energy sector research and development), and to the GGRF[97] which invests in projects that can demonstrate measurable reductions in greenhouse gas emissions. Because each of these funding sources is authorized for specific purposes—none of which is explicitly water—energy uses and greenhouse gas funds need to be structured to assure compliance with the respective statutes that authorized these funds. EPIC funds can only be used to achieve water benefits if energy benefits also accrue; and the GGRF funds can only be used to fund water efficiency benefits if greenhouse gas benefits are also achieved.

Although water is vital to all Californians, it does not have an equivalent of the energy sector's public purpose programs that specifically invest in activities that create public benefits. The topic of a water equivalent of the energy sector's public purpose programs has been raised in the past through multiple forums, but ultimately did not move forward for two primary reasons:

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95 See *Appendix A: California's Drought Policies, Table A-1: Proposition 1 Funding Allocations and Balance Remaining.*

96 *Making Water Conservation a California Way of Life, Implementing Executive Order B-37-16, Final Report.* Joint California Agencies: California Department of Water Resources, State Water Resources Control Board, California Public Utilities Commission, California Department of Food and Agriculture, California Energy Commission. April 2017.

97 Also known as California Climate Investments. Proceeds from the Cap-and-Trade Program are used for a wide variety of purposes but must show that they reduce greenhouse gas (GHG) emissions in the State. Source: California Climate Investments website: http://www.caclimateinvestments.ca.gov/about-cci/.

1. Water and wastewater services as a percentage of most residents' and businesses' operating costs are small when compared to energy bills, making it difficult to construct a public benefit surcharge that could raise enough funds to support a robust program while not significantly increasing the costs of basic water and wastewater services. That may change, as more investments are made in water sector resources and infrastructure to mitigate risks of drought and other events; however at least at present, it would be difficult to construct a water and/or wastewater fee that would be both affordable to customers and sufficient to support water demand side programs comparable to that of energy programs.
2. California's water sector is comprised of thousands of municipal, community, special districts, and private water and wastewater utilities.[98] In California, three large electric utilities serve 88 percent of the state's population (39 public utilities serve the remaining 12 percent), making it much simpler to implement a cohesive statewide energy program.

This is not a simple problem, and whenever the topic is raised, the water sector—comprised primarily of public agencies—becomes concerned about appearing to invite regulation (which it clearly does not want). Yet, having access to programs and funds that support customer-side drought resilient actions has considerable appeal; and given the fact that water year 2018 is once again dry (questioning whether California really ever left the 2012 drought), could be a very important mechanism for investing in drought resilient strategies and technologies. Given the two new bills signed by Governor Brown on May 31, 2018 that implement mandatory urban water use reductions over time, this issue is extremely timely. Water agencies now have a statutory need to substantially reduce urban water use, and neither Senate Bill 606 [Hertzberg 2018] nor Assembly Bill 1668 [Friedman 2018] provide any financial assistance to help water agencies achieve the unprecedented requirement to establish and achieve stipulated water use efficiency goals. In short, the new "California Statutes on Making Conservation A California Way of Life" are an unfunded mandate.

Since it will likely take years to develop and implement a public investment program in drought resilience, it is not too soon to commence an exploration of options and to develop and implement pilot programs to test different program theories and funding mechanisms. The dialogue will be more successful if it could be made perfectly clear that it need not result in regulating public water and wastewater agencies. Several potential approaches appear viable if the risks of regulation perceived by the water sector can be appropriately addressed (Table 8).

Table 8: Potential Sources of Water Public Purpose Funds

Potential Source	Potential Opportunity
General Obligation Bonds. California Proposition 1 stipulated that "Special consideration will be given to projects that employ new or innovative technology or practices, including decision support tools that support the integration of multiple	Award preference points to water infrastructure grants to public agencies that establish programs that help their customers implement distributed water resources and systems. Grant applications should adjust demand projections for water use

98 "Drinking Water Watch," *SWRCB* website: https://sdwis.waterboards.ca.gov/PDWW/.

Potential Source	Potential Opportunity
jurisdictions, including, but not limited to, water supply, flood control, land use, and sanitation." While technology was considered, the funds were designated for public water agency improvements—no grants, incentives or loans were made available to customers (water users).	reductions and customer-side wastewater treatment, recycle, and reuse. Public funds could be used to directly fund distributed water resources, provided that private use restrictions can be satisfactorily addressed. One way that might be accomplished is by procuring the distributed water resources created.
Create a Multi-Benefit Public Purpose Fund. Current programs with prescribed regulatory purposes often result in sub-optimal investment decisions. The Energy Commission noted in its 2005 Integrated Energy Policy Report: "… single focus [public investments] causes underinvestment in programs that would increase the energy efficiency of the water use cycle, agricultural and urban water use efficiency, and generation from renewable resources by water and wastewater utilities."	A pilot investment program could combine funds from electric, gas, water, wastewater, and greenhouse gas emissions reduction programs to compensate projects for the multiple resource, environmental, and economic benefits that they achieve. A composite statewide metric that computes incentives on the basis of the multiple benefits achieved would help to determine the amount of compensation (incentives) that should be provided to "cross-cutting," multiple benefit projects (see Figure 8).
Create a California Water, Energy and Climate Investment Fund that mutual fund managers can include in retirement plan options. Californians could then select plans that invest a portion of their retirement funds in projects and activities that build drought resilience, energy sustainability, and environmental quality.	A fund of this kind would need to be investment-grade and appropriately risk-managed. Such a fund could be used to "procure" water and energy savings, and greenhouse gas reductions, as a public benefit. It could also potentially be used to provide low interest loans to local businesses that achieve the state's water, energy, and climate vision.[a, b, c]

a. In July 2018, a small food processing company in southern California advised that its planned purchase of a packaged wastewater treatment and recycled water plant has been deferred indefinitely due to the company's inability to obtain a small business loan. Had it proceeded, this project would have reduced the food processor's potable water demand by 80%.

b. See Access to Capital prepared by the California Financial Opportunities Roundtable with assistance of a grant from the U.S. Department of Agriculture Rural Development, August 2012. Retrievable at http://www.indianaglink.com/wp-content/uploads/2013/09/USDA_Publication_ACCESS_TO_CAPITAL.pdf.

c. See Appendix J for additional information.

Source: Water Energy Innovations, Inc.

Valuation of Distributed Water Resources

Appropriate valuation of all resource, environmental, and economic benefits created through customer-side Distributed Water Resources programs is crucial, but there are significant legislative and regulatory hurdles to overcome.

The Correct Statewide Perspective is Holistic

In May 2012, as part of its water-energy nexus rulemaking, the California Public Utilities Commission (CPUC) authorized recognition of "embodied energy," or "energy embedded in water," for purposes of CPUC energy efficiency programs. Specifically, the CPUC agreed with stakeholders' testimony that the sum of all energy inputs by all energy providers to water and

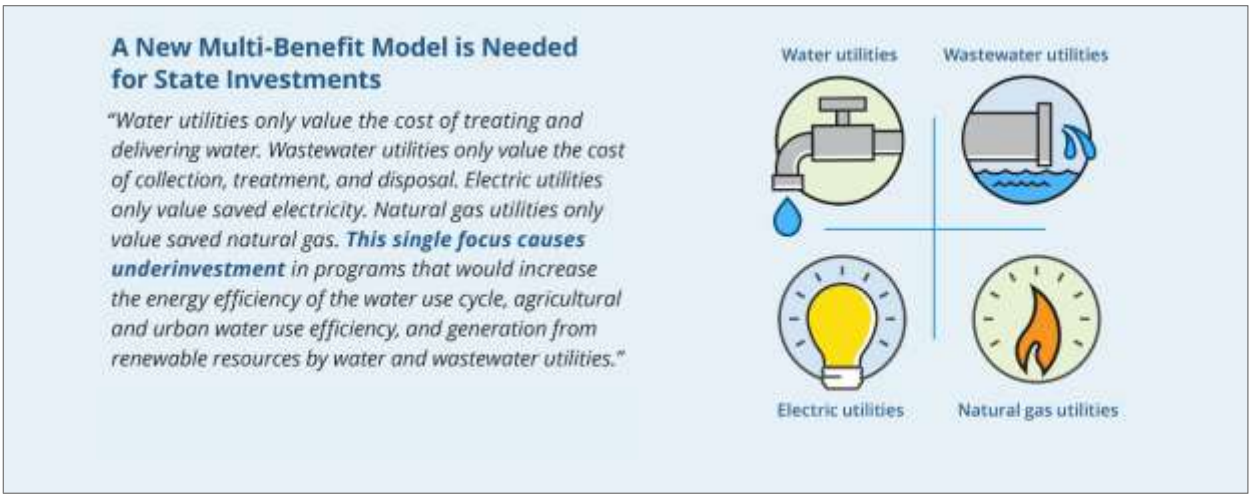
wastewater that could be avoided (saved) by saving water should be included when computing incentives for energy efficiency programs.[99]

Recognition of energy inputs to water and wastewater both upstream and downstream of an energy customer's site is a departure from prior CPUC policies that recognized only on-site energy savings. In adopting the concept of "embodied energy" in water, the CPUC's primary caveat was that since unregulated energy utilities do not pay into the regulatory public purpose program[100] that funds customer energy efficiency projects, only energy provided by the state's regulated energy utilities can be included in the embodied energy computation.

This is a clear example of how jurisdictional boundaries can result in sub-optimal results.

- The CPUC stopped short of a holistic methodology that recognized all benefits created for the state because it has no jurisdiction over unregulated energy utilities, nor does it have specific responsibility for protecting ratepayers of unregulated energy utilities.
- While other state agencies such as the Energy Commission, CDWR, and the Air Resources Board do have a statewide perspective, each is constrained by its authorized mission that requires optimizing outcomes for single resources (energy, water, and climate, respectively).

Figure 10: A Need for a New Multi-Benefit/Multi-Utility Model



Source: 2005 Integrated Policy Report, California Energy Commission, Publication Number: CEC-100-2005-007CMF, p. 150.

As noted in the Energy Commission's *2005 Integrated Energy Policy Report*, most state programs are presently managed from a single utility perspective—water, wastewater, electric, or gas—resulting in sub-optimal investment decisions.

Recognition of all value streams created by distributed water resources is essential to the success of a Distributed Water Resources program. A new model is needed that enables

99 *Decision Providing Guidance on 2013-2014 Energy Efficiency Portfolios and 2012 Marketing, Education, and Outreach.* CPUC Rulemaking 09-11-014. Decision 12-05-015, May 10, 2012.

100 Then known as the "Public Goods Charge", or "PGC".

optimizing the state's investments (1) for the state, as a whole, and (2) across water, energy, and climate.

Evaluated solely from a single resource, single customer site perspective, California's current policies dissuade customers from investing in distributed resources.

- When water users invest in onsite collection, treatment, and recycle/reuse of their own wastewater, they increase electric use at their site since they are now performing functions that would otherwise be performed by centralized municipal water and wastewater treatment facilities. Customer-side water treatment, recycle and reuse projects thus become ineligible for electric efficiency incentives.
- This single resource, single-site impact model ignores the true benefits to California:
  - A water user makes an investment to treat, recycle, and reuse its own wastewater, substantially reducing its potable water demand and reducing municipal wastewater treatment.
  - The water utility reduces its energy use by reducing the amount of water it needs to supply, treat, and deliver.
  - The wastewater utility reduces its energy use by reducing wastewater collection and treatment; and, where applicable, also reduces energy associated with production and delivery of recycled water.
- Greenhouse gas emissions are reduced by the amount of statewide electric savings.

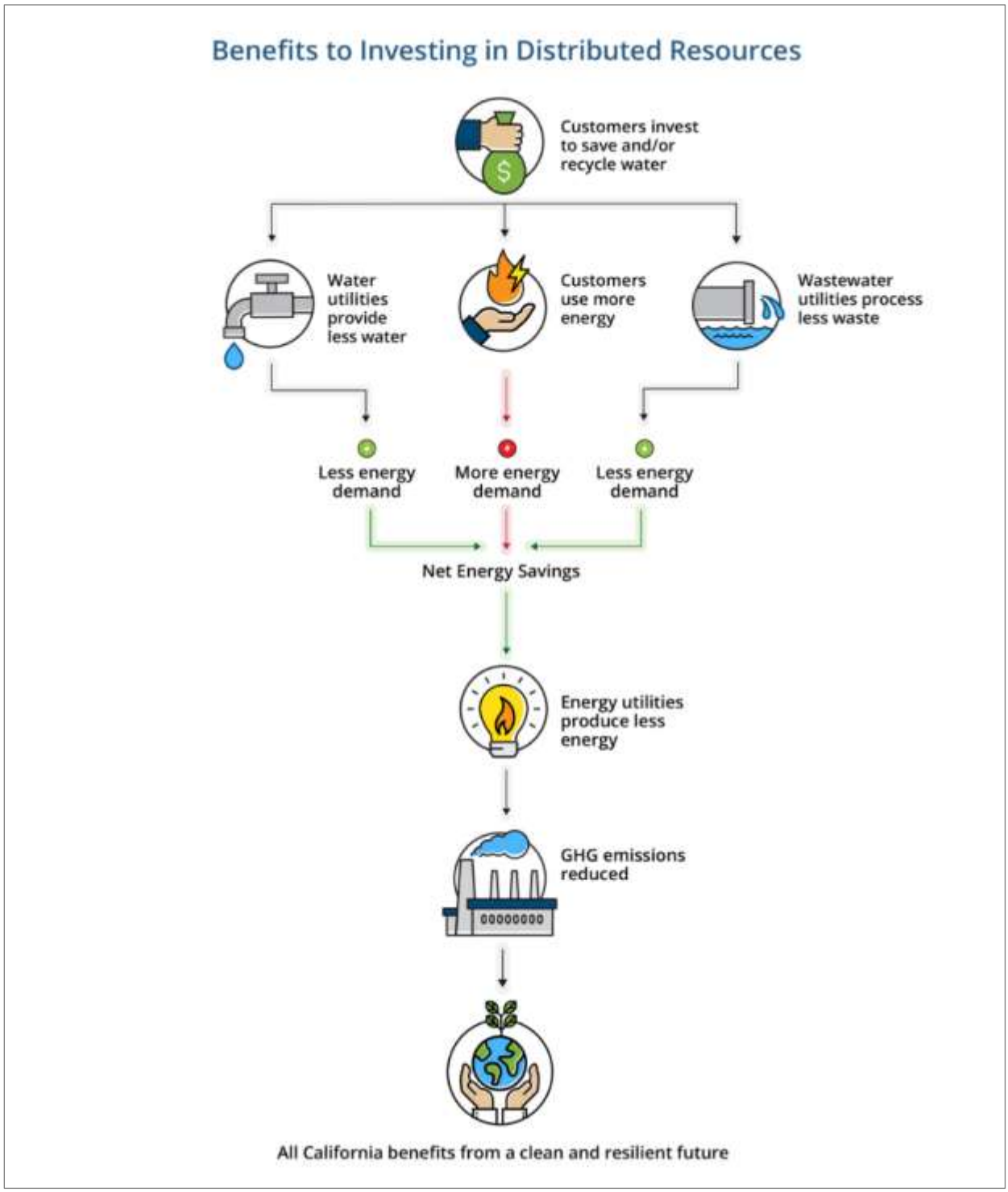
The net impacts for California are thus positive.

Incremental Benefits through Accelerated Implementation

Many policies and protocols governing California's energy efficiency investments were established to protect the ratepayers that fund those programs. In so doing, important resource, environmental, and economic benefits are sometimes inadvertently deterred.

As noted in Chapter 2, Energy Commission staff's evaluation of 2015 changes to Title 20 for toilets, urinals, faucets, and showerheads showed that substantial resources and environmental benefits would be achieved. However, the expected annual benefits at inception were dwarfed by the magnitude of annual benefits that would be achieved by 2038, when "full turnover" is envisioned.

Figure 11: Multiple Benefits Created by Distributed Water Resources



Source: Water Energy Innovations, Inc.

Table 9: Incremental Annual Statewide Value of Early Title 20 Water Fixtures Changeouts[101]

California Title 20 Changes to Water Efficiency Standards	Estimated Annual Savings at Inception vs. "Full Turnover"				
	Projected Year	Water (MG)	Electricity (GWh)	Gas (Mtherm)	GHGs (tons eCO_2)
First Full Year	2018	12,250	303	45	3,511,151
At "Full Turnover"	2038	127,392	2,999	425	36,099,844
Incremental Annual Value of Early Changeouts		**115,142**	**2,696**	**380**	**32,588,693**

Sources: Compiled from [1] California Energy Commission. *Staff Analysis of Water Efficiency Standards for Toilets, Urinals and Faucets*. Publication Number CEC–400–2015–021; [2] California Energy Commission. *Staff Analysis of Water Efficiency Standards for Showerheads*. Publication Number CEC-400-2015-027.

"Full Turnover" occurs when installed fixtures and appliances of the type subject to the Title 20 changes have finally been changed out and meet "today's" code. The projected value at "full turnover" does not include potential additional savings that may accrue over the 20 year period due to anticipated future enhancements to Title 20.

The incremental benefits at "full turnover" are too significant to defer. Figure 10 shows the incremental water, energy and greenhouse gas benefits that would be achieved by performing early changeouts of all existing toilets, urinals, faucet aerators, and showerheads that do not comply with at least 2015 Title 20 code. The incremental water and greenhouse gas reduction benefits that could be achieved today versus over a period of 20 years are significant and irresistible.

Transitioning to New Markets, Technologies and Business Models

One of the major barriers to a distributed water resources model is stranded investments. Both public and private agencies have struggled for years to obtain authorization for major system retrofits and improvements that enable reliable provision of critical water and wastewater services. These agencies are likely to resist reducing customers' uses of these services and potentially reducing revenues to levels that may not be sufficient to cover operating and/or financing costs. This was a key concern when California's electric sector was required to divest its generation assets to support transition to a competitive electric market. The regulated electric utilities' concerns were addressed by creation of a regulatory "competition transition charge."[102]

This report has identified dozens of customer-side technologies, many of which are poised and ready for widescale deployment, that could substantially contribute to California's drought resilience.[103] Significantly, many of these technologies are (1) available today, (2) much smaller

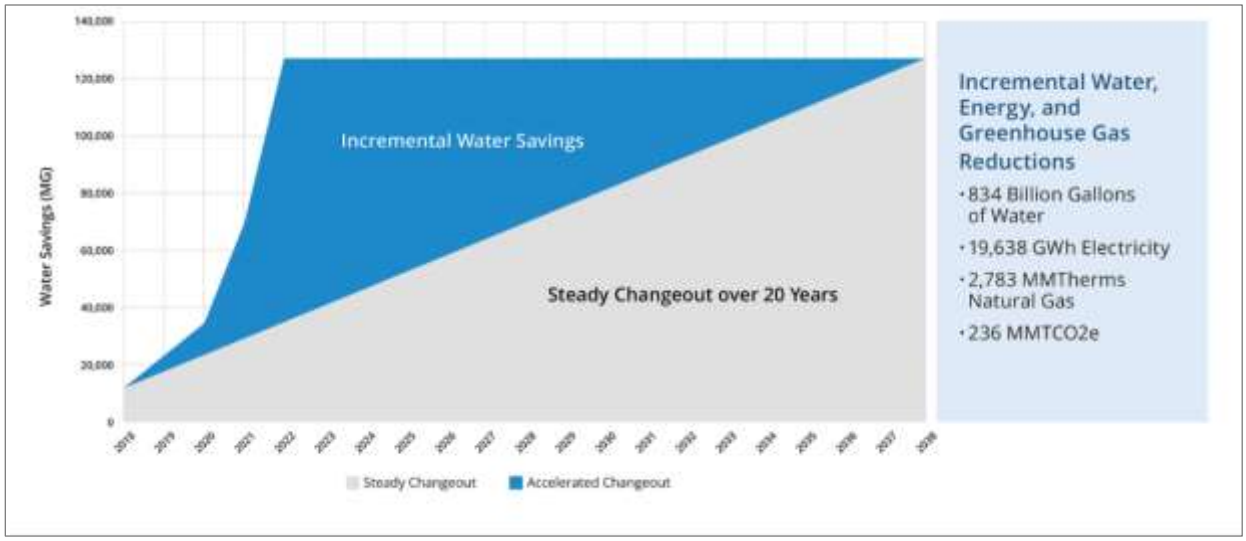
101 See *Appendix K: Accelerated Compliance with New Codes and Standards* for more information.

102 California State Senate. *Background on Electricity Policy, Historical Context—1900-1996.* California State Senate's website: http://seuc.senate.ca.gov/committeehome.

103 See *Chapter 2.* and *Appendix H, Drought Resilient Technologies.*

and quicker to implement than changes to centralized water and wastewater infrastructure,[104] (3) reduce stress on aged water and wastewater infrastructure, (4) reduce the amount of incremental capacity needed by centralized water and wastewater treatment facilities to meet growth in demand, (5) provide economic benefits for water and wastewater ratepayers through avoided costs of future centralized infrastructure expansions, repairs and replacements, and (6) enhance drought resilience by increasing the quantity, quality, and diversity of water resources and water and wastewater delivery systems.[105]

Figure 12: Incremental Annual Statewide Benefits by Accelerating Title 20 Changeouts



Source: Water Energy Innovations, Inc.

Although many water managers understand the essential role of customer side water resources in drought resilience, it is difficult for them to create programs that will ultimately reduce the water and wastewater revenues they need to pay for the costs of the infrastructure and assets that will become "stranded." To make the transition, water and wastewater agencies will need assurance that their ratepayers will not be left with hundreds of millions of dollars in stranded costs. The state can help to alleviate the stranded cost barrier, just as it did for electric utilities.

The actual mechanism for implementing relief for thousands of water and wastewater agencies from stranded investments will be more complicated than it was for the state's three largest regulated electric utilities; however, there are potential opportunities to provide some near-term financial mitigation. One means could be to include provisions in future water bonds for stranded cost incentives and grants to agencies that implement distributed water resources programs that reduce current and future demand for centralized water and wastewater capacity.

104 Many distributed technologies have the added benefit of being relatively quick to implement, since they are much smaller in scale than centralized water and wastewater infrastructure, are much less expensive, and typically do not require complex, multi-year environmental permits and approvals.

105 See *Figure 8 Multiple Benefits Created by Distributed Water Resources* and *Appendix J: Comprehensive Valuation of Multiple Benefits.*

CHAPTER 5: Recommendations

The purpose of this project was to identify high potential opportunities to advance near-term drought resilience in Tulare County while concurrently providing electric and other benefits, including but not limited to greenhouse gas emission reductions. As a market facilitation project, a major part of the project's activities involved extensive engagement of stakeholders to understand the types of technologies in which they are interested, and the barriers they face when implementing new technologies.

One of the consequences of being in a near constant state of drought emergency for multiple years is that pausing to plan and assess feels like a luxury that few can afford. Many stakeholders advised that while they believed this project was worthy, they had little time to participate because they needed to focus on urgent water issues.

It is therefore not surprising that a single drought plan or vision for the county has not yet emerged. The county's General Plan created a platform for adopting some countywide water conservation and recycled water goals; but those are guidelines for future development, not for proactive programs that target near-term actions. With state policymakers focused on bringing near-term assistance to severely impacted communities, many state programs are being tapped at once, with the result that multiple drought plans and visions are presently being developed by many separate stakeholders, each focused on addressing its own water supply challenges and goals for itself and its customers, constituents, and stakeholders.

Some separate efforts come together when there is an intersection of goals and objectives. In Tulare County as well as other parts of South San Joaquin Valley, the most prominent unifying goal is the need to protect, manage, and restore the region's critical groundwater resources. The 2014 SGMA provides an infrastructure for collaboration among the many stakeholders in the region's groundwater resources. However even within this seemingly unifying initiative, there are splintered efforts as 15 GSAs were established to develop GSPs for three sub-basins.[106]

Meanwhile, local governments, water utilities and their key stakeholders are concurrently addressing three mission-critical activities:

- Proactive measures to mitigate the adverse health and human impacts of the current drought.
- Complying with the myriad of state and local water policies, rules and regulations that have been implemented over the past 5 years to address drought and related health, water supply, water quality, environmental, and economic impacts.
- Applying for state and federal technical and financial assistance.

106 See *Appendix D: Groundwater Management* and *Figure D-3. Groundwater Sustainable Agencies in Tulare County.*

To merit attention, candidate technologies must be able to demonstrate that they are both beneficial and cost-effective in helping Tulare's residents, businesses, and local governments achieve their urgent priorities.

Summary of Key Findings

1. Chapter 1, Introduction:
    - The term drought is a condition of water scarcity accompanied by significant public health, safety, environmental, economic, and other impacts. "Drought resilient" must consider the amount of water supplies available to meet water demands over a certain amount of time, within a specific location. Building this requires re-examining both water supplies and water uses. Tulare County's drought impacts highlighted the critical role of place and drought resilience: while more residents survived the drought with minor inconveniences, more residents were left with no water at all. Currently, a market and cultural change is underway in order for water users within all sectors to become increasingly more aware of their pivotal role in building drought resilience.
    - Tulare County has many drought challenges. This county has dry climate as it experiences less annual precipitation than many other areas in California. Because of how little diversity the county's water resource portfolio is, many residents and businesses are left vulnerable to shortages of surface water and groundwater. Residents who depend on private groundwater wells are vulnerable to health and safety risks when wells do fail. The State Water Resources Control Board found that 40 percent of tested wells by community water systems exceeded the Maximum Contaminant level for nitrates.
    - In Tulare County, the three largest municipal wastewater treatment facilities in Visalia, Porterville, and Tulare, produce recycled water, primarily for agricultural irrigation and groundwater recharge. However, the primary constraint on beneficial use of tertiary treated recycled water is lack of recycled water distribution systems in Tulare County. Some water users already recycle and reuse water, but since there is no requirement for customers to report this information, the amount of water recycled and reused is unknown.
    - This project identified technologies that could help build drought resilience by reducing Tulare County's vulnerability to fluctuation in hydrology and short-term availability of traditional water supplies. Four primary principles emerged. First, the highest value water resource from the perspective of drought resilience is water use efficiency. Second, recycled water production is also a high value water resource. Third, runoff, whether urban or storm water, should be collected and used, and treated if needed. Fourth, groundwater recharge opportunities from natural flows should be maximized to the greatest possible extent.

2. Chapter 2, Drought Resilient Technologies:

- Annual savings of water, electricity and natural gas, and associated greenhouse gas reductions increase by a factor of about ten, once the existing inventory of noncompliant plumbing fixtures is fully exhausted (that is, all noncompliance plumbing fixtures are replaced with fixtures that comply with codes effective as of 2018).
- Substantial incremental water, electric, gas, and greenhouse gas emissions benefits are achievable by accelerating the change out of California's existing water fixtures (toilets, urinals, faucet aerators, and showerheads) as quickly as possible.

3. Chapter 3, Government Plans and Policies:
    - The Governor and the Legislature directed state agencies to work with local water suppliers and local governments to save more water, increase enforcement of water conservation, streamline government response, and invest in new technologies. Commencing 2015, cities and counties were required to reduce urban water usage by 25 percent from 2013 usage levels. On May 31, 2018, Governor Brown signed Senate bill 606 [Hertzberg] and Assembly Bill 1669 [Friedman] that:
        - Establishes a goal of 55 gpd per person for indoor water use by 2022, decreased to 52.5 gpd in 2025, and decreasing again to 50 gpd in 2030.
        - Creates incentives for water suppliers to recycle water.
        - Requires both urban and agricultural water suppliers to establish annual water budgets and prepare for drought.
    - There is no single drought plan or vision for the county. Instead, many drought mitigation and resilience activities are being separately conducted by multiple stakeholders to comply with rapidly evolving state and regional water policies, rules, and regulations. Groundwater is one of Tulare County's two major water resources, with surface water serving most of the county's agricultural and environmental water demand during wet years, and groundwater serving most of all water demand during dry years. All three of the groundwater sub-basins serving Tulare County (Kings, Tule, and Kaweah) are deemed "critically over drafted". Consequently, the county's water stakeholders are presently focused on implementing the state's Sustainable Groundwater Management Act (SGMA).
    - The level of staff and consultant resources dedicated to SGMA is unprecedented, complicated by establishment of fifteen Groundwater Sustainability Agencies (GSAs) for the county's three sub-basins. Many water stakeholders stated that although they feel a need to participate in multiple GSAs, they have neither the time nor the staff resources to cover them all. They therefore pick and choose which meetings appear most important, leaving gaps in both their opportunity to provide input and their knowledge about what each GSA is planning.

- Multiple state grants have been established to help GSAs, farmers, dairies, and other affected stakeholders implement the plans and actions that are needed to comply with new state water regulations. Still, the portfolio of actions that affected stakeholders will need to implement is daunting, and the process of applying for and obtaining state financial assistance is not simple, and not guaranteed. In addition, while grants are being made available to water and wastewater utilities, and agricultural water suppliers, there is no state grant program to encourage and help their customers (water users) adopt high potential drought resilient technologies.
- Most of the populated areas of Tulare County are classified as "disadvantaged" by the state's CalEnviroScreen tool that computes numeric scores by census tract to determine eligibility for DAC assistance. Local government officials observed that many of the impacts DAC programs are designed to address, such as water quality and air pollution, do not observe census tract boundaries.

4. Chapter 4, Accelerating Development of Distributed Water Resources:
    - California has invested considerable funds in protecting water resources, systems, infrastructure, and ecosystems. However, there is not yet a water equivalent of the energy sector's consumer demand side management funding programs. While the state provides billions of dollars in financial assistance to public water and wastewater agencies to address a multitude of water supply and quality challenges, none of these programs yet considers the substantial contribution that could be made by water customers to California's drought resilience.
    - The primary barrier to implementing high potential, near-term, cost-effective drought resilient technologies is that California's water sector does not have the ability to fund customer-side programs that advance distributed water resources at a level anywhere nearly comparable to that of the state's electric sector or its climate action (greenhouse gas reduction) programs.
    - Another primary barrier to a distributed water resources model is stranded investments. Both public and private agencies have struggled for years to obtain authorization for major system retrofits and improvements that enable reliable provision of critical water and wastewater services. These agencies are likely to resist reducing customers' uses of these services and potentially reducing revenues to levels that may not be sufficient to cover operating and/or financing costs. This was a key concern when California's electric sector was required to divest its generation assets to support transition to a competitive electric market.
    - Most state programs are currently managed from a single utility perspective—water, wastewater, electric, or gas—resulting in sub-optimal investment decisions. Recognition of all value streams created by distributed water resources is essential to the success of a Distributed Water Resources program.

A new model is needed that enables optimizing the state's investments for the state, as a whole, and across water, energy, and climate.

Recommendations

1. Increase and accelerate funding and incentives for distributed water resources. Creating a statewide distributed water resources program will not be simple; but since the potential for substantial near-term drought resilient benefits is very high, it is worth exploring.[107] Existing and future state programs can be leveraged to begin the transition. For example, the state could:
    - Convert historical state policies governing investments of public funds from a "compliance" mindset, to a comprehensive public benefits perspective that employs new metrics that value all resource, environmental and economic benefits on a holistic statewide basis and enables optimizing public funds in a manner that rewards multiple benefits.
    - Award preference points for water and wastewater infrastructure grants to public agencies that commit to establish technical and/or financial assistance programs that help their customers purchase and install distributed water resource systems.
    - Implement a pilot program that combines funds from electric, gas, water, wastewater, and greenhouse gas emissions reduction programs to help water customers implement high priority drought resilient measures that achieve multiple benefits.
    - Create a Water Investment Loan Fund that streamlines access to low interest loans to customers willing to make investments in distributed water resource projects (similar to programs that offer financing for customer energy efficiency projects).
    - Implement new state policies and programs that help water and wastewater utilities mitigate the costs and risks of assets that may become stranded by encouraging customers to develop distributed water resources and systems.
2. Accelerate retirements of inefficient water fixtures. Fund accelerated retirements of water fixtures that are not yet compliant with the 2015 Title 20 Appliance Efficiency Regulations and its successor(s). Consider all water, energy, and greenhouse gas benefits when determining which potential funds may be available to achieve these early retirements. Modify state policies, programs, and funding to enable investing in early retirements as "procurements" of the targeted resource and environmental benefits (differentiated from "utility incentives" that are designed to protect ratepayers from over-investing in measures that are likely to occur at a future date without intervention). Concurrently, continue to increase water and energy efficiency and greenhouse gas reductions through continuous upgrades to codes and standards.

107 See *Chapter 4 Accelerating Development of Distributed Water Resources.*

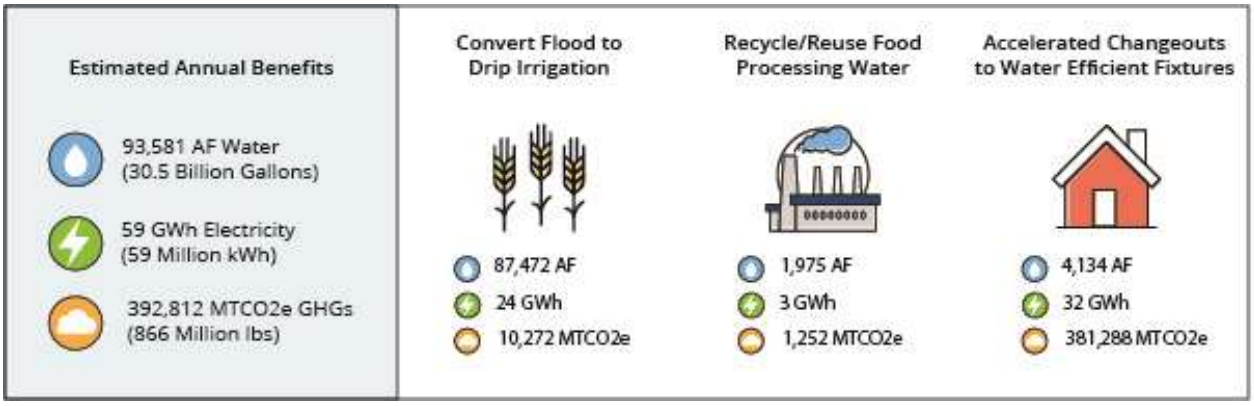
3. Leverage state financial assistance programs (grants) to improve data about water supplies and uses. There is little reliable and current data about the amount of water needed by commercial and industrial customers by end use. These types of data are particularly important in areas like Tulare County where private unmetered groundwater wells have historically served major portions of the county's water demand. Every grant, subsidy or incentive provided to a water user is an opportunity to collect this type of basic information. In addition, request water and wastewater agencies that obtain state funding assistance to provide information about water use by industry sector and customer segment (for example, office buildings, shopping centers, restaurants). More granular and current water use data will streamline both the cost and time to match candidate technology solutions to targeted adopters. It will also improve estimates of potential water and energy savings, and energy related greenhouse gas reductions, providing a rational basis for determining the appropriate level of state investment in various projects and technologies.
4. Establish centers of excellence in technologies that achieve California's vision for a clean and resilient future. California drives technology advancement through visionary policy goals that are supported with billions of dollars in public investments. This rare combination of policy commitment and investment distinguishes California from many entities, both public and private, that may have ambitious goals but lack either the resources or the commitment needed to build markets and industries. The state should capitalize on its enormous market influence to advance partnerships that accelerate research, development, and commercialization of products and technologies that help the state build a clean, healthy, affordable, and resilient future, while also building a robust economy and solidifying its position as a technology visionary.
5. Water and Wastewater utilities can substantially accelerate drought resiliency by encouraging customers to purchase and install distributed water resources and systems. However, while diversification from centralized utility services to customer-owned and operated electric, water, and wastewater systems is conceptually simple, implementation can be difficult and costly. Public investment in the development of distributed water resources is relatively low, therefore, building drought resilience requires that customers invest and take risks. These investments in water conservation and efficiency, on-site wastewater treatment, and/or on-site production and use of recycled water need to be made by both large water users and residential customers. These types of customer-side strategies alleviate pressure on centralized municipal water and wastewater treatment systems. Over time, less municipal water and wastewater treatment capacity will be needed, reducing capital and operating costs of centralized municipal water and wastewater systems.
6. Integrating key policies and goals into local government policies and plans that are relevant to accelerating the adoption of technologies that will save water and energy and reduce greenhouse gas emissions will help cities and countries become more drought resilient and, as a result, will help California achieve its aggressive goals for energy efficiency. These policies include recycling water, reusing gray water, managing

groundwater through the Sustainable Groundwater Management Act, and regulating the quality of groundwater through rules that govern salt and nitrate management in California's South San Joaquin Valley.

Benefits to California

The potential water, energy and greenhouse gas benefits that can be achieved by implementing these recommendations are substantial. Implementing only three of the technologies identified through this project—converting flood irrigation to drip; treating food processing wastewater for onsite recycle/reuse: and accelerating changeouts of water fixtures to meet or exceed current Title 22 codes and standards—could reduce water use within Tulare County by 93,581 acre-feet (AF) (30.5 billion gallons) each year. That amount of saved water could meet 100 percent of Tulare County's urban water demand.

Figure 13: Estimated Annual Benefits to Tulare County from Three Drought Resilient Strategies



- **Water savings from the above technology solutions exceed Tulare County's annual urban water demand.**
- **Converting flood irrigation to drip statewide could save 1 million acre-feet each year (326 billion gallons, about 12-1/2 percent of the state's annual urban water demand).**

Source: Water Energy Innovations, Inc.

Additional Benefits

California advances its market leading water, energy, and climate policy goals through continual enhancements to policies, codes and standards, supported by billions of dollars of public investment. California's commitment to a drought resilient and clean energy future has already driven technology innovation in multiple key markets: energy efficient lighting, solar photovoltaics, battery energy storage, and water efficient fixtures. There is every reason to expect that when California establishes performance standards for agricultural water efficiency, sustainable groundwater management, groundwater quality, and greenhouse gas emissions, technology developers and markets will rush to accept the challenge, bringing new industries and jobs.

Knowledge Transfer

The research, data, analyses, insights, tools, and other work products developed by this project, including video interviews of diverse stakeholders and the project recommendations, are on the project website: http://droughtresilience.com.

The project website (also-known-as the online toolkit) mentioned above outlines strategies that increase drought resilience by implementing innovative technologies, policies and financing mechanisms. The Key Findings and Recommendations provide overviews of effective strategies, including:

- Technologies that are relatively simple and cost-effective to implement.
- Pairing technologies that are not cost-effective with incentives, subsidies, or low-interest loans.
- Local and regional planning that encourages customer investment in cost-effective water resources and systems.
- Changes to state programs that increase multi-beneficial projects.

These strategies are detailed within each of the online toolkit's parent-menu pages.

The online toolkit recommends the following for continued technology transfer to increase drought resilience: increasing funding for distributed water resources, accelerating retirements of inefficient water fixtures, leveraging state programs to improve data about water supplies and uses, and establishing centers of excellence in technologies that achieve California's vision for a clean and resilient future.

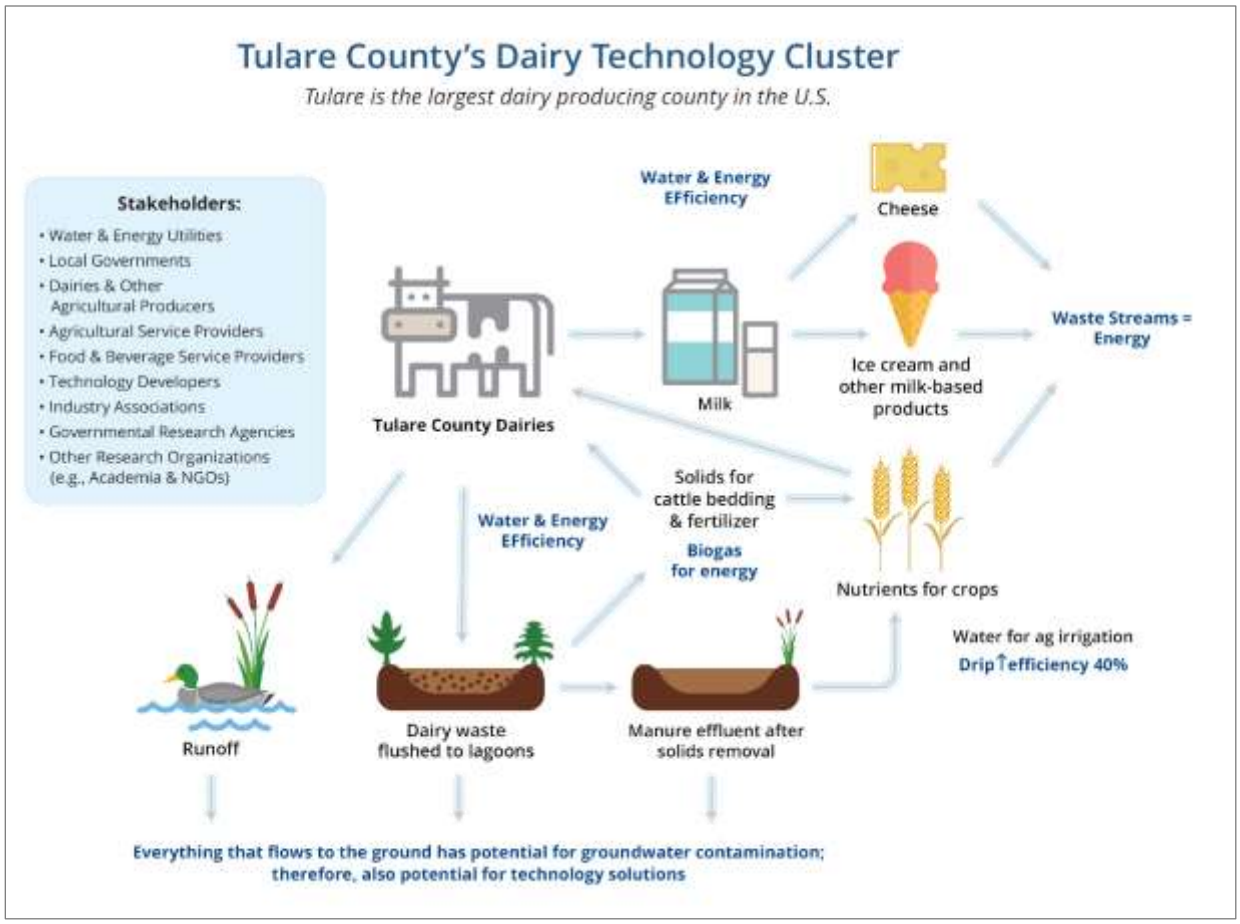
A Proposed Center of Excellence for Drought Resilient Technologies

Tulare County is ideally situated to become an international center of excellence for drought resilience, with Tulare's dairies, dairy related industries and services, and other agricultural producers and stakeholders at its center. Tulare County already hosts one of the largest annual agricultural technology events in the world, the World Ag Expo. The 51st annual expo in February 2018 hosted 106,700 attendees from 49 states and 63 countries[108] at its International Agri-Center.[109]

108 International Agri-Center press release, February 15, 2018.

109 The International Agri-Center is a non-profit corporation formed in 1976 to produce World Ag Expo and to promote California's agriculture industry. It is led by an all-volunteer board of directors; has a full-time staff and more than 1,200 volunteers who dedicate their time to World Ag Expo, the California Antique Farm Equipment Show and other International Agri-Center programs. Source: International Agri-Center website: http://www.internationalagricenter.com/about-us.

Figure 14: Tulare County's Dairy Technology Cluster



Source: Water Energy Innovations, Inc.

Figure 14 depicts the pivotal role of Tulare County's dairy industry in addressing the region's priority resource and environmental issues: water use efficiency, groundwater sustainability, renewable energy production, and reductions of both water and air pollutants and greenhouse gas emissions.

Leading with Dairy

Home to more cows than people, Tulare County is the natural choice to foster statewide, national, and international collaboration on strategies and technologies that can address California priority resource and environmental challenges: drought, nitrates, air pollution, and greenhouse gas emissions. Since many food and beverage processors sited in Tulare County to be near milk producing facilities, Tulare is also home to many dairy-related industries, including food processing, fodder crops, manufacturing, and support services.

Tulare Dairy Industry's vital statistics include:[110]

- 258 dairy farms

110 California Department of Food and Agriculture. *California Dairy Statistics Annual 2017* and *Appendix N: Tulare County's Water-Energy Nexus.*

- 471,081 milk cows
- More than 10 billion pounds of milk
- Allocated economic values for the state at 25 percent:[111]
    - $16.25 billion direct and indirect economic values
    - 47,500 jobs created
- 17.2 billion gallons (52,785 AF; this does not include agricultural irrigation by dairy farmers in fodder crops)
- 431.2 GWh Electricity
- 184,128 MTCO2e

The challenges that Tulare County's dairy industry are presently addressing are representative of the challenges currently faced by all similarly situated California agricultural communities. The urgent need to address drought resilience, nutrient management, air and water pollution, and greenhouse gas reduction will bring technology solutions providers from around the globe.

Benefits of this Approach

The time is opportune to establish a formal program focused on bringing best-in-class drought resilient strategies, practices, and technologies to Tulare County, the South San Joaquin Valley, and the state.

Over the past few years, tremendous public resources have been brought to help Tulare build drought resilience. Concurrently, stakeholders convened multiple forums to collaborate on drought solutions. The problem is that there is now so much activity, few stakeholders are able to participate in all the activities that they believe have merit, leaving many stakeholders frustrated and confused.

In this dynamic environment:

- Bringing stakeholders together to collaborate on identification, evaluation, financing, and implementation of high potential technology solutions to difficult resource, environmental, and economic challenges can help to shift stakeholders' attention from emergency actions to a drought resilient future.
- A methodical approach to vetting and matching technology solutions with appropriate adopters can help overcome some of the classic challenges encountered by all technology providers.
- Applying sound and consistent analytic rigor would help to overcome the concerns that technology adopters have about new technologies.

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111 California farm milk sales in 2014 were about $9.4 billion, and sales of processed dairy products (wholesale) were about $25 billion. The total economic value to the state attributable to milk production and processing was about $65 billion. About 190,000 jobs in California were dependent on the state's milk production and processing. Source: Summer, Daniel A., Josué Medellín-Azuara, Eric Coughlin. *Contributions of the California Dairy Industry to the California Economy, A Report for the California Milk Advisory Board*. University of California Agricultural Issues Center. May 14, 2015.

- Providing a structured forum for sharing of ideas, collaboration, and frank discussions about barriers to technology adoption would be timely and invaluable.

Here, state agencies, regulated and unregulated energy and water utilities, technology solutions providers, and market participants along all segments of the dairy, agricultural, and food processing industries and the supply chains that serve them could coordinate to optimize public investments in projects and technologies that achieve multiple benefits. Through this Center, the many diverse stakeholders confused as to constantly evolving policies, programs, technologies, codes and standards, etc. in California's dynamic marketplace can seek common ground, share information, coordinate their activities, and collectively assure that the state's multiple resource and environmental policies, rules and regulations will be achieved in the most efficient and cost-effective means possible.

Through open communications, participants can strive to minimize confusion and misunderstandings, patch gaps in their knowledge and understanding as to who is doing what, and leverage their collective resources to reduce the huge burdens on their time and costs.

In addition to becoming a central point for collaboration, coordination, and communication, a Center of Excellence in Drought Resilient Technologies would be ideally situated to serve as a testbed for the strategies recommended herein, including but not limited to development and implementation of a pilot Distributed Water Resources program that employs comprehensive valuations of multiple benefit streams to optimize public investments.

GLOSSARY AND ACRONYMS

Term	Definition
AF (acre-foot or acre-feet)	The volume of water needed to cover one acre with one foot of water. One acre-foot is equivalent to 325,851 gallons.
AFY (acre-feet per year)	Number of acre-feet over a one year period.
Applied water	Water delivered and applied to a use.
ARB (Air Resources Board)	State agency responsible for protecting the public from the harmful effects of air pollution and developing programs and actions to fight climate change.
Cal/EPA (California Environmental Protection Agency)	State agency charged with restoring, protecting and enhancing the environment, to ensure public health, environmental quality and economic vitality.[112]
CalEnviroScreen	A mapping tool provided by the California Office of Environmental Health Hazard Assessment (OEHHA) that helps identify California communities that are most affected by many sources of pollution, and where people are often especially vulnerable to pollution's effects.
CCSF (City and County of San Francisco)	The only consolidated city and county in California.[113]
CDFA (California Department of Food and Agriculture)	State agency charged with protecting and promoting agriculture.[114]
CECs (constituents of emerging concern)	Unregulated chemicals are referred to as constituents of emerging concern with regards to monitoring recommendations for recycled water.[115]
CO2 (Carbon Dioxide)	A colorless, odorless, noncombustible gas; principal greenhouse gas.

112 "About Us." *California Environmental Protection Agency*. https://calepa.ca.gov/about/.

113 "List of Consolidated City-County Governments". *National League of Cities*. https://www.nlc.org/list-of-consolidated-city-county-governments.

114 "About CDFA." California Department of Food and Agriculture. https://www.cdfa.ca.gov/CDFA-History.html.

115 Drewes, Jörg E. and Paul Anderson, Nancy Denslow, Walter Jakubowski, Adam Olivieri, Daniel Schlenk, and Shane Snyder. "Monitoring Strategies for Constituents of Emerging Concern (CECs) in Recycled Water Recommendations of a Science Advisory Panel." Science Advisory Panel Convened by the State Water Resources Control Board. April 2018. SCCWRP (Southern California Coastal Water Research Project) Technical Report 1032.

Term	Definition
CO2e (Carbon Dioxide equivalent)	A metric used to represent the quantity of CO2 that that would have the same global warming potential (GWP) as other greenhouse gases when measured over a specified timescale (usually 100 years).
CPUC (California Public Utilities Commission)	State agency responsible for regulating privately owned electric, natural gas, telecommunications, water, railroad, rail transit, and passenger transportation companies.
CV-RWQCB (Central Valley Regional Water Quality Control Board)	One of nine regional water quality control boards established by the 1970 Porter-Cologne Water Quality Control Act that delegated long-term planning and water quality enforcement authority to regional boards.
CV-SALTS (Central Valley Salinity Alternatives for Long-term Sustainability)	A multi-stakeholder effort to produce a salt and nitrate management plan (SNMP) for the Central Valley.
CVSC (Central Valley Salinity Coalition)	Created as a non-profit member organization in 2008 to assist with implementing the SNMP into the basin plans, as well as to manage salts and nitrates in the Central Valley.
CY (Calendar Year)	The 12 month period: January through December of any year.
DAC (Disadvantaged Community)	A regulatory policy term used by federal and State agencies to identify communities eligible for different types of assistance. Different programs use different definitions and criteria to identify DACs (for example, some target communities at risk for health and safety issues due to environmental and other factors, others target populations based on economic factors).
DER (Distributed Energy Resource)	Generally used to identify energy resources that are connected at the energy distribution utility level, including distributed electric generation and renewable natural gas resources, energy efficiency, energy storage, electric vehicles, and demand response technologies.
DG (Distributed Generation)	Electricity production that is on-site or close to the load center and is interconnected to the utility distribution system.

Term	Definition
Disinfected secondary 2.2 recycled water	Recycled water that has been oxidized and disinfected so that the median concentration of total coliform bacteria in the disinfected effluent does not exceed a most probable number (MPN) of 2.2 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed, and the number of total coliform bacteria does not exceed an MPN of 23 per 100 milliliters in more than one sample in any 30 day period.
Disinfected Secondary 23 Recycled Water	Recycled water that has been oxidized and disinfected so that the median concentration of total coliform bacteria in the disinfected effluent does not exceed a most probable number (MPN) of 23 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed, and the number of total coliform bacteria does not exceed an MPN of 240 per 100 milliliters in more than one sample in any 30 day period.
distributed water resources	A term developed for this project that refers to customer side water resources such as water conservation and efficiency, and on-site production and use of recycled water.
DR (Demand Response)	Short-term changes in electric usage made in response to price signals, incentives, or operating agreements to support electric reliability.
drought	Hydrologic conditions during a defined period, greater than one dry year, when precipitation and runoff are much less than average and impacts to people, the environment, and the economy are severe.
drought resilience	The ability to sustain extended periods of low precipitation and water supplies without significant harm to people, the economy and the environment.
DSM (Demand Side Management)	Programs that reduce energy and water usage through user (customer) conservation and efficiency.
CDWR (California Department of Water Resources)	State agency responsible for water planning and management.
EE (Energy Efficiency)	Using less energy to perform the same unit of work.
EPIC (Electric Program Investment Charge)	A surcharge established by the CPUC and assessed to electric customers of PG&E, SCE, and SDG&E for the purpose of funding clean energy technology research.

Term	Definition
electric reliability	The ability of an electric system to avoid instability, uncontrolled separation, or cascading failures due to a sudden disturbance or unanticipated failure of system elements.
Electrochemical Activated Water (ECA)	Process that uses water, salt and electricity to produce a disinfectant and detergent.
EI (Energy Intensity)	The average amount of energy used to perform a unit of work.
Embedded energy	The amount of energy deemed embedded in (input to) a product, system, or process.
EO (Executive Order)	A signed, written, and published directive from the Governor of California to state agencies.
F&B (Food & Beverage)	An industry segment that processes or manufactures food products and beverages.
FY (Fiscal Year)	The fiscal year for state and most local governmental entities in California typically run from July to June.
GGRF (Greenhouse Gas Reduction Fund)	A fund established in 2012 to receive Cap-and-Trade auction proceeds appropriated by the Legislature and Governor for projects that support the goals of Assembly Bill 32, California Global Warming Solutions Act.[116]
GHG (Greenhouse Gas) emissions	Any gas that absorbs infrared radiation in the atmosphere and contributes to global warming (for example, water vapor, methane, nitrous oxide, hydrochlorofluorocarbons, ozone, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride).
GPCD (Gallons per capita per day)	In context of California's mandatory urban water efficiency policies, indoor use is aggregated across population in an urban water supplier's service area (not each household).[117]
gpd (gallons per day)	Number of gallons per day (used, pumped, treated, etc.).
gpm (gallons per minute)	The number of gallons per minute that are flowing at any particular point in a water or wastewater utility's system.

116 "CCI (California Climate Investments) Funded Programs." *Air Resources Board.* https://ww2.arb.ca.gov/our-work/programs/california-climate-investments/cci-funded-programs.

117 California State Water Resources Control Board (SWRCB), *Water Conservation Fact Sheet, Water Efficiency Legislation will Make California More Resilient to Impacts of Future Droughts*, (Sacramento, CA, June 7, 2018).

Term	Definition
GSA (Groundwater Sustainability Agency)	A new structure required by the Sustainable Groundwater Management Act (SGMA) for managing California's high and medium priority groundwater basins and sub-basins.[118]
GSP (Groundwater Sustainability Plan)	Detailed roadmaps that describe the steps that high and medium priority groundwater basins and sub-basins will implement to achieve groundwater sustainability in accordance with the Sustainable Groundwater Management Act (SGMA).[119]
GWh (Gigawatt hour)	One million kilowatt hours.
HPU (High Power Ultrasound)	Low frequency, high-power ultrasound (20kHz - 1MHz) can be applied to industrial processes including food safety.[120]
HRAP (High Rate Algal Ponds)	Ponds designed to optimize algae biomass growth.
Integrated Energy Policy Report	Biennial energy assessments and forecasts conducted by the Energy Commission as required by state legislation to support development of energy policies that conserve resources, protect the environment, ensure energy reliability, enhance the state's economy, and protect public health and safety.
kWh (kilowatt hour)	One kWh is the use of one kilowatt of electricity for one hour.
MAF (Million Acre-Feet)	One million acre-feet (280,026 million gallons).
MBR (Membrane Bioreactor)	An advanced wastewater treatment technology that uses a combination of biological treatment and microfiltration.
MG (Million Gallons)	One million gallons (3,571,097 acre-feet).
MGD (Million Gallons per Day)	Number of millions of gallons per day (used, pumped, treated, etc.).
MTCO2e (Metric Tonne of CO2 Equivalents)	One metric tonne (2204.6 pounds) of greenhouse gases.

118 "Groundwater Sustainability Agencies." California Department of Water Resources. https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management/Groundwater-Sustainable-Agencies.

119 "Groundwater Sustainability Plans." California Department of Water Resources. https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management/Groundwater-Sustainability-Plans.

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Term	Definition
MWD (Metropolitan Water District of Southern California)	California's largest supplier of urban water serving 19 million residents in southern California through 26 member public agencies.
MWELO (Model Water Efficient Landscape Ordinance)	Established by the California Water Commission to reduce the percentage of landscaped areas that can be planted with high water use plants, including turf, to 25 percent. Local agencies can establish their own ordinances as long as they adhere to the principles.
NAICS (North American Industry Classification System)	A 6-digit coding system used by federal statistical agencies to classify business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the national business economy.
"normal" hydrology	Long term recorded historical average annual precipitation.
Non-Potable Water Program (NPWP)	The City and County of San Francisco's model Non-Potable Water Program.
Primary Wastewater Treatment	The process of filtering out large particles in liquid waste.
Recycled Water	Water that is captured and treated after use so that it can be beneficially reused.
Secondary Undisinfected Wastewater Treatment	This is oxidized wastewater.
Secondary Wastewater Treatment	Use of additional filtration, aeration and/or oxidation to improve the quality of primary treated wastewater effluent.
SFPUC (San Francisco Public Utilities Commission)	The City and County of San Francisco's department of water, wastewater, and energy utility services.
SGMA (Sustainable Groundwater Management Act)	State legislation requiring local governments and water agencies of high and medium priority basins to halt overdraft and bring groundwater basins into balanced levels of pumping and recharge.
SNMP (Salt and Nitrate Management Plan)	Adopted by the Central Valley Regional Water Quality Control Board (RWQCB) on June 1st, 2018 to mitigate threats to groundwater quality from salts, nitrates, and other contaminants.

Term	Definition
Stranded Costs	Investments made in facilities, systems, infrastructure, etc. that cannot be financially recovered in the manner initially contemplated at the time that the investment decision was made.
SWA (Surface Water Augmentation)	Surface water augmentation" means the planned placement of recycled water into a surface water reservoir used as a source of domestic drinking water supply."121
SWRCB (State Water Resources Control Board)	State agency responsible for preserving, enhancing, and restoring the quality of California's water resources and drinking water for the protection of the environment, public health, and all beneficial uses, and to ensure proper water resource allocation and efficient use.
TAF (thousand acre-feet)	One thousand acre-feet (280 million gallons).
Tertiary Wastewater Treatment	Additional treatment to improve the quality of the secondary effluent before it is discharged to the environment or used as recycled water; typically involves removing more solids through filtration, further reducing biochemical oxygen demand, and disinfection.
TID (Tulare Irrigation District)	An irrigation special district in Tulare County operating under the California Water Code.
Title 20	California Code of Regulations, Public Utilities and Energy. California's Appliance Efficiency Regulations, including water efficient fixtures and appliances, reside within Title 20, Division 2, State Energy Resources Conservation and Development Commission.
Title 22	California Code of Regulations, Social Security. California's Water Recycling Criteria resides within Title 22, Division 4, Environmental Health.
Title 24	California Code of Regulations, Building Standards Code. California's Plumbing Code resides within Title 24, Part 5.
USBR (U.S. Bureau of Reclamation	Federal agency responsible for managing, developing, and protecting water and related resources that are collected and delivered from federal water projects.

121 California Water Code, Section 13561 (d) Surface Water Augmentation.

Term	Definition
USGS (U.S. Geological Survey)	Sole science agency for the federal Department of the Interior.[122]
UV (Ultraviolet)	A type of electromagnetic radiation found effective for disinfection.
UWMP (Urban Water Management Plan)	Required at 5 year intervals by California Water Code Division 6 Part 2.6 Urban Water Management Planning by all urban water suppliers providing water for municipal purposes either directly or indirectly to more than 3,000 customers or supplying more than 3,000 acre-feet of water annually.
Water Use Cycle	A framework established by the Energy Commission to estimate the amount of energy embedded in water resources and water and wastewater systems. The purpose of the framework is to enable computing the energy intensity of alternative water resources or water savings for purposes of determining the appropriate amount of energy investment in water efficiency.
WCP (Water Conservation Plant)	Term used to describe wastewater treatment plants that produce recycled water.
WPCF (Wastewater Pollution Control Facility)	Term used to describe wastewater treatment plants.
WWTF (Wastewater Treatment Facility)	Another term used to describe wastewater treatment plants.
WY (Water Year)	October through September. WY2018 begins on October 1, 2017 and ends on September 30, 2018.

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APPENDIX A:
California's Drought Policies

The driest four-year precipitation record for California is from 2012 to 2015, where 2015 also marks the smallest snowpack on record at 5 percent of average.[123] This most recent drought (2012-2016) showered the state with record setting heat and spurred several important policies that have enabled California to enact a long-term framework (Water Action Plan) that prioritizes conservation, funding and actions necessary to deal with water supply sustainability. Below are the main pieces of legislation that were signed into law to coordinate and improve drought relief.

> "We can't make it rain, but we can be much better prepared for the terrible consequences that California's drought now threatens, including dramatically less water for our farms and communities."
>
> Governor Brown Declares Drought State of Emergency, January 17, 2014

In May of 2013, Governor Edmund G. Brown, Jr. issued Executive Order B-21-13 that directed the State Water Resources Control Board (SWRCB) and the California Department of Water Resources (CDWR) to expedite the process and review of water transfers with specifications to "alleviate critical impacts to San Joaquin Valley agriculture."[124] This EO was enacted after a record dry January-May and after CDWR's snow survey determined that, on May 2, 2013, the Sierra snowpack was at 17 percent of normal conditions. December of 2013 also marked a record dry month that resulted in the Governor's establishment of an Interagency Drought Task Force to coordinate responses to water shortages between federal and local agencies.

In January 2014 the Governor's administration released California's Water Action Plan which was adopted to put California on a path to sustainable water management. The Plan was updated in 2016 and includes the following 10 key actions which have—and continue to—comprehensively ground the policies discussed within this paper.

1. Making conservation a California way of life.
2. Increase regional self-reliance and integrated water management across all levels of government.
3. Achieve the co-equal goals for the Delta.
4. Protect and restore important ecosystems.
5. Manage and prepare for dry periods.
6. Expand water storage capacity and improve groundwater management.

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123 Office of Governor Brown, *Governor Brown Lifts Drought Emergency, Retains Prohibition on Wasteful Practices*, April 7, 2017.

124 Governor Brown, Executive Order B-21-13.

7. Provide safe water for all communities.
8. Increase flood protection.
9. Increase operational and regulatory efficiency.
10. Identify sustainable and integrated financing opportunities.

In January 2014, Governor Brown also declared a drought State of Emergency following 2 dry years of hydrology—2012 and 2013 respectively. The Governor's Proclamation of a State of Emergency (Proclamation No. 1-17-2014), paved the way for California to deliver much needed emergency drought relief assistance to severely impacted communities throughout CA. These efforts began through the following directives that complement the key actions within the Water Action Plan:

- CDWR was directed to lead state agencies in implementing a water conservation campaign to have Californians reduce their water usage by 20 percent. The campaign was to build upon the existing Save Our Water campaign.
- Local urban water suppliers and municipalities were ordered to implement their local water shortage contingency plans immediately.
- The state's Drinking Water Program was directed to work with local agencies to identify communities that may run out of drinking water and to identify emergency interconnections that exist and could help threatened communities.
- CDWR and the SWRCB were directed to expedite the processing of water transfers, expedite the funding for water supply enhancement projects and to take the actions necessary to make water immediately available.

On April 25, 2014, Governor Brown issued an Executive Order (April 2014 Proclamation) to increase drought efforts due to three years of drought conditions. This EO most notably required the SWRCB to adopt emergency regulations to limit wasteful urban water usage and directed California residents to stop wasting water on sidewalks, driveways, landscapes, vehicles and more.

A few months later in September of 2014, three pieces of legislation were signed into law that include Assembly Bill 1739, Senate Bill 1168 and Senate Bill 1319. Collectively these three bills are known as the Sustainable Groundwater Management Act (SGMA)—California's first framework to manage groundwater sustainability for long-term reliability benefits. For more information on SGMA refer to Chapter 4.

Days later, EO B-26-14 was issued to help streamline efforts for families without drinking water to provide temporary supplies under the California Disaster Assistance Act. 2014 ranked as the third driest water year on record in terms of statewide precipitation and California lawmakers put Proposition 1 (AB 1471, the Water Bond) on the ballot November 4, 2014 which was passed by 4,771,350 voters (67.13 percent). The Water Action Plan provided the foundation for this bond.

Prop 1 allocated $7.545 billion in general obligation bonds to fund the following items shown in Table A-1.

Table A-1: Proposition 1 Funding Allocations and Balance Remaining

Prop 1 Funded Item	Allocation	Committed	Balance
Statewide Water System Operational Improvement and Drought Preparedness	$2.7 billion	$2,646,000,000	$54,000,000
Protecting Rivers, Lakes, Streams, Coastal Waters and Watersheds	$1.495 billion	$1,161,661,000	$333,339,000
Groundwater Sustainability	$900 million	$859,066,000	$40,934,000
Water Recycling	$725 million	$694,834,000	$30,166,000
Regional Water Security, Climate and Drought Preparedness	$810 million	$512,726,000	$297,274,000
Clean, Safe and Reliable Drinking Water	$520 million	$480,451,000	$39,549,000
Flood Management	$395 million	$111,000,000	$284,000,000
Statewide Bond Costs	X	$150,900,000	($150,900,000)
Total	**$7.545 billion**	**$6,616,638,000**	**$928,362,000**

Source: California Natural Resources Agency Bond Accountability Website.

As dry conditions continued, the Governor directed the SWRCB—on April 15, 2015—to implement a mandatory water reduction in cities and towns across California to reduce statewide potable water usage 25 percent by February 28, 2016. This mandatory reduction (EO B-29-15) was a first for the state and the Executive Order also included provisions to replace 50 million square feet of lawns with drought tolerant landscapes, prohibit new developments from irrigation with potable water unless using water-efficient drip irrigation systems and investing in new technologies.

2015 also marked the year that the Governor had to issue two executive orders for the State of Emergency due to California wildfires (EO B-33-15 and EO B-35-15) and in November issued EO B-36-15 to bolster drought responses as the state entered its fifth year of drought.

Though the beginning of 2016 brought some much needed precipitation, the Governor introduced E0 B-37-16 (Making Water Conservation a California Way of Life) in May to ensure and increase long-term water conservation in the state since drought conditions continued to persist in many regions, especially the Central Valley. This EO mentions the priorities in the California Water Action Plan and calls on Californians to use water more wisely, eliminate water waste, strengthen local drought resilience, and improve agricultural water use efficiency.

Conditions continued to improve and in April of 2017, through Executive Order B-40-17, Governor Brown lifted the drought State of Emergency for all of California except for the following counties: Fresno, Kings, Tulare and Tuolumne.

Most recently, on May 31, 2018 the Governor approved Assembly Bill 1668 and Senate Bill 606 that add more performance measures for indoor water and for more efficient water use overall. SB 606 includes an amendment that changes "water conservation" to "efficient use of water."

Tulare County Actions

As EO B-40-17 emphasized, Tulare County was deeply impacted by the drought and dry conditions persisted after the drought State of Emergency was rescinded. Prior to the drought, water demand in the Southern San Joaquin Valley already exceeded the supplies available from surface streams, imports and sustainable groundwater extraction. In the four decades from 1962 to 2002, groundwater storage in the Tulare Basin dropped by nearly 70 million acre-feet.[125] Unlike the Sacramento Valley, San Joaquin Delta and San Joaquin Basin, the basin supplying the Southern San Joaquin Valley fell dramatically during dry periods, and failed to recover during wet periods.[126] By 2012—the first year of the drought—CDWR estimated groundwater overdraft for the Tulare Basin to be 820,000 acre-feet per year, more than any other basin in the state and a majority of California's total groundwater overdraft.[127]

In East Porterville and other disadvantaged communities (DACs), many homes were dependent on domestic wells dug when groundwater levels were higher. By June of 2017, Tulare County had experienced over 1,600 domestic well failures, with more than 300 in East Porterville alone.[128] Extensive media coverage highlighted the community of East Porterville's wells running dry and the emergency supplies of bottled water that needed to be trucked in. To create a sustainable solution, the state (CDWR, Governor's Office of Emergency Services, SWRCB) worked with Porterville and Tulare County organizations to implement the East Porterville Water Supply Project. This project began construction in January 2016 to connect 755 homes to a permanent piped water supply.

Under the Tulare County Water Conservation Program Statute, which applies in areas where the county provides domestic water, restrictions on water use apply in escalating "stages" based on the severity of the drought.[129] Stage 1 includes general requirements to avoid waste, such as not allowing excess runoff, not using hoses without shut-off nozzles to wash outdoor surfaces, and not watering landscapes or refilling swimming pools during mid-day in the summer.[130] Stage 2

125 U.S. Geological Survey. 2009. Fact Sheet 2009-3057. California's Central Valley Groundwater Study: A Powerful New Tool to Assess Water Resources in California's Central Valley. Retrieved from https://pubs.usgs.gov/fs/2009/3057.

126 Ibid.

127 Tulare County General Plan 2030 Update (2012). Retrieved from http://generalplan.co.tulare.ca.us/.

128 Tulare County. 2017. Drought. Retrieved from http://tularecounty.ca.gov/emergencies/index.cfm/drought/drought-effects-status-updates.

129 Tulare County Ordinance Code §§ 8-07-1000 et seq. Tulare County also mandates water efficient landscaping practices, such as using permeable surfaces to maximize retention of rainfall. See Tulare County Ordinance Code §§ 7-31-1000 et seq.

130 Tulare County Ordinance Code § 8-07-1145.

establishes voluntary guidelines on the time and manner of outdoor watering, while Stage 3 imposes mandatory limits, including restricting outdoor watering to two days a week.[131] Stage 4 ("Water Emergency") imposes additional mandatory limits, including prohibitions on watering between 6:00 a.m. and 8:00 p.m. (even on designated days), refilling swimming pools and other outdoor water uses.[132] Currently, the county is enforcing Stage 4 restrictions for residents served by the Seville Water Company, and Stage 3 restrictions for customers of two other county-operated water systems.[133]

Many of Tulare County's cities have adopted similarly structured ordinances, though the restrictions associated with each stage vary.[134] Below are the major county ordinances that were enacted to help improve drought conditions.

Table A-2: Tulare County Drought Actions

Local Actions	Date	Description
Tulare County City Council-Resolution 2014-0090	February 4, 2014	State of Emergency declared by Tulare County City Council
Tulare County Ordinance: 8-07-1000	January 6, 2015	It is the purpose and intent of this Chapter to minimize outdoor water use and to control unnecessary consumption of the available potable water supplies in certain unincorporated areas wherein the County supplies potable domestic water to residents of the County of Tulare. Within are specific provisions and penalties for excessive use of water.
City of Visalia-Ordinance 13.20	June 2, 2015	It is the purpose and intent of this ordinance is to prevent waste or unreasonable use or unreasonable method of use of water in the city. Details specific regulations on the use of water and water conservation stages.
City of Porterville-Ordinance 1830	November 17, 2015	The city council has adopted by resolution its water conservation plan which sets forth water conservation phases and conservation measures including mandatory restrictions on water usage by property owners and water consumers.
City of Tulare-Ordinance 7.32	February 16, 2016	The ordinance codified in this chapter specifies the purpose and goal of eliminating water waste and to minimizing outdoor water use and to control unnecessary consumption of the available potable water supplies in the city. It details specific regulations and prohibitions.

Source: Tulare County Website

131 Tulare County Ordinance Code §§ 8-07-1155, 8-07-1170.

132 Tulare County Ordinance Code § 8-07-1175.

133 Tulare County. 2017b. Outdoor Water Conservation. Retrieved from http://www.tularecounty.ca.gov/rma/index.cfm/public-works/water-sewer-services/outdoor-water-conservation/.

134 City of Tulare Ordinance Code §§ 7.32.010 et seq., City of Visalia Municipal Code §§ 13.20.010 et seq., City of Farmersville Ordinance Code §§ 13.06.010 et seq.; and City of Dinuba Municipal Code §§ 13.05.010 et seq.

Key Policies to Increase Tulare County's Drought Resilience

The state responded to the drought by enacting multiple laws and regulations that are meant to increase California's resilience to climatic extremes by creating a more sustainable water supply. Below are the key policies relevant to accelerating adoption of technologies that will increase Tulare County's drought resilience by saving water and energy for a productive agricultural region that meets its water needs from a combination of surface water, imported water and groundwater.

Recycled Water

With advancements in technology, recycling water has become a reliable, safe and sustainable alternative supply for the state and especially for regions like Tulare County that are heavily dependent on surface and imported water supplies. [*See Appendix B: Recycled Water for more information about Tulare County's recycled water opportunities.*]

Gray Water

Gray water utilizes wastewater from bathtubs, showers, bathroom washbasins, washing machines and laundry tubs for residential potable water use in landscape and toilet applications. This onsite reuse saves water and energy and reduces residents' water bills. Because showers, sinks and laundry water comprise 50-80 percent of residential wastewater, gray water systems have a large market opportunity within Tulare County.

Groundwater

Tulare County is heavily dependent on groundwater, especially when surface water supplies are low. Tulare is also served by critically overdrafted sub-basins that are subject to the Sustainable Groundwater Management Act.

Groundwater Quality

There are multiple regulations and rules to govern salt and nitrate management in California's South San Joaquin Valley that are enacted to sustain and increase the region's water quality. These policies include waste discharge requirements for milk cow dairies and the Central Valley-wide Salt and Nitrate Management Plan (SNMP). The SWRCB is also required to develop pilot projects that focus on nitrates in groundwater in the Tulare Lake Basin. [See *Appendix E: Groundwater Quality* for more information.]

CHAPTER V

State and Local Policies, Rules and Regulations

Tulare County General Plan 2030 Update

Goals and Policies Report

Chapter 11, Water Resources

(Major Goals for Water Conservation and Reclaimed Wastewater)

Tulare County's General Plan Update states that the County's long-term strategy for water centers on "protecting and conserving existing water supplies and identifying new sources of water. As Tulare County continues to grow, new methods for conserving, treating and supplying water will enable County residents and farmers to continue to have an adequate supply of quality water that limits long-term impacts on groundwater." Chapter 11 identifies the following goals, polices and implementation measures to ensure sustainable management of the County's water resources:

GOAL WR-1 (Water Quantity) Provide for the current and long-range water needs of the County and for the protection of the quality and quantity of surface and ground water resources.

> **POLICY 1.5 Expand Use of Reclaimed Wastewater:** To augment groundwater supplies and to conserve potable water for domestic purposes, the County shall seek opportunities to expand groundwater recharge efforts
>
> **POLICY 1.6 Expand Use of Reclaimed Water:** The County shall encourage the use of tertiary treated wastewater and household gray water for irrigation of agricultural lands, recreation and open space areas, and large landscaped areas as a means of reducing demand for groundwater resources.

GOAL WR-2: (Water Quality) Provide for the current and long-range water needs of the County and for the protection of the quality of surface water and groundwater resources;

GOAL WR-3 Provide a sustainable, long-term supply of water resources to meet domestic, agricultural, industrial and recreational needs and to assure that new urban development is consistent with available water resources.

> **POLICY WR-3.1 Develop Additional Water Sources:** The County shall encourage, support and, as warranted, require the identification and development of additional water sources through the expansion of water storage reservoirs, development of groundwater banking for recharge and infiltration, and promotion of water conservation programs, and support of other projects and programs that intend to increase the water sources available to the County and reduce the individual demands of urban and agricultural users.
>
> **POLICY WR-3.5 Use Native and Drought Tolerant Landscapes:** The County shall encourage the use of low water consuming, drought-tolerant and native landscaping and emphasize the importance of utilizing water conserving techniques, such as night watering, mulching and drip irrigation.

POLICY WR-3.6 Establish a Water Use Efficiency Education Program: The County shall support educational programs targeted at reducing water consumption and enhancing groundwater recharge.

POLICY WR-3.7 Establish an Emergency Water Conservation Plan for County-operated water systems to identify appropriate conservation policies that can be implemented during times of water shortages..."

IMPLEMENTATION MEASURES (IMs) help achieve the above policies and include:

IM 10: The County shall incorporate provisions, including evaluating incentives, for use of reclaimed wastewater, water conserving appliances, drought tolerant landscaping, and other water conservation techniques into the County's building, zoning and subdivision ordinances. (pages 11-12 - 11-13) Supports Policies WR-1.5, WR-3.1, 3.5, 3.6.

IM 21: The County shall maintain and implement its water efficient landscape ordinance or the Dept. of Water Resources Model Water Efficient Landscape Ordinance (page 11-14). Supports Policy WR-3.5.

APPENDIX B:
Recycled Water

California defines recycled water as "water which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur and therefor considered a valuable resource." California Code of Regulations (CCR) Title 22 Division 4 Environmental Health Article 3 Uses of Recycled Water stipulates the minimum level of water quality required for application to various types of beneficial uses.

Table B-1: Minimum Treatment Levels for Specific Uses of Recycled Water

Urban Uses and Landscape Irrigation	Disinfected Tertiary	Disinfected Secondary	Undisinfected Secondary
Fire protection	✔		
Toilet & urinal flushing	✔		
Irrigation of parks, schoolyards, residential landscaping	✔		
Irrigation of cemeteries, highway landscaping		✔	
Irrigation of nurseries		✔	
Landscape impoundment	✔	✔*	
Agricultural Irrigation			
Pasture for milk animals		✔	
Fodder and fiber crops			✔
Orchards (no contact between fruit and recycled water)			✔
Vineyards (no contact between fruit and recycled water)			✔
None-food bearing trees			✔
Food crops eaten after processing		✔	
Food crops eaten raw	✔		
Commercial/Industrial			
Cooling & air conditioning - w/cooling towers	✔	✔*	
Structural fire fighting	✔		
Commercial car washes	✔		
Commercial laundries	✔		
Artificial snow making	✔		
Soil compaction, concrete mixing		✔	
Environmental and Other Uses			
Cooling & air conditioning - w/cooling towers	✔		
Structural fire fighting		✔	
Commercial car washes	✔	✔*	
Groundwater Recharge			
Seawater intrusion barrier	✔*		
Replenishment of potable aquifers	✔*		

* Restrictions may apply

Source: "Water Facts: Water Recycling." Department of Water Resources No. 23. October 2004. https://water.ca.gov/LegacyFiles/pubs/conservation/water_facts_no._23__water_recycling/waterfact23.pdf

In addition to the above uses, there are currently two water reuse options to transform wastewater into drinking water that are dominating California legislation and policy: indirect potable reuse (IPR) and direct potable reuse (DPR).

- Indirect potable reuse requires blending the treated water with another source (for example augmenting with groundwater, surface water, etc.) for a certain amount of time (retention time) before distributing it into the water system.
- Direct potable reuse is the purification of wastewater to such a high quality that it is safe to distribute directly into a drinking water system or into a raw water supply immediately upstream of a treatment plant.

With advancements in technology, recycling water has become a reliable, safe and sustainable alternative supply.

The Evolution of California's Recycled Water Policy

The state's Recycled Water Policy was first adopted on January 6, 1977 via the State Water Resources Control Board (SWRCB) Resolution No. 77-1. The Resolution set forth the following general principles for SWRCB investment:

- "Beneficial use will be made of wastewaters that would otherwise be discharged to marine or brackish receiving waters or evaporation ponds,
- "Reclaimed water will replace or supplement the use of fresh water or better quality water,
- "Reclaimed water will be used to preserve, restore, or enhance instream beneficial uses which include, but are not limited to, fish, wildlife, recreation and esthetics associated with any surface water or wetlands."

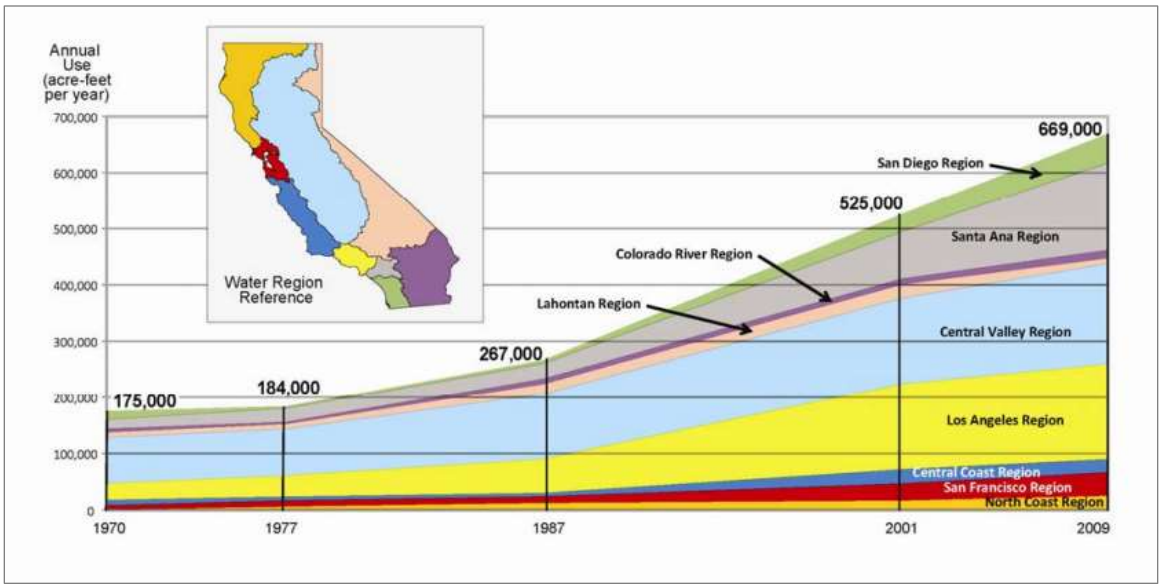
The Resolution further stated that "The State and the Regional Boards shall (1) encourage reclamation and reuse of water in water-short areas of the State, (2) encourage water conservation measures which further extend the water resources of the State, and (3) encourage other agencies, in particular the Department of Water Resources, to assist in implementing this policy."

Periodic surveys were conducted by the SWRCB since 1970 to categorize and quantify the volume of recycled water produced and beneficially used throughout the state.

Figure B-2 on the next page illustrates the growth in recycled water production and use in California from 1970 through 2009.

- Between 1970 and 2001, recycled water production and use increased three-fold: from 175,000 AF/year (AFY) to 525,000 AFY.
- Between 2001 and 2009, recycled water increased an addition 144,000 AFY (a 27.4 percent increase over 2001, and 282 percent over 1970).

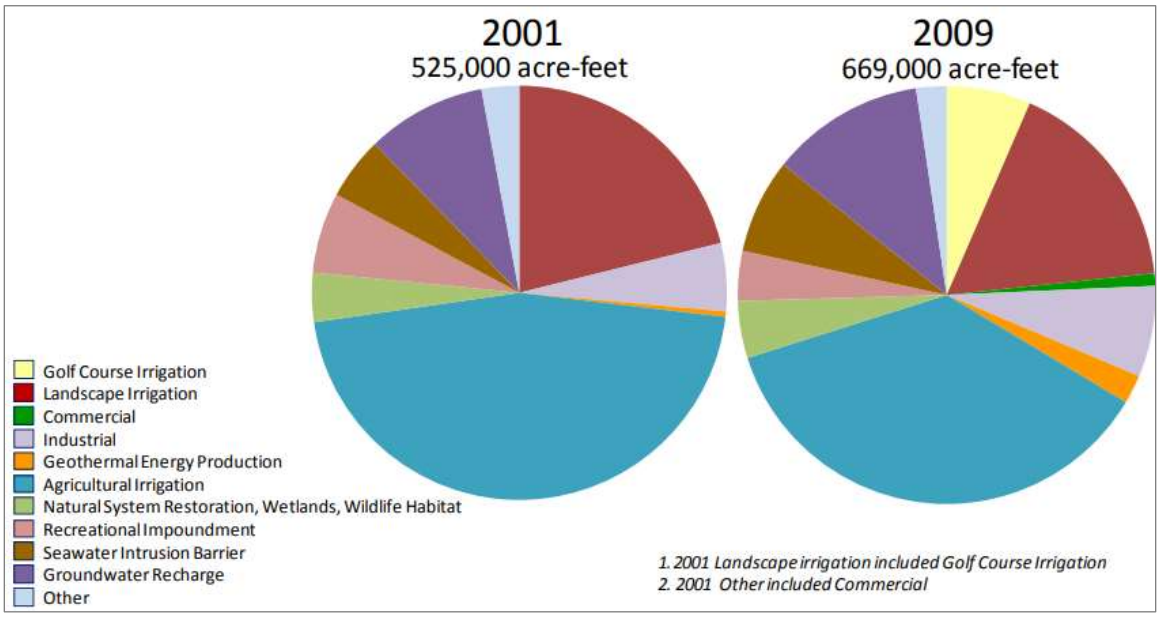
Figure B-2: Growth in Recycled Water Production and Use (1970-2009)



Source: "Results, Challenges, and Future Approaches to California's Municipal Wastewater Recycling Survey." State Water Resources Control Board and Department of Water Resources. 2009. Figure 1.

Figure B-3 shows the change in beneficial uses of recycled water between 2001 and 2009. The primary changes were additional recycled water use by golf courses, and the beginning of recycled water use by the Commercial sector.

Figure B-3: Change in Beneficial Uses of Recycled Water (2001 and 2009)



Source: "Results, Challenges, and Future Approaches to California's Municipal Wastewater Recycling Survey." State Water Resources Control Board and Department of Water Resources. 2009. Figure 2.

On February 3, 2009, after conducting multiple public workshops and issuing a draft report certifying regulatory program environmental analysis with CEQA checklist for public review, the SWRCB adopted *A Policy for Water Quality Control for Recycled Water*. The 2009 Policy [*SWRCB Resolution No. 2009-0011*] update was designed to support one of the priorities articulated in the SWRCB's Strategic Plan Update 2008-2012: "to increase sustainable local water supplies available for meeting existing and future beneficial uses by 1,725,000 acre-feet per year, in excess of 2002 levels, by 2015, and ensure adequate water flows for fish and wildlife habitat. This Recycled Water Policy (Policy) is intended to support the Strategic Plan priority to Promote Sustainable Local Water Supplies. Increasing the acceptance and promoting the use of recycled water is a means towards achieving sustainable local water supplies and can result in reduction in greenhouse gases, a significant driver of climate change. The Policy is also intended to encourage beneficial use of, rather than solely disposal of, recycled water."

SWRCB Resolution No. 2009-0011 directed the SWRCB to convene a "blue-ribbon" advisory panel (Panel) to provide guidance on future actions related to monitoring constituents of emerging concern (CECs) in recycled water. On January 22, 2013, the Policy was amended to specify monitoring requirements for constituents of emerging concern (CECs) in recycled water for groundwater recharge projects based on recommendations from a 2010 Science Advisory Panel. In December 2016, the State Water Resources Control Board (SWRCB) adopted Resolution No. 2016-0061, which directed staff to "reconvene the Science Advisory Panel to update its recommendations for monitoring CECs in recycled water and update the Recycled Water Policy considering changes that have taken place since 2013." The Science Advisory Panel issued its report *Monitoring Strategies for Constituents of Emerging Concern (CECs) in Recycled Water Recommendations of a Science Advisory Panel* in April 2018. The Proposed Amendment to the *Policy for Water Quality Control for Recycled Water (2018)* was released for Public Comment on May 9, 2018.

Key Recycled Water Policies

- Assembly Bill 371 Water Recycling Act of 2006 [Goldberg 2006] required, among other things, the Department of Water Resources to adopt and submit to the California Building Standards Commission regulations to establish a state version of Appendix J of the Uniform Plumbing Code to provide design standards to safely plumb buildings with both potable and recycled water systems.
- Senate Bill 918 Water Recycling [Pavley 2010] and Senate Bill 322 Water Recycling [Hueso 2013] required adoption of uniform water recycling criteria for groundwater recharge and surface water augmentation.
- Assembly Bill 574 Potable Reuse [Quirk 2017]
    - Added "raw water augmentation" and "treated drinking water augmentation" to the definition of "direct potable reuse";
    - Changed the term "surface water augmentation" to "reservoir water augmentation";

- And redefined that term to mean the planned placement of recycled water into a raw surface water reservoir used as a source of domestic drinking water supply for a public water system or into a constructed system conveying water to such a reservoir.
- AB574 also recommended that the SWRCB establish a framework for regulating potable reuse projects before June 1, 2018.
- AB574 further required the SWRCB "to adopt uniform water recycling criteria for direct potable reuse through raw water augmentation."
- The bill further prohibits the SWRCB from adopting the uniform water recycling criteria until the expert review panel adopts a finding that the proposed criteria would adequately protect public health.

Recycled Water Regulations

In compliance with AB574, the SWRCB issued A Proposed Framework for Regulating Direct Potable Reuse in California in April 2018. Also, in compliance with AB574, Surface Water Augmentation (SWA) Regulations were approved by the Office of Administrative Law on August 7, 2018, and filed with the Secretary of State: August 7, 2018. These new regulations become effective on October 1, 2018.

Many parts of California are reliant on imported water and with multi-year droughts creating huge unknowns with respect to delivery and supply availability, recycled water has become a reliable, safe and sustainable alterative supply for the state.

At the most basic level, recycled water—as defined in Section 13050 of the Water Code—"means water which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur and therefore considered a valuable resource."

California's Title 22 Recycling Criteria provides the state with guidelines on how recycled water is treated, discharged and used. Treatment levels include un-disinfected secondary (oxidized but not disinfected), disinfected secondary and disinfected tertiary (oxidized, filtered and disinfected). Table B-1 demonstrates the beneficial uses of note that include agricultural and landscape irrigation, replenishing groundwater basins, industrial processes, and toilet flushing.

Recycled Water Regulations

Within the United States, there are no federal regulations for water recycling or recycled water reuse. The responsibility thus falls to state and local agencies.[135] However, there are certain overarching federal laws that do impact the planning state of projects.

In California, the State Water Resource Control Board (SWRCB) and the nine Regional Water Boards hold jurisdiction over recycled water in California (the Drinking Water Program [DWP]). Prior to 2014, the California Department of Public Health shared joint jurisdiction over the public health and drinking water supplies but in 2014 the Division of Drinking Water (DDW)

135 California Environmental Protection Agency, 2012 *Guidelines for Water Reuse,* September 2012.

was transferred to the SWRCB. The following is a brief description of the agencies and their roles.

- The SWRCB is tasked with the overall protection of water quality, drinking water and water supplies. To that end, the SWRCB is responsible for establishing the policies that govern permitting of recycled water projects, makes sure the recycled water use goals are met and develops the general permit for irrigation uses of water.
- The Regional Water Boards protect surface and groundwater resources and are the entity that issue permits with the DDW. Permits include the below:
    - Water Supply Permit for water purveying agency: Issued after project implementation incorporating state and federal drinking water requirements and project specific requirements.
    - NPDES Discharge Permit for augmentation discharger: Issued by the Regional Board and US EPA after CEQA and before the project start. Permit incorporates the Clean Water Act requirements, state and regional water quality standards and site-specific discharge requirements and other SWRCB requirements. This permit is valid for 5 years.
- The California Department of Water Resources (CDWR) updates and reviews the California Water Plan every five years. This review includes looking at the current and future uses of recycled water. CDWR will also help the SWRCB issue bonds for recycling water incentives.
    - The California Public Utilities Commission (CPUC) approves the terms of service and rates for recycled water use by investor-owned utilities.
    - The state's Recycled Water Regulations are found in Title 22, Division 4, Environmental Health.

California's Recycled Water Policy Goals

1. Increase recycled water over 2002 levels by at least one million acre-feet per year (afy) by 2020 and at least two million afy by 2030.
2. Increase use of stormwater over 2007 levels by at least 500,000 afy by 2020 and at least one million afy by 2030.
3. Substitute as much recycled water for potable water as possible by 2030.

Table B-2: Evolution of California's Recycled Water Policy

1943	California Water Code General Provisions enacted.
1969	Porter-Cologne Water Quality Control Act establishes the State Water Resource Control Board's (SWRCB) and the state's nine Regional Water Boards, which have primary responsibility for protecting water quality, allocating surface water, permitting and inspecting water projects.
1977	Resolution No. 77-1: SWRCB Policy with Respect to Water Reclamation in California.

1996	Memorandum of Agreement (MOA) between the Department of Health Services and SWRCB that sets forth principles, procedures and agreements related to use of reclaimed water in California.
2000	Title 22 revisions listing allowable recycled water uses, are adopted.
2009	SWRCB adopts Recycled Water Policy to support the Strategic Plan priority to Promote Sustainable Local Water Supplies and increase beneficial uses of recycled water.
	SWRCB adopts statewide general permit for landscape irrigation uses of recycled water.
	The state sets the goal to increase recycled water over 2002 levels by at least 1 million acre-feet (AF) per year by 2020 and 2M AF by 2030 (Resolution No. 0061).
2010	SB 918 amends the Water Code and required the adoption of uniform water recycling criteria for groundwater recharge (by 2013) and surface water augmentation (by 2016).
2013	SWRCB adopts the Recycled Water Policy Amendment (Resolution No. 2013-003).
2014	Drinking Water Program (DWP) transferred from DHS to the SWRCB, which includes "the development of recycled water criteria and regulations pertinent to the use of recycled water to augment drinking water supplies and registration of residential water treatment."
	Title 22 revisions, which include notes on indirect potable reuse for groundwater and surface water augmentation.
	SWRCB adopts groundwater replenishment regulations using recycled water.
2016	SWRCB releases final report on recommendations for feasibility of direct potable reuse (DPR).
2018	SWRCB adopts resolution for Surface Water Augmentation March 6, 2018

Tulare County's Recycled Water Potential

The county's wastewater treatment facilities treat a combined 13.4 billion gallons of water annually (about 36.7 million gallons per day (MGD) or 41.6 thousand acre-feet (TAF) per year). With Visalia having recently completed their upgrade, and Dinuba progressing on its RCR plan, about 37 percent of the county's municipal recycled water will be available for tertiary-standard reuse within this decade. Tulare and Porterville are in the very early stages of tertiary treatment updates, which makes them a high priority for enhancing drought resilience and providing energy benefits for the county, as their chosen upgrades have not yet been set in stone and can still be influenced. Once all four facilities have been upgraded, 80 percent of the municipal wastewater in the county will be available for tertiary-standard reuse.

The total urban water demand for these four cities is 67.7 TAF. Urban reuse programs could meet almost 50 percent of the urban water demand in these cities. This would be capped by the quantity of urban water demand that is non-potable.

If recycled water production is increased to displace use of potable water in applications that don't require it, there would be significant impacts on the availability of high-quality groundwater for potable uses (that is, drinking, cooking, and other uses that require high quality potable water).

More research is needed to determine what proportion of urban water demand in these cities can be offset by non-potable, tertiary-quality recycled water; but, under a conservative estimate that assumes all water for landscaping and at least 30 percent of industrial water needs can be offset, only 2.7 TAF would be required to meet most eligible applications within these urban centers, less than 10 percent the potential volume of recycled water.

Direct potable reuse is gaining traction in California. In December 2016, an expert panel determined the feasibility of developing uniform water recycling criteria for direct potable reuse, defined in the California Water Code as the "planned introduction of recycled water either directly into a public water system, as defined in Section 116275 of the Health and Safety Code, or into a raw water supply immediately upstream of a water treatment plant."

The Orange County Water District has developed the world's largest potable water reuse project, using reverse osmosis to treat water that exceeds all state and federal drinking water quality standards. While the stigma against "toilet to tap" is still significant, public acceptance is growing. A study in San Diego indicated that public acceptance of direct potable reuse increased from 26 percent in 2004 to 73 percent in 2012. Similar studies have not been performed in the Central Valley or Tulare County.

Treating wastewater to potable quality is energy-intensive and expensive, requiring advanced technologies such as reverse osmosis or membrane bioreactors, which have both been shown to treat water to drinking water standard. Because there is an abundance of agricultural demand for water in Tulare County, most facilities are very small, and many communities are considered disadvantaged, the fit-to-purpose strategy for recycled water would likely dictate that treating water to potable quality is too expensive for the value it would bring to most areas served by wastewater treatment.

Porterville might be the best candidate for implementing a potable reuse program in Tulare County. East Porterville, which sends its sewage to the Porterville facility, experienced extreme water shortages during the drought and is still operating a bottled water program for residents. It became the poster child for the effects of drought in California communities. Implementing a DPR program in Porterville would enhance East Porterville's drought resilience by providing an independent and consistent source of drinking water, creating a new source of water for the City that does not significantly shift in volume during a drought. The site of the Porterville facility being in the center of Porterville, rather than on the outskirts, is another reason to direct Porterville's effluent toward DPR and other urban applications. Implementing a DPR program in Porterville would create a lot of awareness around Tulare County's water challenges that could lead to increased investment in the future and support California's goals of being a global leader in DPR.

Visalia's MBR system treats effluent to drinking water quality standard, and could be made available for direct potable reuse if the regulations and permitting were established. Their current relationships with TID and CalWater leaves a maximum of 18 percent of their effluent available for use within the City of Visalia, making it challenging for them to participate in DPR projects, but it should be considered as a viable opportunity when discussing future recycled water projects.

Potential for Agricultural Reuse

Agricultural reuse is by far the most common form of wastewater discharge in Tulare County, accounting for an estimated 62 percent of discharged effluent. Future agricultural water demand in which conservation measures are implemented is estimated to be 2,230 TAF[136]. The 41.6 TAF treated by Tulare County's wastewater treatment facilities only represents 1.8 percent of the county's estimated agricultural demand. Conversion of agricultural land to urban use will decrease demand for water, but recycled water will remain only a small portion of the source water for agricultural irrigation.

Agricultural concerns over water quality are some of the most significant barriers to adoption of recycled wastewater. Farmers are concerned over the public perception issues of growing food using water that was once sewage, and recycled water is usually higher in salinity and is more alkaline than fresh waters. Secondary undisinfected water also contains traces of chemicals from pharmaceuticals, personal care products, and potential pathogens, as well as chemicals of emerging concern (CEC). Additionally, irrigation equipment is susceptible to clogging due to the increased dissolved solids content of recycled water over that of ground water. Flood irrigation of receiving crops prevents clogging, but is an inefficient use of water resources.

California has the strictest water recycling regulations in the US, and studies have consistently shown that the regulations are sufficient for protecting human health and safety, but more work is being conducted to determine the full scope of recycled water's impacts on farmworkers and the environment[137]. Public perception is still an issue for recycled water programs, but they are becoming more acceptable throughout the state as necessity demands a solution to the public water crisis and groundwater overdraw. The public must be involved in the conversation at every stage.

Another issue around agricultural reuse is seasonality. During the winter months, reclamation areas don't grow crops, and so they don't need irrigation. Agricultural irrigation with recycled water can only use about half of available recycled water annually. The question of what to do with treated water during these periods is critical to maximizing the impact of recycled water on offsetting potable water demand.

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136 Tulare County (2009). *Tulare County General Plan Update*. Retrieved from http://generalplan.co.tulare.ca.us/documents/GeneralPlan2010/Appendix%20G%20-%20Phase%20I%20Water%20Supply%20Evaluation.pdf.

137 Dudley, Stacia (2018). Emerging Contaminants and Recycled Water Reuse in Agriculture. Presentation to Agricultural Reuse Workshop, January 31, 2018, Sacramento, CA. Retrieved from The Water Research Foundation website: http://www.werf.org/c/Events/2017/Ag_Reuse_Workshop/Ag_Reuse_Workshop.aspx.

Potential for Groundwater Recharge

The Tulare Basin has been overdrawing groundwater resources throughout the drought. Farmers know this isn't sustainable, and with the passing of SGMA, it is estimated that 1-1.5 million acres of farmland will go out of production throughout the Central Valley to safeguard groundwater supplies. Wastewater treatment facilities already play a role in recharging groundwater. Most facilities in Tulare County dispose of a portion of their effluent in evaporation or percolation ponds. While these ponds do lead to groundwater and is indirectly reused, percolation basins are not considered recycled water programs by the state. This type of discharge doesn't require high levels of treatment, whereas direct injection for groundwater recharge requires tertiary quality effluent.

The Tulare Irrigation District has entered into an agreement with Visalia to exchange tertiary water from Visalia's water conservation plant for surface water. TID will sell the water when possible, but can also use it to recharge groundwater, especially during winter months when agricultural demand is low. TID uses designated groundwater recharge basins for this purpose. The TID drought management plan also states that TID has entered discussions with Tulare to form a similar agreement when Tulare begins tertiary treatment of its wastewater.

If secondary-treated wastewater is left in percolation basins, nutrients such as nitrogen and phosphorous will filter into groundwater, leading to slow degradation of groundwater quality, a critical resource for drinking water during periods of drought. Tertiary treatment removes these nutrients and agricultural irrigation allows plants to take advantage of them. During the winter, agricultural applications are not available so effluent stays in percolation basins. Diversifying recycled water discharge opportunities that have less seasonal variation will increase the volume of water being recycled and reduce the amount of water that is sent to evaporation/percolation ponds.

Researchers in California are exploring the possibility of utilizing agricultural land for groundwater recharge during the winter months to maximize the benefit of reclamation areas[138]. This strategy would allow facilities to use their reclamation areas during the winter, eliminating the need for percolation basins altogether. More research needs to be completed as to the feasibility of this strategy, especially concerning salt loading and pathogen risk, but Tulare County could offer potential demonstration sites.

Additional Considerations for Recycled Water

Crop Efficiency

Statewide, 80 percent of agricultural reuse occurs within ten miles of the discharging facility. The types of crop within a ten-mile radius of the facility should form the basis of the fit-to-purpose strategy used by the State Water Board, in which treatment level is determined by the type of crop the treated water will be used on.

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138 Richardson, Dave (2018). *Use of Recycled Water for Groundwater Recharge on Farmlands.* Presentation to Agricultural Reuse Workshop, January 31, 2018, Sacramento, CA. Retrieved from The Water Research Foundation website: http://www.werf.org/c/Events/2017/Ag_Reuse_Workshop/Ag_Reuse_Workshop.aspx.

With a few exceptions, most recycled water programs in Tulare County discharge water for alfalfa, sudangrass, pasturelands, corn fodder, cotton, and winter wheat. Alfalfa and pasturelands demand the most water of any other crop category by a significant margin, requiring 4.9 af/acre/yr. However, alfalfa, sudangrass, and winter wheat are very efficient at taking up nitrates, so the RWQCB considers them to be good uses of secondary-treated recycled wastewater, despite being water inefficient.

Encouraging more efficient agricultural crops in reclamation areas could increase the efficiency of water reuse by 27-49 percent, depending on the type of crop being produced. Stigma against recycled water is one of the largest impediments to efficient crop utilization. High-end crops such as vineyards are more water efficient than feed or fodder crops, but private owners of these farms don't want to add any risk of health and safety hazards due to recycled water irrigation, nor do they want the public shying away from their products. However, consumers are rarely concerned with the irrigation water used to grow their crops, and in many crops, using recycled water adds to crop value. Crops like tomatoes and strawberries, for instance, respond to salinity stress by producing more sugars, color, and flavor. Alfalfa responds by increasing protein and total digestible nutrient content[139]. Crops should be matched with water quality and location to make the best use of recycled water resources. In many cases, reclamation areas are city- or community-owned, giving those regulatory bodies control over the types of crop being produced.

Resource Recovery

For most of their history, wastewater treatment facilities were designed to be linear systems that remove and safely dispose of enough contaminants within wastewater to prevent significant human health impacts. More recently, there have been increased efforts to recapture value from the resources that move through wastewater streams. This can be seen in increased recycled water programs, biogas and energy generation, and biosolid fertilizer programs.

Nutrients, salts, metals, and other minerals are other constituents in wastewater that can potentially be recovered and there are technological solutions that can separate these constituents from wastewater, but they are often costly. Byproducts recovered from wastewater must be turned into saleable products in order to ensure affordability, and products from wastewater are often stigmatized due to their association with human waste, even if they have been rendered perfectly safe. This presents a market barrier that many facilities would rather avoid altogether. As natural resources of these materials become scarcer, there will be increased pressure to avoid wasting the resources in wastewater and the market should grow.

This shift in mindset toward a circular role of wastewater treatment can be seen at a few of the facilities in Tulare County that are increasing their water and biosolids recycling programs and generating their own energy with digested biosolids. There are many emerging technologies operating on the water-energy-agriculture nexus by treating water and converting the waste into energy or fertilizer. As the most productive agricultural county in the state of California, Tulare

139 USDA (2008). *Opportunities and Challenges in Agricultural Water Reuse.*

County WWTFs have the opportunity to be more intricately integrated into the agricultural system by converting waste into value-added agricultural by-products.

Water Storage

The ability to retain treated water until it is needed could significantly increase the use of recycled water. Adding capacity for storing water enables more recyclable water to be produced than can be immediately used at any point in time, and enables water providers to meet high water demands during hot summer months. The feasibility of water storage depends on the quality of the recycled water and characteristics of the storage mechanism. Storing recycled water for months at a time can lead to bacteria and pathogen contamination. Many urban water agencies use surface reservoirs for recycled water storage. Siting new water storage infrastructure is very expensive, in part due to wildlife protection laws. Pumping recycled water to underground aquifers allows for long-time storage, especially where geologic conditions prevent mixing with existing groundwater supplies.

APPENDIX C:
Gray Water

Gray water is untreated wastewater that has not come into contact with bathroom or kitchen waste. The states that have adopted the International Plumbing Code can collect gray water from bathroom sinks and washing machines in addition to showers and baths up to specific limits unless a local government has declared otherwise.

By using gray water onsite, residents save both water and energy. Because showers, sinks and laundry water comprise 50-80 percent of residential wastewater, gray water systems have significant potential within Tulare County.

California Gray Water Policy

It has been legal to use gray water everywhere in California since 1992 when Assembly Bill 3518—the Gray Water Systems for Single Family Residences Act of 1992—was enacted. Legislation has extended use to the commercial sector and given the California Department of Water Resources (CDWR) authority to manage gray water standards.

Below is a summary of the key gray water policies that have been adopted by the state.

- Assembly Bill 3518 [*Sher 1992*] required CDWR to adopt standards for installation of gray water systems in residential buildings.
- Assembly Bill 313 [*MacDonald 1995*] allowed for gray water to be used in subsurface irrigation and in commercial buildings.
- Senate Bill 1258 [*Lowenthal 2008*] required the California Building Standards Code to adopt standards for construction, installation and alteration of gray water systems for indoor and outdoor use.
- California Plumbing Code [Cal. Code of Regulations, Title 24, Part 05, 2016, Chapter 16A: Nonpotable Water Reuse Systems] states that gray water systems that utilize only a single domestic clothes washing machine in one-or-two family dwelling may be installed or altered without a permit.
- Assembly Bill 849 [Gatto 2011] eliminated the ability of cities or counties to entirely prohibit the use of gray water.

The following regulations are specific to Tulare County.

- County-1993-Ordinance Code Part V11, Chapter 31 Water Efficient Landscaping: Section 7-31-1035 which states that the use of gray water may be considered on an individual case basis upon approval by the Tulare County Health Department.
- City of Tulare Code: § 10.196.084 Recycled water and gray water systems which states that gray water systems are encouraged to assist in on-site landscape irrigation and shall conform to the California Plumbing Code and any applicable local ordinance standards.

These regulations are summarized below.

Assembly Bill 3518 [Sher 1992] was the first significant gray water bill in the State of California that required the Department of Water Resources, in consultation with the Department of Health Services, to adopt standards for the installation of gray water systems in residential buildings and authorized the installation of gray water systems in these buildings, based on the city or county's determination that the proposed system complies with the adopted standards. The bill also gave cities or counties the authorization to adopt more stringent standards or to prohibit gray water systems.[140]

Assembly Bill 313 [MacDonald 1995] allowed gray water to be used in subsurface irrigation and in commercial buildings. This bill required the inclusion of drip systems as an approved method of subsurface irrigation. Under AB313, cities, counties or local agencies had the ability to adopt standards that prohibited the use of gray water or gray water standards that are more restrictive than the standards adopted by the Department of Water Resources.[141]

Senate Bill 1258 [Lowenthal 2008] required that the California Building Standards Code adopt standards for the construction, installation and alteration of gray water systems for indoor and outdoor use. This act terminated the authority of the Department of Water Resources to manage gray water standards. Under SB1258 cities, counties or other local agencies may adopt ordinances or resolutions that prohibit the use of gray water or develop standards that are more restrictive than those set forth in the California Building Standards Code.[142]

Chapter 16A "Nonpotable Water Reuse Systems" was added to the California Plumbing Code in 2009 to address Gray Water. Sections 1601-1603 below were excepted from Chapter 16A.

> 1601A.0-General. A city, county, or city and county or other local government may, after a public hearing and enactment of an ordinance or resolution, further restrict or prohibit the use of gray water systems as pursuant in the Health and Safety Code Section 18941.7.
>
> 1603A.1.1 Clothes Washer System and/or Single Fixture System. A clothes washer system and/or a single fixture system in compliance with all of the following is exempt from the construction permit specified in Section 108.4.1 and may be installed or altered without a construction permit.
>
> 1603A.1.2 Simple System. Simple systems exceed a clothes washer system and/or a single fixture system that have a discharge capacity of 250 gallons (947 L) per day or less requires a construction permit.

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140 California Legislative Information website: http://www.leginfo.ca.gov/pub/95-96/bill/asm/ab_0301-0350/ab_313_cfa_950406_165012_asm_comm.html.

141 California Legislative Information website: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180AB313.

142 California Legislative Information website: http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200720080SB1258.

1603A.1.3 Complex System. Any gray water system that is not a clothes washer system, single fixture system or simple system that has a discharge capacity over 250 gallons (947 L) per day requires a construction permit.

Assembly Bill 849 [Gatto 2011] "eliminated the ability of cities or counties to entirely prohibit the use of gray water and prohibited cities or counties from adopting gray water standards that are more restrictive than the California Building Standards Code."[143]

The California Plumbing Code

The California Plumbing Code states that "a gray water system, utilizing only a single domestic clothes washing machine in a one-or-two family dwelling, in compliance with all of the following, may be installed or altered without a construction permit:[144]

1. If required, notification has been provided to the Enforcing Agency regarding the proposed location and installation of a gray water irrigation or disposal system.
2. The design shall allow the user to direct the flow to irrigation or disposal field or the building sewer. The direction control of the gray water shall be clearly labeled and readily accessible to the user.
3. The installation, change, alteration or repair of the system does not include a potable water connection or a pump and does not affect other building, plumbing, electrical or mechanical components including structural features, egress, fire-life safety, sanitation, potable water supply piping or accessibility.
4. The gray water shall be contained on the site where it is generated.
5. Gray water shall be directed to and contained within an irrigation or disposal field.
6. Ponding or runoff is prohibited and shall be considered a nuisance.
7. Gray water may be released above the ground surface provided at least two inches of mulch, rock, or soil, or a solid shield covers the release point. Other methods, which provide equivalent separation, are also acceptable.
8. Gray water systems shall be designed to minimize contact with humans and domestic pets.
9. Water used to wash diapers or similarly soiled or infectious garments shall not be used and shall be diverted to the building sewer.
10. Gray water shall not contain hazardous chemicals derived from activities such as cleaning car parts, washing greasy or oily rags, or disposing of waste solutions from home photo labs or similar hobbyist or home occupational activities.

143 California Legislative Information website: http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201120120AB849.

144 The amount of water from the washing machine is considered to be 15 gallons per person per day.

11. Exemption from construction permit requirements of this code shall not be deemed to grant authorization for any gray water system to be installed in a manner that violates other provisions of this code or any other laws or ordinances of the Enforcing Agency.
12. An operation and maintenance manual shall be provided. Directions shall indicate the manual is to remain with the building throughout the life of the system and indicate that upon change of ownership or occupancy, the new owner or tenant shall be notified the structure contains a gray water system."[145]

Specific Tulare County gray water regulations include the following:

County-1993-Ordinance Code Part VII, Chapter 31 Water Efficient Landscaping: Section 7-31-1035 -The use of gray water may be considered on an individual case basis upon approval by the Tulare County Health Department.[146]

City of Tulare Code: § 10.196.084 Recycled water and gray water systems:

- The installation of recycled water irrigation systems shall allow for the current and future use of recycled water.
- All recycled water irrigation systems shall be designed and operated in accordance with all applicable local and state laws.
- Landscapes using recycled water are considered special landscape areas. The ET adjustment factor for new and existing (non-rehabilitated special landscape areas shall not exceed 1.0.
- Gray water systems promote the efficient use of water and are encouraged to assist in on-site landscape irrigation. All gray water systems shall conform to Cal. Plumbing Code (Title 24, Part 5, Chapter 16) and any applicable local ordinance standards. Refer to § 10.196.040 (C) for the applicability of this chapter to landscape areas less than 2,500 square feet with the estimated total water use met entirely by gray water (Ord. 15-11, passed 12-15-2015; Ord. 10-24, passed 12-21-2010).

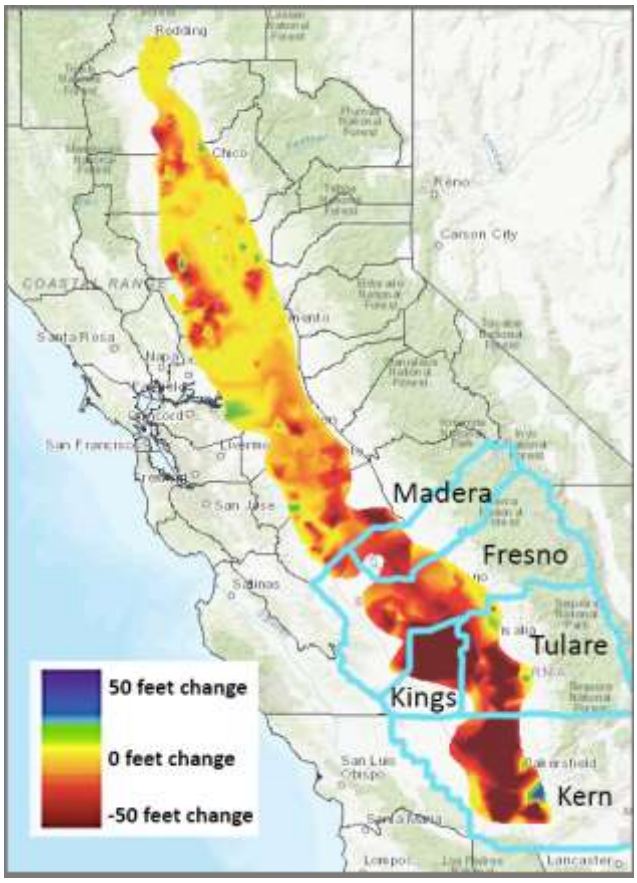
145 California Plumbing Code, 2013.

146 Tulare County's website: http://tularecounty.ca.gov/rma/index.cfm/documents-and-forms/planning-documents/tulare-county-zoning-ordinance/portions-of-the-ordinance-code-of-tulare-county/part-vii-chapter-31-water-efficient-landscaping/.

APPENDIX D:
Groundwater Management

Tulare County occupies 4,839 square miles in South San Joaquin Valley.[147] It is bounded on the north by Fresno, to the west by Kings, and to the south by Kern. Tulare, Kern, Kings, and Fresno comprise 4 of the 5 counties referred to collectively as "South San Joaquin Valley." Madera, on the northern border of Fresno, is the fifth.

Figure D-1: Changes in Groundwater Elevations (Water Years 2011-2016)



Source: Department of Water Resources. Groundwater Information Center Interactive Map Application. https://gis.water.ca.gov/app/gicima/ .

These five counties, with very high water demands in critically overdrafted groundwater basins, need to become drought resilient as soon as possible. All have experienced substantial land subsidence due to over-pumping of groundwater basins, are contending with significant water quality concerns due to decades of agricultural runoff carrying fertilizers and pesticides into

147 U.S. Census Bureau, *QuickFacts*. July 1, 2017. https://www.census.gov/quickfacts/fact/table/tularecountycalifornia/PST045217.

groundwater basins and into natural waterways, and have had significant dry hydrology over the past ten years.

Note that except for a very small area in Kern County (blue) and several spots in Tulare and Kern (green), groundwater elevations decreased considerably since Water Year 2011.

Of the five South San Joaquin counties, Tulare experienced the most serious drought impacts:

- Tulare has very little diversity in its water supply portfolio, meeting most of its urban water demand with groundwater. Residents that are wholly dependent on a single resource (groundwater) are susceptible to health and safety risks when wells fail.
- All 3 of the groundwater sub-basins serving Tulare County (Kings, Tule, and Kaweah) are deemed "critically overdrafted".
- A study conducted by the State Water Resources Control Board (SWRCB) found that 40 percent of tested wells by community water systems exceeded the Maximum Contaminant Level (MCL) for nitrates.

These factors, combined with very low annual precipitation over the past ten years, created serious problems for the county and its residents. Residents in remote areas that historically provided their own water supplies had no groundwater to pump. At the height of drought impacts, the Tulare County Office of Emergency Services reported 1,988 well failures (Figure D-2).

Consequently, the county's water stakeholders are presently focused on implementing the state's Sustainable Groundwater Management Act (SGMA).[148]

Sustainable Groundwater Management Act

Three bills were signed into law in September of 2014—Assembly Bill 1739, Senate Bill 1168, and Senate Bill 1319—and are collectively known as the Sustainable Groundwater Management Act (SGMA), California's first framework to manage groundwater sustainability for long-term reliability and benefits.

SGMA requires that all "high or medium priority" groundwater basins identified by CDWR as "subject to critical conditions of overdraft" be managed under a Groundwater Sustainability Plan (GSP) that is to be adopted by a Groundwater Sustainability Agency (GSA).[149] GSAs within critically overdrafted basins must chart a path to sustainable groundwater management within 20 years. In Tulare County, most GSAs have finalized their boundaries, and all are required to prepare GSPs by January 31, 2020.[150]

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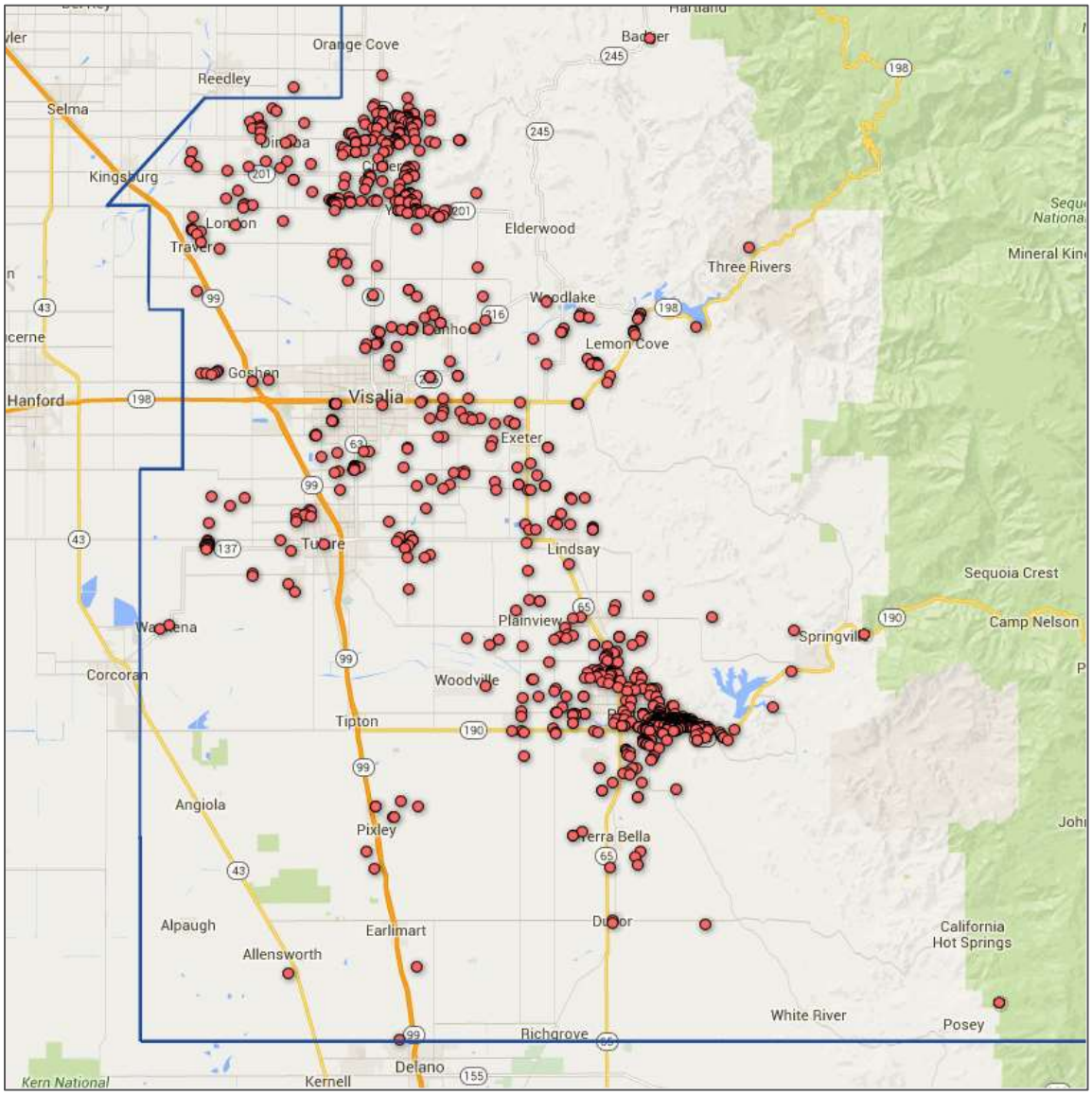
148 A three-bill legislative package, composed of AB 1739 (Dickinson), SB 1168 (Pavley), and SB 1319 (Pavley), collectively known as the *Sustainable Groundwater Management Act (SGMA)*, signed into law by Governor Brown on September 16, 2014 [California Water Code § 10720]. Source: Department of Water Resources website, https://www.water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management.

149 These requirements do not apply to adjudicated basins.

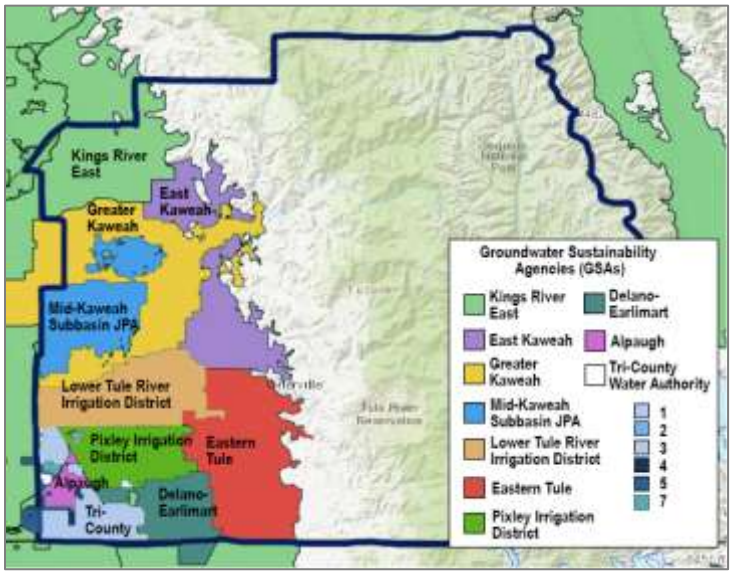
150 Cal. Water Code § 10720 et seq.; California DWR, 2016c.

Figure D-2: Reported Well Failures in Tulare County as of November 2, 2015



Source: Tulare County Office of Emergency Services, Report for Week of November 2, 2015.

Figure D-3: Groundwater Sustainable Agencies in Tulare County



Source: Department of Water Resources Sustainable Groundwater Management (SGMA): GSA Map Viewer, available at the Department of Water Resources (DWR) website: http://sgma.water.ca.gov/webgis/index.jsp?appid=gasmaster.

SGMA Implementation

The following entities are responsible for SGMA implementation:[151]

- GSAs are the planning and implementing agencies that will do the following:
  - Lead communication, outreach and engagement efforts
  - Develop and implement a GSP and complete 5-year updates
  - Monitor, evaluate and report progress towards achieving sustainability goals
- CDWR is the regulating and assisting agency that will do the following:
  - Lead communication, engagement and coordination efforts at the statewide level
  - Provide data and information, tools, funding and non-technical and technical support
  - Review GSPs for adequacy and evaluate implementation and 5-year updates
  - Develop Basin Boundary and GSP Emergency Regulations
- SWRCB is the enforcing agency that will do the following:
  - May intervene and create an interim plan if a GSA is not formed or it fails to implement a GSP
  - May assess fees for purposes of supporting interim plan intervention

SGMA Basin Prioritization Results (May 2018) found that of the state's 517 groundwater basins, 109 are prioritized as high and medium and 408 are prioritized as low and very low.[152]

151 California Department of Water Resources, *Groundwater Sustainability Plan (GSP) Emergency Regulations*, July 2016.

152 California Department of Water Resources, *2018 Basin Prioritization Process and Results*, May 2018.

Groundwater Sustainability Agencies (GSAs)

SGMA allowed local agencies to apply to form GSAs. Authorities delegated to GSAs include the following:

- Adopt and enforce a Groundwater Sustainability Plan (GSP) to align with the state's sustainability goals.
- Regulate, limit or suspend extractions of groundwater.
- Authorize temporary and permanent transfers of groundwater allocations.
- Impose fees for permits, extraction, development of the plan.
- Monitor compliance and enforcement.
- Acquire property.
- Transport, reclaim, purify, desalinate, treat or otherwise manage and control polluted water and wastewater.
- Enforce the GSP plan and impose fines.

In Tulare County, 15 GSAs were established. Every basin in Tulare County (Kaweah, Tule, Kings, and Tulare Lake) is considered "subject to critical conditions of overdraft."[153]

Table D-1: Tulare County GSAs

Name	Bulletin 118 Basin Name	County GSA Overlies
Mid-Kaweah Groundwater Subbasin Joint Powers Authority	Kaweah	Tulare
Tri-County Water Authority-1	Tule	Tulare
Kings River East Groundwater Sustainability Agency	Kings	Fresno Tulare
Alpaugh Groundwater Sustainability Agency	Tule	Tulare
Delano-Earlimart Irrigation District	Tule	Tulare
Tri-County Water Authority-2	Tule	Tulare
Tri-County Water Authority-3	Tule	Tulare
Tri-County Water Authority-4	Tule	Tulare
Lower Tule River Irrigation District	Tule	Tulare
Pixley Irrigation District	Tule	Tulare
Tri-County Water Authority-5	Tulare Lake	Kings Tulare
Tri-County Water Authority-7	Tulare Lake	Tulare
Greater Kaweah Groundwater Sustainability Agency	Kaweah	Kings Tulare
Alpaugh Irrigation District	Tulare Lake	Tulare
East Kaweah Groundwater Sustainability Agency	Kaweah	Tulare

153 California Department of Water Resources, *California's Groundwater Working Toward Sustainability, Bulletin 118 Interim Update*, December 22, 2016.

Groundwater Sustainability Plans (GSPs)

A GSP provides path for achieving the state's groundwater sustainability goals within 20 years with interim milestones in 5-year increments. Each GSA within a basin designated as "high or medium priority" that is not adjudicated must adopt a GSP no later than January 31, 2020.

A GSA is required to provide a written statement of notification to the legislative body of any city or county—or combination of both—located within the area covered by the GSP so that interested parties may participate in the development and implementation.[154] If this includes a public water system regulated by the California Public Utilities Commission (CPUC), then the written notice must also be submitted to the CPUC.

The California Department of Water Resources (CDWR) developed GSP emergency regulations that break down the development of a GSP into 4 phases that include the following:

1. Phase 1: GSA Formation and Coordination that involves realignment of basins and establishment of basin governance through formation of GSA.
2. Phase 2: GSP Preparation and Submission that involves the development and adoption of GSPs by GSAs.
3. Phase 3: GSP Review and Evaluation is a CDWR-driven activity where they review and evaluate GSPs.
4. Phase 4: Implementation and Reporting is locally-driven and includes development of annual reports and GSP assessments completed every 5 years during implementation of GSPs.[155]

CDWR plans to issue a web-based GSP submittal tool.

154 Water Code §10727.8

155 California Department of Water Resources, *Groundwater Sustainability Plan (GSP) Emergency Regulations,* July 2016.

APPENDIX E: Groundwater Quality

There are many different initiatives that California has enacted to ensure long-term groundwater quality. Below are the regulations governing salt and nitrate management in California's South San Joaquin Valley.

Salts

Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) Initiative: The State Water Resources Control Board (SWRCB) and the Central Valley Regional Water Quality Control Board (CV-RWQCB) established this initiative in 2006. It is a multi-stakeholder effort to produce a salt and nitrate management plan (SNMP) for the Central Valley. CV-SALTS is a coalition of representatives from agriculture, cities, industry, state and federal regulators, and members of the public.[156]

The Central Valley Salinity Coalition (CVSC) was created as a non-profit member organization in 2008 to assist with implementing the SNMP into the basin plans, as well as to manage salts and nitrates in the Central Valley. The SNMP will be implemented through amendments to the Water Quality Control Plans (Basin Plans) for each managed basin in the Central Valley region (Region 5).

The Recycled Water Policy, adopted in 2009, directs individual water and wastewater entities to prepare SNMPs to protect groundwater within their subbasins. These entities were given until May 2016 to develop their individual SNMPs, with the input and assistance from CV-SALTS.

Final Central Valley-wide SNMP (Final Plan)[157] was released in January 2017. The CV-RWQCB held a hearing in March 2017 to receive public comments and consider a resolution accepting the Final Plan. As a result of public input, CV-SALTS released amendments to the Final Plan[158] that were presented during a public workshop in January 2018. The public comment period for the amended plan just ended (May 7, 2018). The next hearing is scheduled for May 31-June 1, 2018 to receive public comments and consider adoption of the Central Valley-wide SNMP.

In addition to the SNMP, dairy processing facilities must comply with Order R5-2013-0122 (Dairy Order)[159], which was originally issued in 2007 and reissued in 2013.

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156 CV-SALTS website: https://www.cvsalinity.org/about-us/what-is-the-central-valley-salinity-coalition.html.

157 Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS). *Central Valley Region Salt and Nitrate Management Plan, Final Document for Central Valley Water Board Consideration.* 2016.

158 California Regional Water Quality Control Board, Central Valley Region. *Amendments to the Water Quality Control Plans for the Sacramento River and San Joaquin River Basins and Tulare Lake Basin to Incorporate a Central Valley-Wide Salt and Nitrate Control Program.* 2018.

159 California Regional Water Quality Control Board, Central Valley Region. *Reissued Waste Discharge Requirements General Order for Existing Milk Cow Dairies.* (Order R5-2013-0122). 2013.

Nitrates

SWRCB Resolution No. 88-63, "Sources of Drinking Water" policy of 1988[160] specifies that all surface and ground waters are suitable or potentially suitable for MUN beneficial uses except under specially defined exceptions.

Resolution R5-2017-0088[161], scheduled for potential adoption in 2018, intends to incorporate a MUN evaluation process for agriculturally dominated water bodies, allowing reuse of groundwater supplies that exceed the Maximum Contaminant Level for Municipal and Domestic Supply (MUN MCL) in facilities with no existing or potential MUN use.

Senate Bill X2 1 required the SWRCB to develop pilot projects focusing on nitrate in groundwater in the Tulare Lake Basin and Salinas Valley. SBX2 1 also "required the SWRCB to submit a report to the Legislature on the scope and findings of the pilot projects, including recommendations, within two years of receiving funding."[162]

"In response to SBX2 1, the State Water Board contracted with the University of California, Davis (UC Davis) in 2010 to conduct an independent study on nitrates in the Tulare Lake Basin and the Salinas Valley. The UC Davis Nitrate Report, comprised of volumes 1-8, was delivered to the State Water Board in March 2012."[163] The study was supplemented in 2017 with the results of a 5-year field study (conducted from January 2012 through December 2014, and August 2015 through June 2016) about Nitrogen Fertilizer Loading to Groundwater in the Central Valley.[164]

Proposed Salt and Nitrate Control Program (SNCP) is intended to facilitate implementation of strategies for targeted restoration of groundwater quality. The components of the SNCP that relate specifically to nitrates include providing two pathways for dischargers to comply with nitrate discharge limits. Path A is an individual discharger permitting approach, and Path B is a management zone permitting approach. A management zone would consist of multiple dischargers working collectively to ensure safe drinking water and balanced nitrate loading in the short- and long-term. Other components include the following:

- Prioritized Groundwater Basins for Nitrate Control Program Implementation—Uses data from the CVHM to determine priority groundwater basins for implementation of the Nitrate Control Program. Dischargers in Priority 1 basins will be notified within one year of the effective date of the amendments. Dischargers in Priority 2 basins will be notified within two to four years. The remaining basins will be prioritized at the discretion of the Central Valley Water Board.

160 SWRCB website: https://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/1988/rs1988_0063.pdf.

161 SWRCB website: https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/resolutions/r5-2017-0088_res.pdf.

162 SWRCB website: https://www.waterboards.ca.gov/water_issues/programs/nitrate_project/index.html.

163 Ibid.

164 UC Davis website: http://groundwaternitrate.ucdavis.edu/files/268749.pdf.

- Conditional Prohibition—All permittees discharging nitrate pursuant to Board-issued waste discharge requirements and conditional waivers will be prohibited from discharging upon receiving a notice to comply unless they are implementing the requirements of the Nitrate Control Program. Dischargers regulated under the Irrigated Lands Regulatory Program (ILRP) will instead be required to comply with the Nitrate Control Program through an amendment to the ILRP General Orders, which the Regional Water Board shall consider within 18 months of the effective date of the Basin Plan Amendment.
- Surveillance and Monitoring—The Salt and Nitrate Surveillance and Monitoring Program will periodically assess the effectiveness of the Salinity and Nitrate Control Programs, and develop representative ambient water quality and trend information. Data will come from dischargers' monitoring efforts, regional monitoring programs conducted by state and federal agencies, or from special studies evaluating effectiveness of management practices. A summary report will be submitted to the Board every five years.
- Exception Policy—The Regional Water Board may authorize a discharge that may violate applicable water quality standards in the receiving groundwater basin provided safe drinking water is provided to users of the nitrate-contaminated water. Exceptions are only used when it is not feasible to prohibit the discharge, and the discharger has no feasible way to meet the water quality objectives in a specified time period. Exceptions are time-bound and periodically reviewed.
- Offsets Policy—The proposed Basin Plan Amendment recommends an Offsets Policy of salt and nitrate to groundwater, which would allow dischargers to comply with waste discharge requirements by managing other sources or loads so that the combined net effect on receiving water quality from the discharge and the offset is functionally equivalent to or better than that which would have occurred by requiring the discharger to comply at the point-of-discharge.

Dairy Order R5-2013-0122 was adopted in 2007 and reissued in 2013 and is the existing regulation affecting water and nutrient discharge of dairy facilities. The Dairy Order specifies dairy-specific actions needed to ensure surface and groundwater quality. Each discharger who applies manure, bedding, or process wastewater to land for nutrient recycling must develop and implement management practices that control nutrient losses and describe these in a Nutrient Management Plan (NMP)[165] which must provide for protection of both surface water and groundwater.

165 "Managing the amount (rate), source, placement (method of application), and timing of plant nutrients and soil amendments." Source: Natural Resources Conservation Service, U.S. Department of Agriculture (October 2013). Conservation Practice Standard, Code 590: Nutrient Management. Retrieved from NRCS website: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1192371.pdf.

Under the Dairy Order, individual dischargers are obligated to apply their nutrient-rich manure and process water at agronomic rates[166]. If they have insufficient land to apply at agronomic rates, they have a few options to achieve compliance with the requirements of the Dairy Order:

1. Export some of their manure/process water.
2. Buy or lease more cropland.
3. Reduce their herd size.
4. Install or modify facilities or equipment.

These and similar practices are considered to be Best Practicable Treatment or Control (BPTC) to minimize degradation. The Dairy Order defines expansion as any increase in the existing herd size (>15 percent), or an increase in the storage capacity of retention ponds, or acquisition of more acreage for reuse of nutrients from manure or process wastewater in order to accommodate an expansion of the existing herd size. Expansions are not authorized as part of the Dairy Order, so any expansion requires dischargers to submit a Report of Waste Discharge (ROWD), document compliance with the California Environmental Quality Act (CEQA), and obtain coverage under individual waste discharge requirements. Acquisition of additional acreage to achieve compliance with the Dairy Order where it is not accommodating an expansion of the existing herd size is not considered an expansion, and so is not subject to these requirements.

The Dairy Order specifies nutrient monitoring processes:

> "Nutrient application rates are to be monitored for each land application area, defined as land under control of the milk cow dairy owner or operator, whether it is owned, rented, or leased, to which manure or process wastewater from the production area is or may be applied for nutrient recycling."

166 "Agronomic rates" is defined as the land application of irrigation water and nutrients (which may include animal manure, bedding, or process wastewater) at rates of application in accordance with a plan for nutrient management that will enhance soil productivity and provide the crop or forage growth with needed nutrient for optimum health and growth. The rate is defined by the applied-to-removed ratio for Nitrogen, targeting a ratio of 1.4 and the amount removed is measured by plant tissue sampling during harvest. Sources: Dale Essary, Senior Engineer, Confined Animals Unit, Central Valley Water Board, & Central Valley Water Board, Dairy Plan: https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/general_orders/r5-2013-0122.pdf.

APPENDIX F:
Technology Solutions for Nitrates

Nitrate accumulation is of significant concern to the long-term sustainability of Tulare County. Nitrate concentrations in many domestic wells in Tulare County exceed safe drinking water standards. Nitrates in drinking water are known to cause reproductive issues such as methemoglobinemia, or "blue baby disease."[167,168] In response to nitrate concerns, the State Water Board contracted with the University of California, Davis (UC Davis) in 2010 to conduct an independent study on nitrates in the Tulare Lake Basin and the Salinas Valley. The 5-year field study, called *Nitrogen Fertilizer Loading to Groundwater in the Central Valley*, identified the anthropogenic sources[169] that contribute to nitrate accumulation in groundwater in the Tulare Lake Basin and Salinas Valley[170]. The study found the following sources of nitrates:[171]

- Cropland (96 percent of total), where nitrogen applied to crops, but not removed by harvest, air emissions, or runoff is leached from the root zone to groundwater. Nitrogen intentionally or incidentally applied to cropland includes:
  - Synthetic fertilizer (54 percent).
  - Animal manure (33 percent).
  - Irrigation source water (8 percent).
  - Atmospheric deposition (3 percent).
  - Municipal effluent and biosolids (2 percent).
- Percolation of wastewater treatment plant (WWTP) and food processing (FP) wastes (1.5 percent of total).
- Recharge from animal corrals and manure storage lagoons (1 percent of total).
- Leachate from septic system drainfields (1 percent of total).
- Urban parks, lawns, golf courses, and leaky sewer systems (less than 1 percent of total).
- Downward migration of nitrate-contaminated water via wells (less than 1 percent of total).

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167 "Nitrate poisoning, called methemoglobinemia ("blue baby" syndrome). Toxic effects occur when bacteria in the infant's stomach convert nitrate to more toxic nitrite. When nitrite enters the bloodstream, it interferes with the body's ability to carry oxygen to body tissues. Symptoms include shortness of breath and blueness of the skin around the eyes and mouth. Infants with these symptoms need immediate medical care since the condition can lead to coma and eventually death." Source: *SWRCB Groundwater Information Sheet: Nitrate. Revised November 2017*. Retrieved from the State Water Resources Control Board (SWRCB) website: https://www.waterboards.ca.gov/gama/docs/coc_nitrate.pdf.

168 Fan, A. M., & Steinberg, V. E. (1996). *Health Implications of Nitrate and Nitrite in Drinking Water: An Update on Methemoglobinemia Occurrence and Reproductive and Developmental Toxicity*. Regulatory Toxicology and Pharmacology. 23:1.

169 Caused or influenced by human activity.

170 University of California, Davis (2012). *Technical Report 2: Nitrogen Sources and Loading to Groundwater With a Focus on Tulare Lake Basin and Salinas Valley Groundwater*. Retrieved from http://groundwaternitrate.ucdavis.edu/files/139110.pdf.

171 Summarized by the SWRCB on its website: https://www.waterboards.ca.gov/water_issues/programs/nitrate_project/index.html.

A Central Valley-wide Salt and Nitrate Management Plan (SNMP)[172] was adopted by the Central Valley Regional Water Quality Control Board (RWQCB) on June 1st, 2018 and will be implemented over the next four years. The Nitrate Control Program within the SNMP will require all dischargers to evaluate their nitrate contributions and address them either individually or in cooperation with other dischargers in a specialized management zone. The SNMP includes a conditional prohibition in which permittees discharging nitrate will be prohibited from discharging upon receiving a notice to comply unless they are implementing the requirements of the Nitrate Control Program. This will lead to increased effort among all dischargers in the region to adopt new technologies and strategies for managing their nitrate contributions. Below is a table of some technologies that can contribute to this regional effort, followed by more detailed descriptions of each of the technologies identified.

Table F-1: Water Quality Technologies

Technology	Components Managed	Suitable Applications
Algae Production	• Nitrogen • Phosphorous	High-rate algae ponds require a large footprint, but use little energy, while photobioreactors have a smaller footprint but use more energy. Both are useful for municipal or industrial wastewater treatment, and algae ponds can be used for animal wastewater treatment. Treated water can be used for municipal application, agricultural irrigation, or groundwater recharge in most cases. Produces algae by-product as an additional revenue stream.
Anammox	• Nitrogen	Appropriate for municipal treatment facilities that lack land to treat nutrients and want to save energy on nutrient removal. Water needs further treatment before being reused. Produces a little sludge.
Biocatalyst Nitrate Removal	• Nitrogen	Useful for direct groundwater remediation or, treating drinking water from wells, or for nitrate removal from wastewater without removing organics. Treated water is potable.
Biochar	• Nitrogen • Phosphorous • Heavy Metals • Pesticides • Soil Acidity	Biochar is most effective in soils that have been highly degraded due to acidity, heavy metals, compaction, or pesticides. Because restorative agriculture management practices can take many years to rebuild soil carbon, biochar application can be used as a shortcut. Reduces application of synthetic fertilizer.
Cover Crops	• Nitrogen • Phosphorous	Useful for crops that don't need surface soil to be cleared annually; reduces application of synthetic fertilizer.
Forward Osmosis	• Nitrogen • Phosphorous • Heavy Metals • Dissolved Solids • Salinity • Pathogens	Forward osmosis is most effective for industrial users that have two solutions: one that must be concentrated and one that must be diluted. It can be used for just one solution but requires additional treatment. Food and beverage processors such as fruit juice or dairy processing are examples. Treated water can be used for municipal application, agricultural irrigation, or

172 Final SNMP adopted on June 1st, 2018 found in sections at CV-SALTS website: https://www.cvsalinity.org/docs/central-valley-snmp/final-snmp.html.

Technology	Components Managed	Suitable Applications
		groundwater recharge Sometimes produces brine, depending on the setup, which is difficult to dispose of.
Membrane Bioreactor	• Nitrogen • Phosphorous • Dissolved Solids • Salinity • Pathogens	Typically used for large municipal wastewater treatment facilities. Treated water can be used for municipal application, agricultural irrigation, or groundwater recharge.
Nitrification/ Denitrification Basins	• Nitrogen	Common for municipal wastewater treatment facilities that need a simple way to meet nutrient discharge TMDLs. Water needs further treatment before being reused. Produces sludge.
No-Till Farming	• Nitrogen • Phosphorous	Useful for agricultural production that has not yet been mechanized, and that does not require raised rows of soil, such as fresh fruits. Requires 3-7 years to realize many of the benefits. Reduces application of synthetic fertilizer.
Reactive Filtration	• Nitrogen • Phosphorous • Dissolved Solids • Salinity • Pathogens	Can be used to treat water from agricultural drainage canals, storm water, or municipal wastewater. Treated water can be used for direct potable reuse, municipal application, agricultural irrigation, or groundwater recharge.
Reverse Osmosis	• Nitrogen • Phosphorous • Heavy Metals • Dissolved Solids • Salinity • Pathogens	Reverse osmosis is most effective for water with high salinity concentrations, or for water that needs to be pure, such as for use within laboratories. Treated water can be used for offsetting water for direct potable reuse, municipal application, agricultural irrigation, or groundwater recharge. Produces brine, which is difficult to dispose of.
Struvite Beads	• Phosphorous • Nitrogen • Magnesium	Struvite replaces traditional fertilizers and lasts for an entire growing season. It is most effective in crops that release organic acid anions from their root systems. Reduces application of synthetic fertilizer.
Struvite Removal	• Phosphorous • Nitrogen • Magnesium	Useful for large municipal facilities with anaerobic digesters and struvite problems. Produces struvite beads which can be sold as an additional revenue stream.
Vermifiltration	• Nitrogen • Phosphorous	Can be scaled to almost any wastewater application. Great for remote areas and small communities. Industries include dairies, food and beverage processors, and municipal wastewater. Treated water can be used for agricultural irrigation. Produces worm castings, a high-value soil supplement, and vermicompost which can also be applied to agricultural land.

The above technologies are described below by type of technology solution.

Soil Amendments

Struvite Beads

Struvite is a mineral compound composed phosphorous, nitrogen, and magnesium. It is most often considered a nuisance material because it tends to form in pipes, creating scaling issues and eventually clogging them. However, when recycled it can be used as an effective soil amendment and nutrient management tool because of its slow-release properties. When applied to soils, struvite beads act as nutrient storage modules. When a nearby plant needs phosphorous, it releases organic acid anions into the surrounding soil. This local increase in acidity activates the struvite beads, which release their nutrients to make them available for uptake by the plant. While this interaction is a plant response to low phosphorous, the nitrogen and magnesium are also delivered to the plant's roots. Nutrients are essentially stored within the beads until the plant needs them, which prevents loss to the environment and reduces the need to apply chemical fertilizers. Crops that produce more organic acid anions, such as buckwheat, are better able to break down struvite to obtain the nutrients within.

Biochar

Biochar is a charcoal-like material produced by thermally treating biological materials in the absence of oxygen. Biochar has many properties that enhance plant growth, prevent nutrient leaching into the environment, and increase the water storage capacity of soils. Biochar is highly porous, which increases that amount of water and water-soluble nutrients that can be stored in the soil. This porosity also creates a large surface area, which, combined with a positively charged surface, makes biochar highly adsorptive. Nutrients that are applied to the soil are adsorbed onto the surface of biochar, which prevents loss to the environment and reduces the need to apply chemical fertilizers. This property increases the bioavailability of nutrients while simultaneously reducing the bioavailability of heavy metals. Biochar can also be used to remove nutrients from water, pulling them onto its surface. This biochar is considered to be "activated," providing an immediate source of nutrients to plants.

Water Treatment: Separation

Reverse Osmosis (RO)

Reverse osmosis is one of the most common advanced water treatment technologies on the market. It excels at the removal of just about any contaminant from water. RO uses high pressure to force water with high concentrations of contaminants through a semi-permeable membrane, leaving the contaminants behind. It is used for desalination and direct potable reuse applications, as well as for tertiary treatment for nutrient removal in wastewater. It is perhaps the best technology available for removing contaminants but is very energy-intensive and leaves behind a concentrated brine solution that is difficult to dispose of. It is so effective at removing nutrients and minerals that many farmers prefer to use groundwater over RO-treated water.

Forward Osmosis (FO)

Forward osmosis is similar to reverse osmosis in that it uses a semipermeable membrane to separate contaminants from water, but rather than using high pressure to force water through the membrane, FO uses natural osmotic forcing to do the work with very little energy input. FO systems have a feed side that contains the solution to be concentrated (water removed), and a draw side that contains the solution to be diluted (water added). Typically, the draw side will be a solution concentrated with something that is easy to remove in a subsequent process, resulting in clean water. If a particular application uses two solutions, one which needs to be concentrated and another that needs to be diluted, then FO becomes incredibly efficient. Similar to RO, however, if used just to treat water, then contaminants on the feed side will be concentrated into a brine solution that is difficult to dispose of.

Membrane Bioreactor (MBR)

MBR is an advanced wastewater treatment technology known for its consistent high level of treatment, easy integration into existing infrastructure, and low footprint. MBR uses a combination of biological treatment and microfiltration. While there are different variations, it generally consists of an activated sludge tank with trains of submerged microfiltration tubes. While biological processes are occurring in the tank, water is simultaneously passing through small pores in the membrane into the interior of the microfiltration tubes and removed as effluent. Aeration simultaneously assists in aerobic growth while preventing fouling of the membranes. Sludge is removed for disposal or digestion. MBR removes 96-99 percent of nitrogen from wastewater[173].

Water Treatment: Degradation

Nitrification/Denitrification Basins

The standard nitrogen degradation technique. Nitrification is the process by which ammonia is converted by aerobic bacteria to nitrite, and then nitrate. In denitrification, anaerobic bacteria convert nitrate to N_2O or nitrogen gas, which is released into the atmosphere. Water treatment facilities can operate these two processes in sequence by storing influent in an aerobic basin, followed by an anaerobic basin. This necessarily requires a large footprint to carry out both processes.

Anammox

Anaerobic ammonia oxidation is a process that takes advantage of a specific bacterial group that is capable of performing both nitrification and denitrification. It occurs in anaerobic environments and does not require aeration, which is the most energy-intensive portion of wastewater treatment. Anammox bacteria are effective at converting both ammonia and nitrates to N_2 while also removing significant portions of biological oxygen demand, reducing the energy

173 Kraume, M., et al. (2005). *Nutrients removal in MBRs for municipal wastewater treatment*. Water Science and Technology. 2005; 51(6-7):391-402.

requirements of subsequent aeration basins. Anammox bacteria grow slowly but provide an energy- and footprint-efficient alternative to traditional nitrification/denitrification processes.

Biocatalyst Nitrate Removal

A biocatalyst is a contained unit of microbes that is capable of processing nitrates without the microbe population increasing. This is accomplished via an engineered polymer-microorganism composite with a high density of organisms. When exposed to water, the microbes are prevented from being released to the environment, but nitrate-rich water is able to pass through the composite. Nitrates are converted into N_2 by the microorganisms, and then the water passes out of the composite. Nitrates are removed from the water without creating sludge or any other waste stream. This technology is ideal in scenarios where water has already been treated to remove organics, and sludge production is undesirable, such as for tertiary treatment additions to existing water treatment systems or for direct groundwater remediation.

Water Treatment: Recycling

Algae Production

Microalgae are highly capable of removing nitrogen compounds from wastewater, including ammonia, nitrate, and nitrite, and rapidly converting them into biomass. This biomass can be used for a variety of purposes, including fertilizer, animal feed, biofuels, nutraceuticals, and consumer products. There are a few ways to produce algae, each with their own advantages and disadvantages. The two primary methods are with high-rate algae ponds and closed algae photobioreactors, though the vast majority of commercial algae production comes from open-air ponds. High-rate algae ponds are shallow ponds designed like raceway tracks, with a paddle wheel moving water around a central divider. Algae needs sunlight to grow, so the movement mixes up the algae in order for more algae cells to have access to sunlight. This method uses very little energy, but has a large footprint and operates better in warm climates.

Photobioreactors use thin, clear tubes, and use artificial lights instead of natural sunlight in order to grow algae. These tubes can be stacked vertically to significantly reduce the footprint, but they are more energy-intensive than high-rate algae ponds.

Struvite Removal

Struvite is a nuisance in wastewater treatment, forming from sludge where nitrogen, phosphorous, and magnesium react to create a scaling material that clogs pipes and destroys pumps. Struvite is commonly produced in facilities that use anaerobic digesters. Methods to prevent and remove struvite not only solve a significant pain point for treatment plant operators, but capture valuable nutrients that can be recycled back into agricultural production. Struvite consists of nitrogen, phosphorous, and magnesium in a 1:1:1 ratio, and because nitrogen often appears at much higher concentrations to phosphorous (16:1 in the natural environment, sometimes much higher in wastewater), this process is more effective at recapturing phosphorous than nitrogen.

Reactive Filtration

Reactive filtration describes a series of interconnected processes. Water is mixed with an iron catalyst and ozone, then flows up through a sand bed filter. The iron catalyst collects contaminants and latches onto the sand, and the ozone destroys pathogens and trace organic compounds. Water is distilled at the surface of the sand bed filter and filtered through biochar. The biochar collects the water's nitrogen and phosphorous on its surface, resulting in water that meets drinking water standards. The nutrient-enhanced biochar itself is collected and used for soil application. The process is energy-efficient and carbon-negative.

Vermifiltration

Vermifiltration uses a combination of earthworms and bacteria within a multi-layer filtration substrate to remove contaminants from wastewater. The process is used as a secondary treatment method, in which large solids are removed from the influent before application to the vermifiltration reactor. The top layer consists of earthworm humus, which contains live earthworms that keep this layer aerated while digesting contaminants from wastewater. Water flows through this layer into sawdust and gravel layers, which physically filter out contaminants as well as support bacterial communities that will biologically break down contaminants. This process removes up to 70 percent of nitrogen within the wastewater, and results in water that is clean enough to recycle for agricultural irrigation. Instead of sludge, the process creates worm castings—a valuable soil amendment—as well as vermicompost, which can also be applied to soil.

Management Practices

No-Till Farming

No-till farming is a best management practice for restorative agriculture. It is a method of farming that doesn't disturb the soil microbial communities in order to improve water infiltration, organic matter retention, and nutrient cycling. In undisturbed soil, mycorrhizal fungi create networks of hyphae, a filamentous structure that connects plants and transfers water, nutrients, and carbon throughout the soil[174]. Tilling breaks up these networks, preventing efficient movement of resources throughout the soil and resulting in poor distribution of nitrogen to all plants. No-till farming reduces nitrate leaching, but nitrate runoff remains similar to conventional tilling methods[175].

Due to health and safety regulations, no-till farming is difficult to use for some applications in California. Where fresh food is grown, the fruit cannot directly contact water in order to prevent infection. They are grown in raised beds in order to run water through the troughs.

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174 Hawkins, HJ., Johansen, A. & George, E. *Plant and Soil* (2000) 226: 275. https://doi.org/10.1023/A:1026500810385.

175 Daryanto, S., Wang, L., & Jacinthe, PA. (2017). *Impacts of no-tillage management on nitrate loss from corn, soybean, and wheat cultivation: a meta-analysis.*

Cover Crops

Cover crops are crops grown in non-productive seasons to provide soil benefits for the growing season. They are used to improve soil health, reduce evaporation, and fix nitrogen for primary crops, among other benefits. Legumes and grasses are the most common cover crops. Legumes in particular are excellent at fixing nitrogen from the atmosphere and making it bioavailable for other crops, reducing the need for synthetic fertilizers. However, in conventional agriculture applications, there is residual nitrogen in the soil from prior fertilizer application, so adding nitrogen through cover crops is undesirable. In this case, cereal grass cover crops are better for nitrogen capture and retention because the establish more quickly than legumes and they stay active in colder temperatures, reducing leaching during the winter[176]. Cover crops also prevent nitrogen loss from runoff by increasing soil water retention during the rainy winter season and providing a physical barrier to horizontal transport of water and nutrients.

176 Shelton, R.E., Jacobsen, K.L., & McCulley, R.L.. *Cover Crops and Fertilization Alter Nitrogen Loss in Organic and Conventional Conservation Agriculture Systems*. Front Plant Sci (2017); 8:2260. doi: 10.3389/fpls.2017.02260.

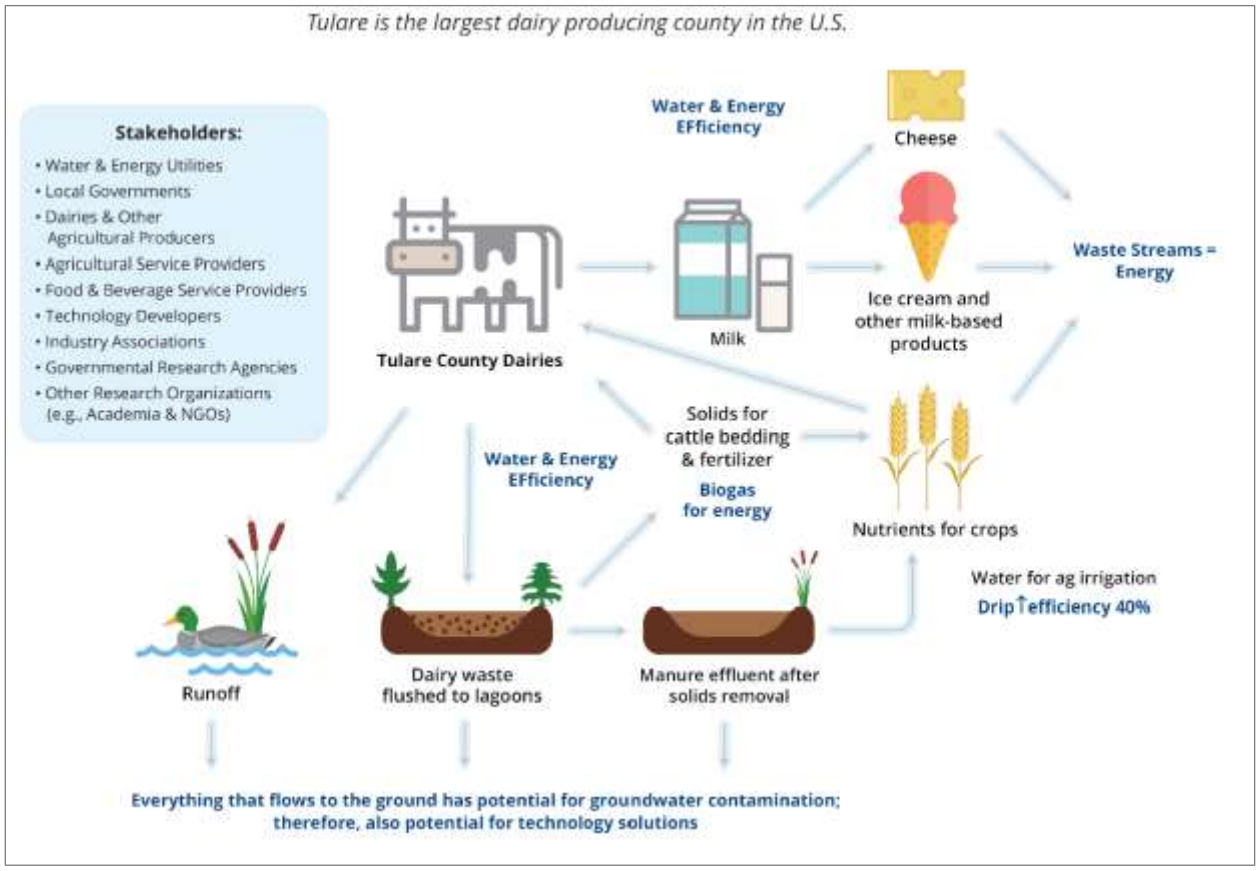
APPENDIX G:
Tulare County's Dairy Cluster

As the largest dairy producing county in California, Tulare is well positioned to be a center of dairy technology innovation. In fact, the makeup of Tulare County's industries reflects a natural evolution in that direction, with most of the county's non-residential water and electric use clustered around its dairies: from dairy farms and milk production, to industries that manufacture milk products (for example, powdered milk, evaporated milk, cheese, ice cream), suppliers that provide food processing machinery, packaging materials and technologies, shipping services, and washing of the vehicles that transport crops and food products.

"Clusters" are dense regional networks of companies, universities, research institutions, and other stakeholders involved in a single industry.

Building a Successful Technology Cluster, Fieldsteel, M.T., Environmental Technology Innovation Clusters Program, U.S. Environmental Protection Agency, Office of Research and Development, March 12, 2013.

Figure G-1: Tulare County's Dairy Technology Cluster

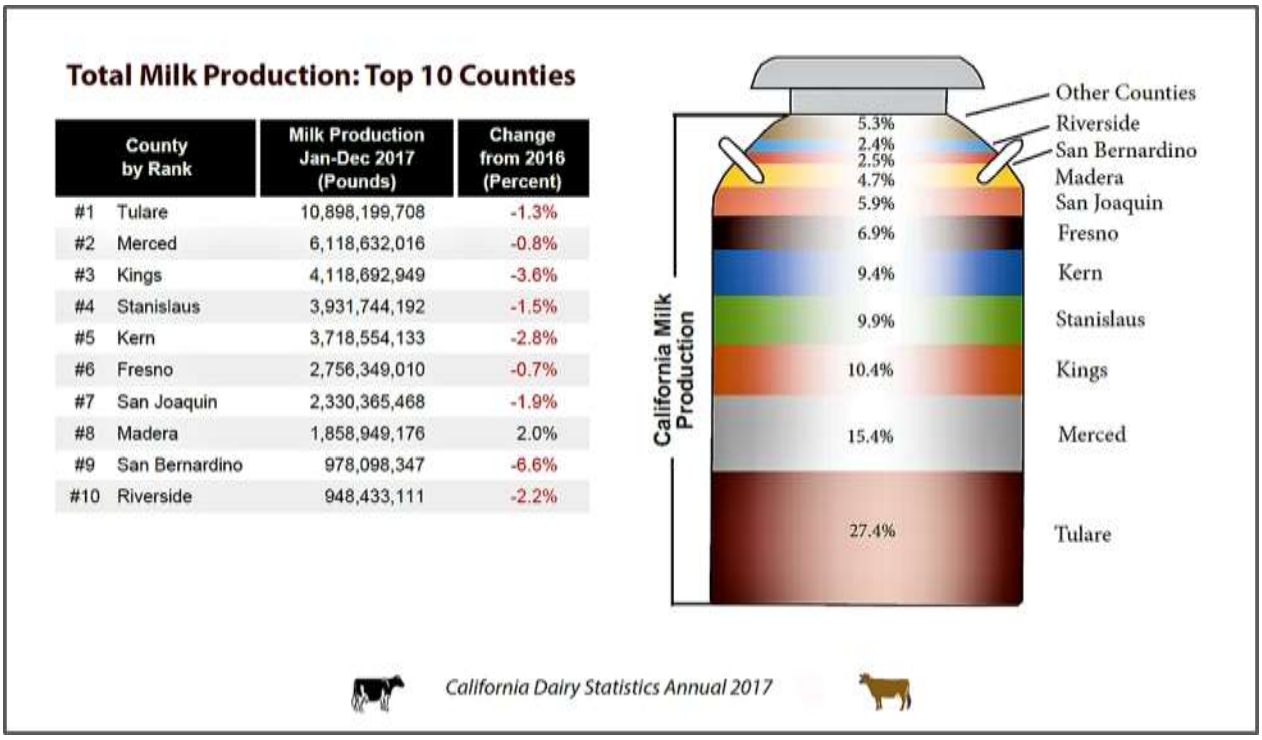


Dairy Farms and Milk Production

In 2017, Tulare County had 258 dairy farms with a total of 471,081 milk cows—27 percent of the total number of milk cows in California.[177] About 1 out of every 5 cows in the country lives in California.

Tulare County is the largest milk producer in California, and has been among the top 3 milk producing counties in the nation for many years.

Figure G-2: California Milk Production by County (2017)



County by Rank		Milk Production Jan-Dec 2017 (Pounds)	Change from 2016 (Percent)
#1	Tulare	10,898,199,708	-1.3%
#2	Merced	6,118,632,016	-0.8%
#3	Kings	4,118,692,949	-3.6%
#4	Stanislaus	3,931,744,192	-1.5%
#5	Kern	3,718,554,133	-2.8%
#6	Fresno	2,756,349,010	-0.7%
#7	San Joaquin	2,330,365,468	-1.9%
#8	Madera	1,858,949,176	2.0%
#9	San Bernardino	978,098,347	-6.6%
#10	Riverside	948,433,111	-2.2%

Source: California Department of Food and Agriculture (CDFA), California Dairy Statistics Annual 2017.

Water and Energy Use by Dairies

Most of the water used by dairies is pumped from private groundwater wells. Since withdrawals from private groundwater wells have historically not been monitored or metered, the exact amount of water used by dairies is not known.

Since the dairy industry is known to be a very large user of water, extensive research is being conducted throughout the world to understand which water (potable, rainwater, recycled or gray water) is being used for which functions, and where freshwater withdrawals can be reduced.

177 California Department of Food and Agriculture. *California Dairy Statistics Annual 2017*.

Figure G-3: Primary Water Uses in Dairies

1. Milking parlor use (cow prep/cleaning)

2. Milk Refrigeration

3. Drinking (25-50 gallons per day per lactating cow)

4. Washing (15-50 gallons per cow per milking)

5. Heat stress abatement (fans and mist)

Dairy water usage varies depending on climate conditions. Studies have shown that water usage can vary anywhere from 100 to 200 gallons per lactating cow per day.

Fresh water usage typically averages 50% in the housing areas and 50% in the milking center. The actual ratio depends on multiple factors, including summer-time heat stress abatement.

Source: Courtesy of Jim Bruer, Applied Quantum Technologies.

Photo Credits: (1) pixinoo / Shutterstock.com, (2) Baloncini / Shutterstock.com, (3) Budimir Jevtic / Shutterstock.com, (4) titipong / CanStockPhoto.com, (5) koolfog.com.

One study conducted by Dr. Craig Thomas of Michigan State University[178] evaluated dairy water use by "direct" and "indirect" functions.

- Direct Water Use was deemed to be drinking water for dairy animals.
- Indirect Water Use consisted primarily of cleaning cows, facilities and equipment in relation to milking operations. The study included a small allowance of water use for milk cooling that was recycled, and a small contingency for "miscellaneous" water uses.

Water use was then estimated for a hypothetical 1,000 cow dairy farm, with and without heifers. This study produced an estimate of 25.5 to 67.5 gallons per day per dairy cow. This estimate does not include any water for cooling cows or for irrigation of fodder crops. It also does not include recycling water within the milking parlor.

Similar studies have been conducted by research organizations in other states with significant variations in the quantity of indirect water use.

A general benchmark that is often cited by industry experts is 100-200 gallons per day per dairy cow. Actual usage varies significantly with climate (temperate and humidity), facility design and operations, and also whether heifers are raised on the same dairy farm.

Using the 100 gallons per day estimate, Tulare County's 471,081 dairy cows would require 17.2 billion gallons per year (52,785 AF). Virtually all of the water used by dairies is groundwater, and the water used for cow drinking and cleaning is mostly freshwater, although there now concerted efforts to recycle water wherever it is economically feasible.

Significantly, however, water used to clean cows, the milking parlor, flushing stalls, and other uses flow to manure lagoons where large solids are removed and dried for use as fertilizer, cattle bedding, and other purposes. The remaining wastewater is typically used to irrigate crops, especially fodder crops such as alfalfa. In this manner, dairies recycle as much effluent from the manure lagoon as possible.

The primary challenge is that biosolids and other particles that are not removed during the manure sludge dewatering process clog drip irrigation systems. Consequently, dairy farmers have needed to flood irrigate alfalfa and other fodder crops.

The California Department of Water Resources (CDWR) estimated that during water year 2010, alfalfa crops consumed 5.2 million acre-feet of water (1,694 billion gallons), 37 percent more than the next highest water consumer: tree nuts (almonds and pistachios).

Technology is currently poised to substantially change alfalfa's standing as the highest agricultural water user in California.

Sustainable Conservation, a California-based 501c3 tax-exempt organization; Netafim USA, an irrigation technology solutions provider; and De Jager Farms, a dairy farm in Madera County, have been working for several years on a technology demonstration

178 Thomas, Dr. Craig V. *Estimating Water Usage on Michigan Dairy Farms (1,000 head).* Michigan State University Extension.

project that mixed fresh water with dairy manure wastewater to produce a liquid manure that could be delivered to a crop's roots via drip tape for maximum absorption. The pilot system "… increased nitrogen use efficiency by more than 50 percent, reduced water use by 30 percent, and increased crop yields. In addition, the system significantly reduced nitrous oxide, a greenhouse gas generated when fertilizer and water mix that is over 200 times more potent than carbon dioxide, compared to traditional flood irrigation."[179]

In 2016, Sustainable Conservation announced that it had received a Conservation Innovation Grant from the U.S. Department of Agriculture in the amount of $833,000 to expand its technology demonstration to additional dairies in San Joaquin Valley. The primary benefit of liquid manure over traditional drip irrigation is the ability to utilize the manure as fertilizer, avoiding need to purchase and apply synthetic fertilizers.

De Jager Farms has reported that applying liquid manure via drip irrigation has reduced applied water for corn silage by 25 percent and increased crop yield 20-25 percent, a net water efficiency gain of 40 percent.

Tulare County dairy farmers are currently investigating multiple technology solutions that could enable use of dairy manure effluent with drip irrigation. One farmer stated that converting his planted alfalfa acreage to drip vs. flood would reduce the quantity of applied water from 3.5 AF/acre to 2.8 AF (water use reduction of 20 percent) while concurrently increasing the alfalfa yield from 9 tons to 12 tons per acre (an increase in yield of 33 percent). The net benefit of this strategy would reduce water use from 3.5 AF of water per 9 tons of alfalfa production (0.39 AF/ton) to 2.8 AF of water per 12 tons of alfalfa (0.23 AF/ton), a savings of 41 percent.

Tulare dairy farmers hope to find a technology solution that will remove enough of the remaining particles in dairy manure effluent to enable using it directly for drip irrigation without the need to add more water. The ideal solution will also remove some, but not all of the nutrients, in order to comply with new regulations reducing nutrient concentration limits[180] while also retaining sufficient nutrients to avoid the need to add synthetic fertilizers.

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179 Sustainable Conservation Press Release. *Sustainable Conservation Receives USDA Grant to Boost Clean Water for Dairies, Communities in Central Valley*. December 23, 2016.

180 Nutrient concentration limits being developed by the SWRCB and the Central Valley Regional Water Quality Control Board (CV-RWQCB) in collaboration with the CV-SALTS (Central Valley Salinity Alternatives for Long-Term Sustainability) initiative, a multi-stakeholder effort to produce a salt and nitrate management plan (SNMP) for the Central Valley. CV-SALTS is a coalition of representatives from agriculture, cities, industry, state and federal regulators, and members of the public.

Figure G-4: Dairy Wastewater Effluent

Source: Air Resources Board Dairy and Livestock Working Group.

Photo Credits: (1) Choksawatdikorn / Shutterstock.com, (2) Dolgachov / CanStockPhoto.com, (3) U.S. Department of Agriculture Natural Resources Conservation Agency website: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/ca/newsroom/stories/?cid=nrcs144p2_064168, (4) L.Park, Water Energy Innovations, (5) Nigel Cattlin / Alamy Stock Photo, (6) Design Pics Inc. / Alamy Stock Photo.

Key Findings

1. Water use for flood irrigating alfalfa and other fodder crops can be reduced by about 40 percent by converting to drip irrigation. The saved manure effluent can be used to grow additional crops. The types of crops that could be irrigated with treated manure effluent depends on the level of treatment applied.

2. A technology that removes both organic and inorganic particles to enable manure effluent to be delivered to fodder crops by drip and that also reduces the contents of nitrates, phosphorus and other nutrients to levels that meet the Salt and Nitrate Management Plan (SNMP) adopted by the Central Valley Regional Water Quality Control Board (CV-RWQCB) on June 1, 2018 will reduce the amount of additional fresh water that farmers currently anticipate will otherwise need to be added to manure effluent for compliance.
3. Use of drip tape that delivers filtered manure effluent to the roots of crops avoids need for adding back synthetic fertilizers.

Recommendation

California should invest in helping dairy farmers find a water-efficient and cost-effective solution for using manure effluent via drip irrigation that also complies with the CV-RWQCB's Salt and Nitrate Management Plan (CV-SALTS).

Dairy-Related Food Processing

Food processing in Tulare County is related to local agricultural production. The county's major agricultural product is milk.

Table G-1: Tulare County's Top Agricultural Products in 2016[181]

Top 10 Agricultural Products	
1. Milk	Agriculture is the largest private employer in the county with farm employment accounting for nearly a quarter of all jobs. Processing, manufacturing, and service to the agriculture industry provides many other related jobs. Six of the top fifteen employers in the county are food handling or processing companies, which includes fruit packing houses and dairy processing plants. One in every 5 jobs in the San Joaquin Valley is directly related to agriculture. In 2016, total gross production value for the county of Tulare was $6.3 billion, down 8.8% from 2015, mostly due to changes in planted acreage, and largely impacted by the drought and a decrease in milk prices.
2. Oranges	
3. Cattle	
4. Grapes	
5. Tangerines	
6. Pistachios	
7. Almonds	
8. Corn	
9. Walnuts	
10. Lemons	

Water Use for Food Processing in Tulare County

Water use by the food processing sector in Tulare County is estimated at 2,217 million gallons per year.

181 Tulare County Farm Bureau website: http://www.tulcofb.org/index.php?page=agfacts.

Table G-2: Estimated Annual Water and Energy Use in Tulare County for Food Processing

Water Use	Electric Use	Natural Gas Use
2,217 MG	404 GWh	600 Million therms

Sources:

[1] Water data estimated from California League of Food Processors Report, The Economic Impact of Food and Beverage Processing in California and Its Cities and Counties, January 2015.

[2] Electric data provided by Southern California Edison (SCE) for CY2015.

[3] Natural gas usage estimated from California Energy Commission Report, California's Food Processing Industry Energy Efficiency Initiative: Adoption of Industrial Best Practices. January 2008. Publication Number CEC 400-2008-006.

Energy Use for Dairies and Food Processing

Dairies accounted for 38.2 percent of the electricity used by the agricultural sector. Dairy-related food processing (cheese, dry and evaporated milk, ice cream, fluid milk) accounted for 56 percent of all electric use for manufacturing. Together, dairies and dairy-related food processing accounted for 32 percent of non-residential electric use.

Key Findings:

1. Tulare County's food and beverage processors have substantial opportunities to reduce groundwater withdrawals through onsite treatment, filtration and disinfection of process water effluent.
2. Technologies are available today that, when considering avoided costs of water and avoided discharges to municipal sewer systems, could pay for themselves within three years or less.
3. Multiple benefit streams could be achieved by adopting these technologies, including reduced groundwater pumping, reduced use of electricity for groundwater pumping, reduced discharges to municipal wastewater systems, increased biogas production, and reduced greenhouse gas emissions.
4. Primary barriers to adoption are:
    a. Lack of knowledge and experience with the technologies,
    b. Incremental capital and operating costs, and
    c. Lack of incentives to adopt.

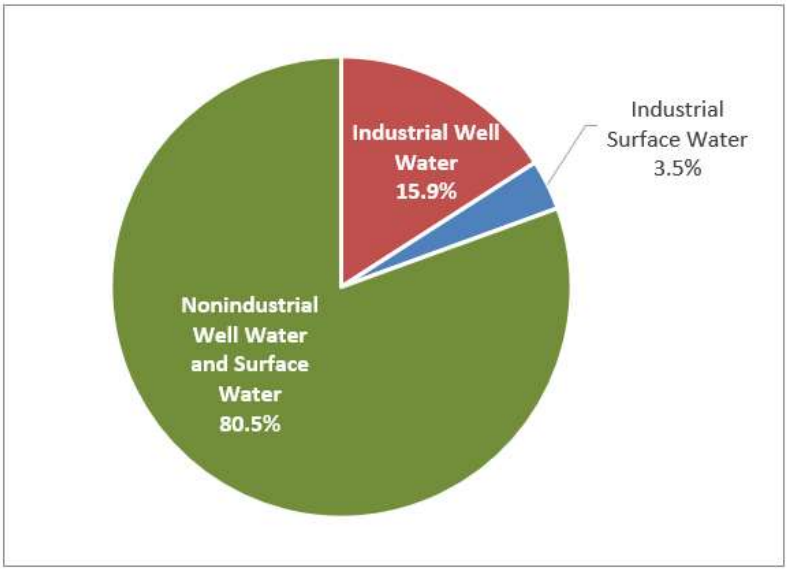
Recommendations:

Energy and water utilities, state and local agencies, and other stakeholders that would benefit from reduced water demand by food and beverage should provide incentives and technical support to encourage distributed water resources by food and beverage processors and manufacturers.

APPENDIX H: Equipment Cleaning and Sanitation Technologies

In Tulare County, many large food processors draw water from their own groundwater wells, while others purchase some or all their water from municipal water utilities. In 2010, the U.S. Geological Survey (USGS)[182] estimated that industrial facilities withdrew an average of 16.07 million gallons of water per day (MGD) from wells in Tulare County and 3.56 MGD from public water supplies for a total of 19.63 MGD industrial water withdrawals.[183] Figure H-1 compares Tulare County's industrial water withdrawals to the county's overall non-irrigation water withdrawals.

Figure H-1: Tulare County Non-Irrigation Water Withdrawals



Water use for cleaning of facilities and equipment is large as a percentage of total water use within the industrial sector. It is particularly high in food and beverage (F&B) processing where 60 percent or more of process (non-food) water is used for cleaning:[184]

182 The U.S. Geological Survey (USGS) estimated self-supplied industrial withdrawals by collecting data from a sample of major industrial facilities, creating water-use coefficients in the form of volume used per employee or per unit of product and using these coefficients to calculate usage for the remaining industrial facilities in the county. Further details, including sample size, were not provided by the USGS, but this estimate is sufficient to justify the need to conserve water in this industry. Industrial withdrawals from public supply were estimated by summing data found in urban water management plans from the top water users in Tulare County. This estimate should be lower than reality because not all municipalities had published urban water management plans.

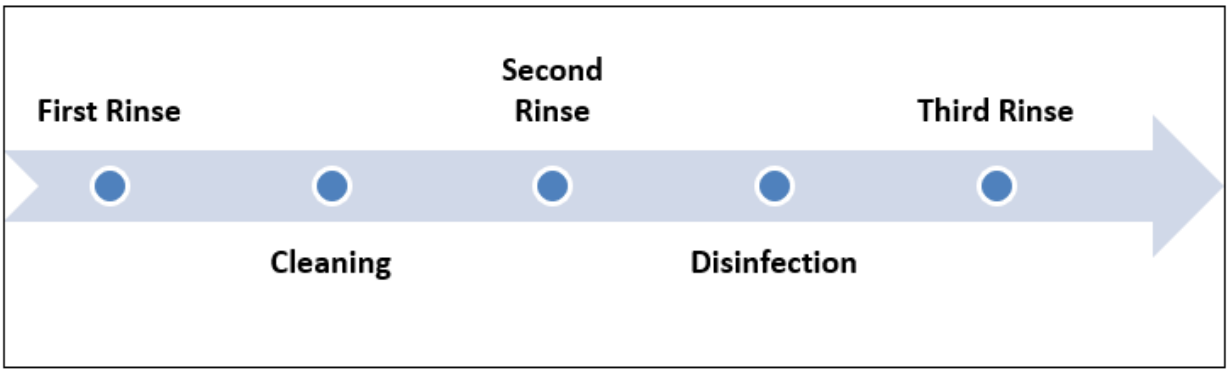
183 "USGS Water Use in the United States - County data download 2010." *U.S. Geological Survey* website. https://water.usgs.gov/watuse/data/2010/.

184 Blake Schomas, Director of Marketing for Nalco Water, an Ecolab company, in an interview with Debra Schug, Food Engineering, *Reducing water usage in food and beverage processing*, April 18, 2016.

- CIP ("clean in place" systems clean the interior surfaces of process equipment without the need to disassemble the system).
- COP ("clean out of place" systems clean equipment that cannot be cleaned "in place", such as areas where process equipment may need to be disassembled, and/or items that are small, complex, sensitive, or difficult to clean).
- Floors and exterior equipment.
- Lubricating and cleaning conveyors.

The cleaning process can include, but is not limited to, the steps shown in Figure H-2.

Figure H-2: Five Steps of Traditional Industrial Cleaning Processes



1. First Rinse

   This initial rinse is intended to wash away any free particles/chemicals on the surface. Water from the second or third rinse can safely be reused for this step.

2. Cleaning

   The cleaning process removes all visible soil and materials from the surface. It typically involves the use of a caustic and/or corrosive alkaline chemical detergent. Many wastewater treatment facilities require companies to reduce the pH range, chemical oxygen demand (COD), and biological oxygen demand (BOD) of waste streams, which typically requires treatment of the runoff from this step.

3. Second Rinse

   Depending on the nature of the chemicals used for the cleaning step, a secondary rinse may be necessary between cleaning and sanitizing. Rinse water from the third rinse can be reused for this intermediate rinsing step.

4. Disinfection

   The process used to sanitize the surface must be an effective disinfectant capable of neutralizing bacteria, viruses, fungus, and many other forms of pathogens.

   Thermal sanitation is easy to apply, readily available, and effective over a broad range of microorganisms. However, it is a slow process that is energy intensive, carries employee

safety concerns, and can contribute to the degradation of equipment through thermal shock/cycling. Chemical sanitizers typically consist of chlorine, peroxides, or various acids.

5. Third Rinse

   For some sanitation chemicals, a third and final rinse is necessary to wash away residual chemicals. This water should be fully sterilized. The FDA maintains a list of sanitizers that do not require rinsing afterward.

Strict cleaning measures are necessary to prevent the contamination of food products. Thorough sanitation of food processing equipment is essential to public health and safety, and food processing facilities feel immense pressure to institute and enforce a strict regime of sanitation procedures. Simultaneously, drought conditions increase the need to conserve water. Food processing facilities can satisfy both pressures by implementing innovative technologies that reduce or eliminate the need for water while maintaining an excellent level of cleanliness.

Many of the traditional cleaning solutions and sanitizers used in the food industry are hazardous to those who use them and those who work around them. Exposure to caustic/corrosive cleaning chemicals can cause skin irritation, rashes, burns, and irritation of the eyes, nose, throat, and lungs.[185] Custodial workers, who frequently encounter cleaning chemicals, are twice as likely to develop asthma compared to other workers.[186] Vegetables have typically been washed with water that contains free chlorine in concentrations less than 30 ppm for several decades, but many researchers have determined that excessive use of chlorine can be harmful due to the formation of carcinogenic disinfection byproducts caused by the reaction of residual chlorine with organic matter.[187]

The five technologies below can replace traditional caustic/corrosive/carcinogenic cleaning chemicals while also decreasing water and energy consumption.

Table H-1: Technologies for Equipment Cleaning and Sanitation

Candidate Technologies	Applications
Dry Ice Blasting	Waterless clean-in-place system that can rapidly clean nearly any surface; ideal for 'dry' facilities such as bakeries
Biomist	Misted sanitizer that can effectively disinfect nearly any surface; highly effective at disinfecting hard-to reach and water-sensitive surfaces
Electrochemically Activated Solutions	Nontoxic, nonthermal cleaning and sanitizing solutions that can be produced on-site and on-demand
Ultrasound Disinfection	High-powered sound waves might be able to effectively sanitize produce and containers submerged in water
Cold Plasma	Electricity applied to gas surrounding produce and containers creates disinfecting plasma that might be an effective sanitizing agent

185 Spruce, L. "Back to Basics: Environmental Cleaning Hazards." *AORN Journal*, Vol. 106, No. 5, pp. 424–432. Nov. 2017.

186 "Green Cleaning, Sanitizing, and Disinfecting: A Curriculum for Early Care and Education." *University of California, San Francisco (UCSF) Institute for Health & Aging*. 2013.

187 McDonald, T.A. and H. Komulainen. "Carcinogenicity of the Chlorination Disinfection By-Product MX." *Journal of Environmental Health*, Part C, Vol. 23, No. 2, pp. 163–214. July 2005.

Dry Ice Blasting

Dry ice blasting, also known as cryoblasting, refers to blasting surfaces with small pellets of solid carbon dioxide (CO2). Upon impact, the pellets simultaneously evaporate and freeze the substrates on the surface. Cryoblasting exerts mechanical and thermal stresses on substrates that effectively strip the material from said surface[188] (see Figure H-3 below).

Figure H-3: Depiction of the dry ice blasting process

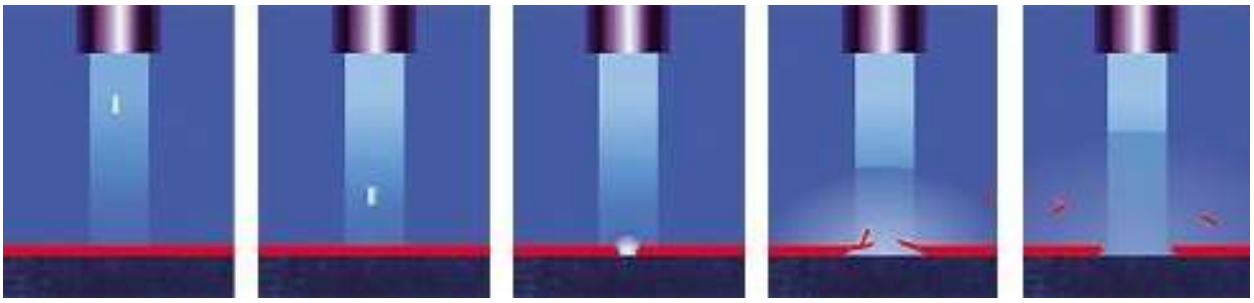


Figure used with permission of Cold Jet.

Because dry ice evaporates upon impact, there is no residual cleaning chemical on equipment surfaces or in cavities of parts, meaning that subsequent clearing or drying of these areas is unnecessary. Dry ice blasters are capable of shooting anything from finely shaved dry ice to larger pellets, which allows the operator to fine-tune the machine to the ideal scrubbing power. This mechanism is ideal for cleaning in place because it can easily scrub hard-to-reach places and doesn't splash liquid. Additionally, there is no drying time delay before the equipment can be put back into production. Dry ice blasting can be implemented with sensitive electronics and applications where water and chemicals could cause considerable damage.

Dry Ice Blasting is not an Effective Sanitizer

Though dry ice blasters are highly efficient at removing built-up residue from all kinds of surfaces and have demonstrated antibacterial properties, they are not considered to be an effective sterilization method for surfaces that contact food products. This is because the process of blasting surfaces can potentially disperse bacteria to nearby surfaces, which increases chances of recontamination.[189] Dry ice blasting alone may be most effective for the removal of dirt, grease, and grime on machines and surfaces that do not come into direct contact with food. For applications within food processing facilities, dry ice blasting can be accompanied by a powerful, invasive disinfectant.[190]

188 Spur, G., E. Uhlmann, and F. Elbing. "Dry-ice blasting for cleaning: process, optimization and application." *Wear*, Vol. 233–235, pp. 402–411. December 1999.

189 Miller, I. "Final Technical Report: Cold Jet - A Novel Technique for Cleaning and Decontaminating Food Processing Areas, Equipment, Carcasses and Foods." *Microchem Bioscience Limited*, B02006. September 2004.

190 Witte, A.K, M. Bobal, R. David, B. Blättler, D. Schoder, and P. Rossmanith. "Investigation of the potential of dry ice blasting for cleaning and disinfection in the food production environment." *LWT - Food Science Technology*, Vol. 75, pp. 735–741. January 2017.

Emissions Associated with Dry Ice Blasting

One concern of cryoblasting is the direct release of CO2 into the atmosphere. The carbon dioxide used to produce pellets is a byproduct that can be captured from ammonia production, oil and gas refineries, and ethanol production. If a carbon sequestration method is developed to divert carbon dioxide from one of these industries for cryoblasting, then there would essentially be no net difference in emissions. In Tulare County, Air Liquide is already capturing and liquefying CO2 from ethanol production.[191] The CO2 currently goes to products such as sparkling mineral water and soda, but could potentially be expanded to accommodate dry ice blasting operations.

Other Factors

Dry ice blasting requires less work for disposal of waste and does not require construction of containment mechanisms, which can further reduce emissions from transportation and treatment processes. A study by the University of Miami found that the use of dry ice blasting would result in fewer carbon dioxide emissions for cleaning a concrete bridge when compared to water jetting or sand blasting.[192] They also determined that dry ice blasting would take 10-20 percent less time than water jetting or sand blasting due to the simpler set up and tear down procedures. Though food processing and cleaning bridges are very different, comparable results are expected regarding the carbon dioxide emissions of cryoblasting.

Technology Benefits

The primary rinse is usually unnecessary because dry ice blasting removes substantial amounts of soil. Depending on the application, the secondary rinse may also be unnecessary. The cleaning step, which typically uses chemicals diluted in water, uses no water whatsoever. In some scenarios, implementing dry ice cleaning with a no-rinse sanitizer can completely clean and sanitize surfaces while removing four out of five water-based steps from the process. The water savings that can be achieved from this implementation are significant. Additionally, case studies have proven dry ice blasting to be incredibly time efficient, reducing cleaning times by up to 90% when compared to manual cleaning methods. Finally, the simplicity and speed of dry ice blasting can save energy and reduce emissions compared to traditional cleaning technologies.

Biomist

Biomist is a misted alcohol technology developed by Biomist, Inc. for the disinfection of food and food processing surfaces. The Biomist formula is bactericidal, viricidal, and tuberculocidal.[193] The alcohol kills germs on contact and evaporates, leaving surfaces and equipment dry and ready for use. Many studies have demonstrated the efficacy of alcohol as a

191 "Food Processing Presents Energy Industry Opportunities in Tulare County, CA," 2015. *Area Development* website: http://www.areadevelopment.com/FoodProcessing/.

192 Millman, L.R. and J. W. Giancaspro. "Environmental Evaluation of Abrasive Blasting with Sand, Water, and Dry Ice." *International Journal of Architecture, Engineering and Construction*, Vol. 1, No. 3, pp. 174–182. September 2012.

193 Musgrove, M.T. and J. K. Northcutt. "Evaluation of an Alcohol-based Sanitizer Spray's Bactericidal Effects on Salmonella Inoculated onto Stainless Steel and Shell Egg Processing Equipment." *International Journal of Poultry Science*, Vol. 11, No. 2, pp. 92–95. February 2012.

disinfectant.[194] Biomist is ideal for dry environments (nuts, bakeries, spices, etc.) because it evaporates away with no residue. No wiping or cleaning off is necessary, which helps to eliminate cross-contamination. Biomist can also be applied to sanitize non-washable equipment, electronics, control panels, and other sensitive items because it is non-corrosive. The penetrating mist can spray surfaces up to 15 feet away and can reach into cracks and crevices that are inaccessible to other sanitizing methods. Biomist is an effective solution for disinfecting surfaces that have been treated with dry ice blasting.[195] Biomist avoids flammability by encasing the alcohol vapor in a stream of CO2 gas, cutting off all oxygen needed for combustion. Consequently, the Biomist formula can be sprayed in places where there is a chance of sparks or open flames.

Figure H-4: Biomist SS20 system

Figure courtesy of Biomist, Inc.

Technology Benefits

Biomist technology saves money through reduced down-time for machinery, eliminating the need for clean-up and disposal, and reduced chemical expenses. The system requires a canister of liquid CO2, which is provided by Biomist. Biomist saves water by eliminating the need for a final rinse and because the misting process uses less water than a foam or disinfecting rinse.

Electrochemically Activated Solutions

Electrochemical activated water (ECA) can be used as a substitute to conventional clean-in-place systems and has been successfully implemented in beverage, meat/protein, grains, starch,

194 Graziano, M.U., K.U. Graziano, F.M.G. Pinto, C.Q. de M. Bruna, R.Q. de Souza, and C.A. Lascala. "Effectiveness of disinfection with alcohol 70% (w/v) of contaminated surfaces not previously cleaned." *Revista Latino-Americana de Enfermagem*, Vol. 21, No. 2, pp. 618–623. April 2013.

195 Cook, R. "Biomist Misted Alcohol Disinfectant Technology Discussion." August 16, 2017.

condiments/seasonings, and liquid foods.[196] It uses water, table salt (NaCl), and electricity to create two solutions: one for cleaning and one for sanitizing. There are no additional chemicals or hot water involved, and its footprint and operational costs are reduced compared to traditional methods. Both chemicals are skin-safe and present little to no danger to workers. ECA sanitizers can be applied to food products without affecting their appearance, taste, or smell.[197] Because the ingredients of ECA are salt and water, it can even integrate as an ingredient in sauces/condiments.[198]

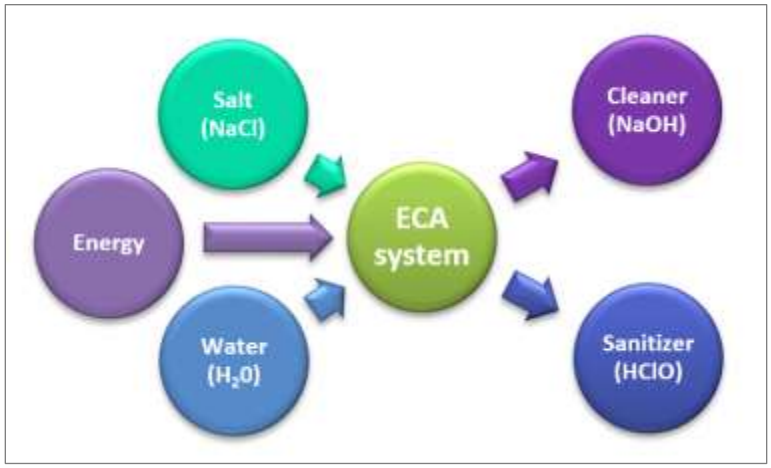
Electrochemical Activation Process

ECA systems are composed of an anode and a cathode, which produce two separate cleaning products.

The cathode splits water (H20) into hydrogen (H2) and hydroxide (OH-). The hydroxide combines with sodium to produce sodium hydroxide (NaOH). This chemical is a mild alkaline anti-oxidizing detergent that is effective at lifting dirt and emulsifying grease. This solution can be used for cleaning fruits and vegetables, effectively removing dirt and potentially even pesticides.[199] It can also be used as the cleaning chemical for equipment and surfaces.

The anode splits water (H20) into oxygen (O2) and hydrogen (H+). These molecules recombine with free chlorine ions, resulting in a nontoxic, non-corrosive hypochlorous acid (HClO). This solution is safe enough to be used as a sanitizing agent for medical procedures to fight infection and is highly effective at killing microbes.

Figure H-5: Electrochemical Activation Process



The transformation of the ECA solution is not permanent. After the solution has been recovered and mixed, the chemical species present will spontaneously shift from this

196 Bramsen, P. "Klarion ECA Technology Discussion." September 7, 2017.

197 Wang, X., A. Demirci, and V. M. Puri. "Electrolyzed Oxidizing Water for Food and Equipment Decontamination," in Handbook of Hygiene Control in the Food Industry. *Elsevier*, 2016, pp. 503–520.

198 "Benefits of ECA." *ECA Consortium*. http://ecaconsortium.com/benefits-of-eca.html.

199 "Electrolyzed Water." *ECA-Water*. http://www.toxicfreecleaning.com/eca-water.

thermodynamically unstable condition to a stable non-active form. The non-active form can be disposed of without treatment with no adverse effects on the downstream effluent environment. The way in which these chemicals are applied to surfaces and machinery will depend on the individual facility. They can be used with a bucket and rag, in a spray bottle, combined with a surfactant and applied as a foam, or implemented into an automated CIP system.

Technology Benefits

The implementation of ECA cleaning systems in industrial facilities can save time, effort, and resources. Water can be saved because the ECA systems can be more effective than traditional chemicals, therefore requiring fewer passes or less immersion. Additionally, because the cleaner and sanitizer are compatible, no rinse is required between these steps. Increased employee satisfaction can result from the lack of corrosive, hot, or otherwise dangerous chemicals. The ECA Consortium estimates that ECA technology, when compared to traditional CIP systems, will save water (60%), cleaning cycle time (70%), chemical expenses (90%) and energy (98%).

Ultrasound Disinfection

High Power Ultrasound (HPU) refers to soundwaves generated at high power and low frequencies (20 to 100 kHz). Several studies have shown HPU to be an effective antimicrobial agent with potential use for disinfecting produce and food containers.[200] Sound waves are generally considered safe, non-toxic, and environmentally friendly.

During ultrasound applications, thousands of microbubbles are generated in liquid surrounding the produce. The gas within the microbubble is heated to a high temperature (up to 5500 C) and pressure (up to 50,000 kiloPascal),[201] with fluctuations occurring in microseconds. When the bubbles collapse, the generated shockwaves are strong enough to shear and break the cell wall and membrane structures of pathogens.[202] This process is called cavitation.

The components of the microbial cells are disrupted by the transfer of kinetic energy generated by ultrasound waves. This energy can disintegrate solids and remove layers of material from surfaces and porous interior structures, kill microorganisms, and prevent undesirable materials from adhering to solid surfaces.[203]

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200 Sango, D.M., D. Abela, A. McElhatton, and V. P. Valdramidis. "Assisted ultrasound applications for the production of safe foods." *Journal of Applied Microbiology*, Vol. 116, No. 5, pp. 1067–1083. May 2014.

201 Kilopascal (kPa) is a "unit of pressure and stress … of one newton per square metre, or, in SI base units, one kilogram per metre per second squared. This unit is inconveniently small for many purposes, and the kilopascal (kPa) of 1,000 newtons per square metre is more commonly used. For example, standard atmospheric pressure (or 1 atm) is defined as 101.325 kPa." Source: Encyclopedia Britannica. https://www.britannica.com/science/pascal-unit-of-energy-measurement#ref187919.

202 Bilek, S.E. and F. Turantaş. "Decontamination efficiency of high power ultrasound in the fruit and vegetable industry, a review." *International Journal of Food Microbiology*, Vol. 166, No. 1, pp. 155–162. August 2013.

203 Jiranek, V., P. Grbin, A. Yap, M. Barnes, and D. Bates. "High power ultrasonics as a novel tool offering new opportunities for managing wine microbiology." *Biotechnology Letters*, Vol. 30, No. 1, pp. 1–6. November 2007.

Furthermore, the localized temperature increase within a collapsing bubble generates primary hydroxyl radicals. Ultrasonic applications accelerated single electron transfers, which results in hydrogen atoms and hydroxyl radicals recombining to form hydrogen peroxide (H2O2), which has important bactericidal properties. The hydroxyl radical is also able to react with the sugar-phosphate backbone of DNA, which results in the breakage of microbial DNA.[204]

HPU treatment (patented as Sonoxide) has been used in over 600 applications worldwide for controlling bacteria and algae in industrial water systems. In addition, HPU has been used in the wine industry since 2006 for the removal of microbiological contaminants and tartrate build-up from wine barrels. The Tom Beard barrel washer operates by filling wine barrels with water and sonicating the interior for 5-12 minutes.[205]

A key factor inhibiting the adoption of HPU disinfecting is the lack of case-studies and proofs-of-concept in a real industrial environment. Much more research and testing is necessary to prove whether ultrasound can be an effective replacement for traditional disinfection methods. There presently are no companies that currently offer ready-to-go technology for the disinfection of produce via ultrasound treatments. One organic lettuce packaging facility (Earthbound, in California) successfully implemented ultrasonic cleaning in their facility,[206] and the University of Patras in Greece determined that ultrasound can disinfect lettuce and strawberries to a level comparable to chlorine and hydrogen peroxide without affecting the product in any way.[207]

Technology Benefits

Though ultrasound disinfection technology is not developed enough for full-scale implementation, it certainly appears to have potential to reduce the amount of water necessary to disinfect produce.

Cold Plasma

Cold plasma decontamination is a promising nonthermal microbial inactivation method. It involves the application of electricity to a gas, creating ions, radiation, and excited molecules that can eliminate pathogens without affecting the product. Cold plasma would serve as an excellent substitute for traditional disinfection methods because it is highly energy efficient and significantly reduces the use of water during product disinfection. Furthermore, cold

204 Bilek, S.E. and F. Turantaş. "Decontamination efficiency of high power ultrasound in the fruit and vegetable industry, a review." *International Journal of Food Microbiology*, Vol. 166, No. 1, pp. 155–162. August 2013.

205 Jiranek, V., P. Grbin, A. Yap, M. Barnes, and D. Bates. "High power ultrasonics as a novel tool offering new opportunities for managing wine microbiology." *Biotechnology Letters*, Vol. 30, No. 1, pp. 1–6. November 2007.

206 "Sound Barrier: Can High-Power Ultrasound Protect Produce from Pathogens? *Scientific American*." https://www.scientificamerican.com/article/ultrasound-to-protect-produce-from-pathogens.

207 Birmpa, A., V. Sfika, and A. Vantarakis. "Ultraviolet light and Ultrasound as non-thermal treatments for the inactivation of microorganisms in fresh ready-to-eat foods." *International Journal of Food Microbiology*, Vol. 167, No. 1, pp. 96–102. October 2013.

plasma treatment is nontoxic, has a wide range of applications, and can disinfect food very quickly.[208]

Cold plasma sterilization treatments involve passing an electric current through a gas that surrounds whatever produce item is to be sanitized. The gas could be air, argon, nitrogen, oxygen, helium, or some mixture thereof. When electricity flows through the gas, the impact of electrons can generate reactive chemicals that will interact with and deactivate pathogens. After the cold plasma treatment, the gases will almost entirely return to a nonreactive state. The electrical charge itself may also affect microorganisms. Though the exact mechanisms have not completely been determined, cold plasma treatment has been demonstrated through multiple experiments to be highly effective at removing biofilms from produce and other surfaces.[209]

In general, the application of cold plasma has a negligible effect on the product matrix, neither altering the sensory qualities of the food nor leaving any form of residue. Furthermore, cold plasma could be applied to both solid and liquid products. However, the process does require additional safety measures to protect against high voltage.

Cold plasma is a dry technology that utilizes non-reactive, non-polluting gases and minimal electricity. It does not result in any liquid waste stream; therefore, it requires no sewage disposal. Cold plasma technology has a significant potential for commercial-scale adoption.

Technology Benefits

Cold plasma treatment virtually eliminates the need for water during the disinfection stage. Furthermore, it is highly energy efficient, can be applied to a wide range of food products, and is highly effective at removing biofilms.

208 Patil, S., P. Bourke, and P. J. Cullen. "Principles of Nonthermal Plasma Decontamination." "Cold Plasma in Food and Agriculture." *Elsevier*, 2016, pp. 143–177.

209 Pankaj, S.K., et al., "Applications of cold plasma technology in food packaging," *Trends in Food Science and Technology*, Vol. 35, No. 1, pp. 5–17. January 2014.

APPENDIX I:
Drought Resilient Technologies

Multiple sources, some public and some private, were scanned to identify technologies that appeared to provide water benefits. Publicly available data sources that were used to identify candidate technologies included the following.

Table I-1: Public Sources of Candidate Drought Resilient Technologies

Data Sources	Database Purpose
Emerging Technologies Coordination Council (ETCC) was created by the state's four largest energy IOUs (PG&E, SCE, SCG, SDG&E) and the Energy Commission with oversight from the California Public Utilities Commission (CPUC). The state's two largest municipal utilities—(the Sacramento Municipal Utilities District (SMUD) and the Los Angeles Department of Water and Power (LADWP) — also participate.	The ETCC provides a collaborative forum for sharing information on emerging technologies opportunities and results. Efforts focus on identification, assessment, and support for commercialization of energy-reducing technologies within all sectors. The ETCC also partners with universities and research organizations, consulting firms, professional associations, technology companies, venture capitalists, and utilities.
E-SOURCE provides focused research and consulting for utilities and their customers by using market research data, expert analysis, and industry experience to achieve that goal.	E-SOURCE emerging technology databases captures studies and articles that help utilities solve problems, make business decisions that serve their customers well, and give them the competitive advantage and intelligence they need to succeed.
Energy Commission Electric Program Investment Charge (EPIC) Program Opportunity Notices (PON) and Grant Funding Opportunity (GFO) Proposals—Energy Commission PONs and GFOs fund clean energy research, demonstration and deployment projects that support California's energy policy goals and promote greater electricity reliability, lower costs, and increased safety. The Energy Commission's electricity innovation investments follow an energy innovation pipeline program design, funding applied research and development, technology demonstration and deployment, and market facilitation to create new energy solutions, foster regional innovation, and bring clean energy ideas to the marketplace.	The Energy Commission through EPIC will fill critical funding gaps within the energy innovation pipeline to advance technologies, tools, and strategies of near zero-net-energy residential homes and commercial buildings, high-efficient businesses, low-carbon localized generation, sustainable bioenergy systems, electrification of the transportation system, and a resilient grid that is supported by a highly flexible and robust distribution and transmission infrastructure. These smarter, safer energy advancements provide ratepayers with better electricity services, reduce air pollution, foster economic development, and help achieve the state's policy goals at the lowest possible cost.

Data Sources	Database Purpose
The Statewide Deemed Workpaper Archive provides public access to documents related to the development, review, approval and use of ex ante values within the energy efficiency portfolio of programs offered by Program Administrators (PAs) as authorized by the California Public Utilities Commission (CPUC).	The Statewide Deemed Workpaper Archive database includes deemed workpapers, submitted supporting documents, and ex ante data which are approved for use for any time period since January 1, 2015 (they are not necessarily currently approved). The database also includes CPUC energy division ex ante dispositions, which apply to workpapers approved for use during any time period since January 1, 2015.
Science Direct/Energy Procedia Scholarly Online Databases Science Direct online research databases combine authoritative, full-text scientific, technical and health publications with research articles covering a range of disciplines including theoretical and applied physical sciences and engineering publications.	

Industry and technology e-newsletters, studies, reports, journals, and other sources were also scanned throughout the course of the project for information about new technologies that appeared to offer both water and electric benefits.

This appendix contains descriptions of the following technologies:

Table I-2: List of Technologies

Technology	Technology Solution Provider	Page
1. Pre-Treatment of Process Water	Carden Water Systems	I-3
2. Integrated System for AC and Production of Drinking Water	N/A	I-6
3. Commercial Laundry Water Recycling	Aqua Recycle	I-9
2. Biofiltration Wastewater Treatment	Biofiltro BIDA System	I-12
3. Forward Osmosis	Porifera - Concentrator	I-15
4. Contaminant Detection and Removal	Porifera - dprShield	I-18
5. Dry Ice Blasting	Cold Jet	I-20
6. Above Ground Irrigation System	Certa-Set®	I-24
7. Novel Membrane	N/A	I-27
8. Biological Reactor	Bioforce	I-29
9. Primary Wastewater Treatment	ClearCove Systems	I-33
10. Ozone Laundry	NuTek	I-38

11. Atmospheric Water Generator	Various	I-42
12. Advanced Disinfection	Puralytics	I-47
13. Smart Metering	Various	I-50
14. Smart Irrigation	Various	I-54

Candidate Technology 1: Pre-Treatment of Process Water[210]

Technology Name	Pre-Treatment of Process Water			
Technology Solution(s)	☐ Water Use Efficiency	☒ Increase Water Supply	☒ Reduce Use of Potable Water for Non-Potable Uses	☐ Water Management Tools
Sector(s)	☒ Agricultural	☒ Commercial	☒ Industrial	☐ Residential
Industry Segment(s)	Agricultural: Dairy and Livestock Commercial: Large Offices, Universities, Hospital Cooling Tower Blow Down Applications Industrial: Breweries, Wineries, Food and Beverage Manufacturing, Oil and Gas, and Landfills			
Drought Resilience	☒ High	☐ Medium	☐ Low	
Water Benefits	☐ Reduces Water Use	☒ Increases Water Supply	☒ Produces/Uses Recycled Water	☒ Reduces Water Loss
Electric Benefits	☐ Energy Efficiency (**Reduces kWh**)	☐ Demand Response (**Ability to Shift Load?**)	☐ Distributed Generation (**Increase Ability to Produce Clean Energy**)	☐ Increase Energy Storage (**Ability to Store Energy**)
GHG Benefits	Yes. Carden Water System proposes to provide GHG benefits by reducing or eliminating the number of disposal wells and trucking and piping costs.			
Implementation Timeline	☒ <= 3 years	☐ 3-7 years	☐ > 7 years	
Estimated Simple Payback	Cost not available to perform payback analysis.			

What is the technology?

Carden Water systems present emerging water treatment technology that provides a clear path for improving water applications to industries with the goals of consolidating water usage and efficiency, decreasing system maintenance, improving business operations, and perfecting system performance while enhancing the earth's environment.

The Carden water technologies include filtration, biological treatment and desalination and propose to treat produced water to higher standards and relieve stress on local water supplies. Carden's water technologies apply to commercial and industrial water regeneration and

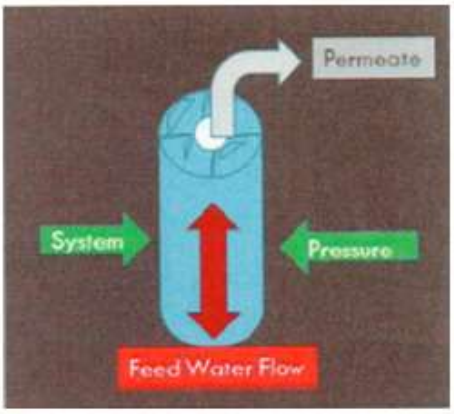
210 "Applications, Clean Water Solutions." *Carden Water Systems.* http://www.cardenwater.com/applications/.

conservation and avoids the requirement to wash billions of gallons of used water down the drain. Carden Water Systems serve a wide variety of water applications that can be used to treat almost any water supply, including, but not limited to, brackish & sea water (desalination), produced water from oil & gas, cooling tower feed & "blow down" water, beverage companies for feed water, Reverse Osmosis (RO) recovery and crushed cane sugar concentration, breweries, wineries, bilge and grey water (Navy, cruise lines, tankers etc.), industrial, landfill & agricultural wastewater and mine discharge.

How does it work?

Every Carden system is a custom water treatment system designed and constructed specific to end-use customers' needs and specifications. Carden's skid mounted water treatment equipment can be configured to process and treat between 10,000 up to over 2.5 million gallons per day (GPD) of feed water and can be scaled to any size or requirement. Since the system is modular, additional "slave" units can be attached. These are fully integrated and automated water systems that can be switched to manual run in case of emergencies. The Carden system proposes to:

- Achieve any standard of purified water from most land, sea, or industrial process source
- Pre-treat almost any water for direct discharge/reuse or use the water as feed water in its membrane purified water production skid.
- Reduce ground or municipal water depletion
- Reject flow control and other reclamation options
- Reduce disposal fees, fines and sewage surcharges
- Ensure superior reclamation yields and efficiencies



Carden Water System Process

Carden's Automation Computer System

What are the benefits?

Technology Name	Carden Water System
Sector	Commercial, Industrial, Agricultural
Industry Segment	Agricultural: Dairy and Livestock Commercial: Large Offices, Universities, Hospital Cooling Tower Blow Down Applications Industrial: Breweries, Wineries, Food and Beverage Manufacturing, Oil and Gas, and Landfills
Water Benefits	Level of Drought Resilience: High based on number of targeted adopters in various sectors. Case studies estimated that the produced water, water generated and used by the oil and gas industry, is expected to spend more than $7 billion dollars a year in North America on handling and treating wastewater alone. The percentage of water that each adopter could save in this specific industry and other applicable industries could be significant.
	Type of Drought Benefit: • Increases Water Supply • Increases Recycle/Reuse • Reduces Water Loss
Water Resources	Type of Water Resource Benefit: • Recycles produced water to fresh standards or acceptable levels for discharge • Separates, recovers and optionally recaptures suspended solids and soluble (as much as 95% as a dry powder) • Provides recycled water for frack makeup or other reuse applications • Reduces use of natural fresh water supplies • Reduces or eliminates the number of disposal wells and trucking and piping costs
Electric Benefits	No explicit electric savings benefits stated from information sources gathered.
	Carden Water Systems allow for improved performance by providing management the tools to quickly respond to changing business conditions with proven solutions for water treatment technology. Batch processing capabilities can put end-use customers in control of the processing through interaction with their current plant controls.
Cost-Benefit Analysis	No explicit electric savings benefits or cost estimates were provided from information sources gathered.
	Estimated Payback (years)
Other Benefits: Health and Safety	Improves Water Quality
Other Benefits: Environmental	• Protects Ecosystems • Reduces GHG Emissions • The small footprint design is disruptive to large traditional Reverse Osmosis systems that lack the ability to optimize efficiency and performance.
Other Benefits: Economic	• Supports economic growth • Increases jobs and/or wages

Candidate Technology 2: Integrated System for AC and Production of Drinking Water[211]

Technology Name	Integrated Systems for AC and Production of Drinking Water			
Technology Solution(s)	☐ Water Use Efficiency	☒ Increase Water Supply	☒ Reduce Use of Potable Water for Non-Potable Uses	☐ Water Management Tools
Sector(s)	☐ Agricultural	☒ Commercial	☐ Industrial	☐ Residential
Industry Segment(s)	Hotels, Banks, and Shopping Centers			
Drought Resilience	☒ High	☐ Medium	☐ Low	
Water Benefits	☒ Reduces Water Use	☒ Increases Water Supply	☒ Produces/Uses Recycled Water	☐ Reduces Water Loss
Electric Benefits	☐ Energy Efficiency (**Reduces kWh**)	☐ Demand Response (**Ability to Shift Load?**)	☐ Distributed Generation (**Increase Ability to Produce Clean Energy**)	☐ Increase Energy Storage (**Ability to Store Energy**)
GHG Benefits	Yes, production of water will reduce the amount of GHG needed to bring more water to a given location			
Implementation Timeline	☒ <= 3 years	☐ 3-7 years	☐ > 7 years	
Estimated Simple Payback	Cost not available to perform payback analysis.			

What is the technology?

The integrated HVAC system is designed to produce water and simultaneously for the air conditioning of commercial hotels, banks and strip malls. It is optimized to maximize the production of water by condensation in the heat exchanger of the chiller. This integrated HVAC system serves as a stepping stone to integrate water filtration to produce potable water.

In one case study, the technology claims that water extraction can supply over 29 percent of the water supply requirements, when the average yearly supply of water is over 24 percent of the total needs. During summer months (July through September), the technology proposes that it is possible to supply over 38 percent of water requirements.

How does it work?

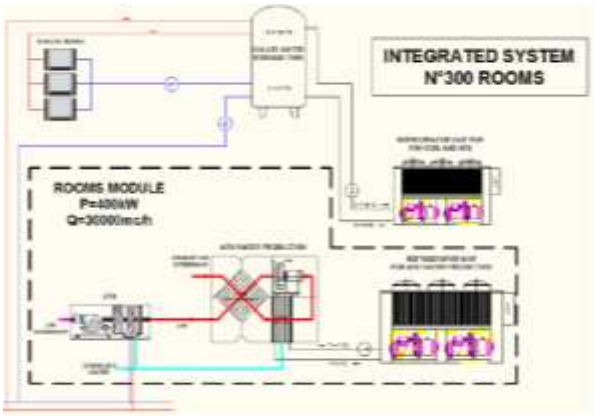
This integrated HVAC system is comprised of two sections: one that treats the air for common areas and the other dedicated to private rooms and to fan-coil supply and primary air control. The air that comes from the water extraction loop, after the heat recovery, is used as fresh air for both the common areas and the private rooms. The HVAC system must be sized considering

211 The 7th International Conference on Applied Energy—ICAE2015 *Integrated systems for air conditioning and production of drinking water—Preliminary considerations.*

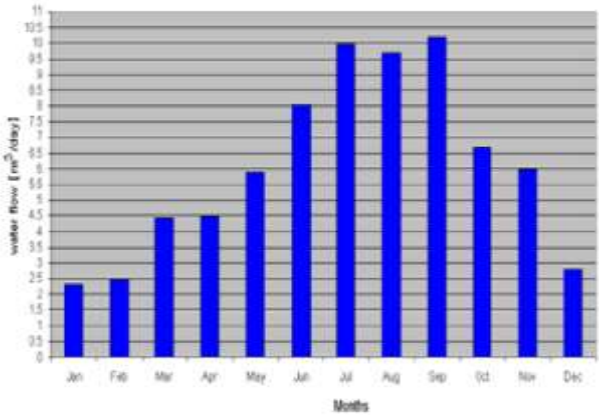
outdoor and indoor thermo-hygrometric conditions and the global heat load of the building. In one case study conducted in Dubai, the hotel test case had a chiller plant system comprised of:

a. A water production treatment unit, a heat recovery unit, a cooling coil, a fan; and
b. An air handling treatment unit, a cooling coil, a fan, a refrigeration unit that provides air treatment, and a refrigerant circulation pump.

Results show with the increased temperature yields increase water production. Further analysis could show profitable treatment of condensed water. This technology will show a possible sustainable way to reduce water consumption.



Integrated Systems for AC and Production of Drinking Water Diagram



Monthly Average Extractable Water Flow

What are the benefits?

Technology Name	Integrated Systems for Air Conditioning and Production of Drinking Water
Sector	Commercial
Industry Segment	Hotels, Banks and Strip Malls
Water Benefits	Level of Drought Resilience: High based on number of targeted adopters in the commercial sector and within the industry segment of hotels, banks and strip malls where commercial chillers are used. The technology claims that water extraction can supply over 29% of the water supply requirements, when the average yearly supply of water is over 24% of the total needs. During summer months (July through September), the technology proposes that it is possible to supply over 38% of water requirements. The impact for adoption in the commercial sector and its applicable industry segments could be significant.
	Type of Drought Benefit: • Increases Water Supply
Water Resources	Type of Water Resource Benefit: • The integrated HVAC system is designed to produce water and simultaneously for the air conditioning of commercial hotels, banks and strip malls.

	• It is optimized to maximize the production of water by condensation in the heat exchanger of the chiller. • This integrated HVAC system serves as a stepping stone to integrate water filtration to produce potable water. • Reduces use of natural fresh water supplies
Electric Benefits	• No explicit electric savings benefits stated from information sources gathered.
	• No explicit information was provided to suggest the technology has energy or water management communication features or feedback.
Cost-Benefit Analysis	No explicit electric savings benefits or cost estimates were provided from information sources gathered.
	Estimated Payback could not be provided as the study did not provide explicit cost or energy savings data.
Other Benefits: Health and Safety	Improves Water Quality: The integrated system is not designed only as a HVAC system, but it contains a water treatment facility that allows to obtain drinking water.
Other Benefits: Environmental	Reduces Pollutants: Mechanical filtration (not only for air), adsorption, ultraviolet germicidal irradiation and ad hoc designed mineralization, are planned to change simple polluted condensate in drinking water.
Other Benefits: Economic	The economic aspects sometime have been considered of secondary importance, even if, in more recent times, the efforts to reduce energy consumption are assuming higher relevance.

Candidate Technology 3: Commercial Laundry Water Recycling[212]

Technology Name	**Aqua Recycle—Commercial Laundry Water Recycling**			
Technology Solution(s)	☐ Water Use Efficiency	☐ Increase Water Supply	☒ Reduce Use of Potable Water for Non-Potable Uses	☐ Water Management Tools
Sector(s)	☐ Agricultural	☒ Commercial	☐ Industrial	☐ Residential
Industry Segment(s)	Commercial Laundry, Hospitality, Corrections			
Drought Resilience	☒ High	☐ Medium	☐ Low	
Water Benefits	☐ Reduces Water Use	☐ Increases Water Supply	☒ Produces/Uses Recycled Water	☐ Reduces Water Loss
Electric Benefits	☒ Energy Efficiency (**Reduces kWh**)	☐ Demand Response (**Ability to Shift Load?**)	☐ Distributed Generation (**Increase Ability to Produce Clean Energy**)	☐ Increase Energy Storage (**Ability to Store Energy**)
GHG Benefits	Yes.			
Implementation Timeline	☒ <= 3 years	☐ 3-7 years	☐ > 7 years	
Estimated Simple Payback	2 years.			

212 Aqua Recycle website: http://www.aquarecycle.com.

What is the technology?

Aqua Recycle is the global leader in recycling laundry wastewater and dryer heat recovery systems for hotels, hospitals, military/governmental/correctional facilities and commercial laundries. This patented, closed loop laundry wash water recycling system reduces incoming water usage by 80 percent, cut energy costs to heat water by up to 50 percent, and reduce sewer discharge by 95 percent for a payback in less than two years.

How does it work?

Quadracycle's state of the art technology reclaims 100 percent of the wastewater. The patented process begins with the removal of suspended solids to under 2 microns. We then filter the laundry wastewater through our proprietary blend of media to remove soaps, organics, free oil and grease, odors, chlorine, detergents and other contaminants in the process water. The final process uses low-pressure ultraviolet light and ozone to disinfect the process water. Recycled water is returned for reuse, clean and disinfected, at an average temperature of 120 degrees.

What are the benefits?

With Aqua Recycle, water and sewer costs are reduced by 80 percent. Water usage is drastically reduced by reclaiming and treating 100 percent of the wastewater. Approximately 10 percent of the total water used in the wash process is lost through evaporation, and an additional 5 percent is used for backwashing the filters. The net amount of water recycled and sent back to the washing machines is 85 percent of the washing machines total water intake.

Energy costs are reduced by up to 50 percent. The unique system provides the added benefits of tremendous energy savings since the recycled water is already pre-heated. In many laundry operations, the combination of high temperature hot water (160 to 180 degrees) with cold water rinses and flushes provides an average wastewater temperature of 110 to 120 degrees. This temperature is maintained throughout our closed-loop, pressurized recycle process. Typical city water sources provide water at temperatures between 55 and 65 degrees. Recycled water only requires heating an additional 30 to 40 degrees to bring it to your desired wash temperature compared to an additional 100 degrees without our Recycle System.

Technology Name	Aqua Recycle
Sector	Commercial
Industry Segment	Commercial: Laundry, Hospitality, Corrections
Water Benefits	Level of Drought Resilience: High based on number of targeted adopters in the commercial sector and the high reduction in water usage per unit
	Type of Drought Benefit: • Increases Recycle/Reuse
Water Resources	Type of Water Resource Benefit: • Enables process water to be reused multiple times, significantly reducing withdrawals of valuable potable water supplies (urban drinking water resources, including surface and groundwater)

Technology Name	Aqua Recycle
Electric Benefits	• Energy costs are estimated to be reduced by 50% because the recycled water only needs to be reheated 30 to 40 degrees to be useful for additional washes, compared to the usual heating of a typical city water source of up to 100 degrees.
Cost-Benefit Analysis	Estimated Payback 1.074 years based on a sample project in San Juan, Puerto Rico
Other Benefits: Health and Safety	• Alleviating aged wastewater collection and treatment infrastructure reduces frequency of regulatory permit violations and inadvertent discharge of untreated and/or nondisinfected wastewater effluent to the environment, reducing risks to people, animals and plants
Other Benefits: Environmental	Reduces GHG Emissions • Reducing natural gas usage which is primary activity of this system will reduce GHG emissions on a net basis • Reducing electric use and electric demand reduce production and/or purchase of marginal electric resources, much of which is produced by natural gas. • Increasing production of distributed renewable energy reduces electric transmission losses and enhances ability to reliably integrate increasing quantities of intermittent renewable energy resources
Other Benefits: Economic	• Reduces costs of municipal water systems resulting from less groundwater pumping • Reduces costs of municipal wastewater system resulting from less wastewater being treated at the plant

Candidate Technology 4: Biofiltration Wastewater Treatment[213]

Technology Name	BioFiltro BIDA© System			
Technology Solution(s)	☐ Water Use Efficiency	☐ Increase Water Supply	☒ Reduce Use of Potable Water for Non-Potable Uses	☐ Water Management Tools
Sector(s)	☒ Agricultural	☐ Commercial	☒ Industrial	☐ Residential
Industry Segment(s)	Industrial: Wastewater Facilities; Food Processors; Agricultural: Slaughterhouses; Dairies; Wineries			
Drought Resilience	☒ High	☐ Medium	☐ Low	
Water Benefits	☐ Reduces Water Use	☐ Increases Water Supply	☒ Produces/Uses Recycled Water	☐ Reduces Water Loss
Electric Benefits	☒ Energy Efficiency (**Reduces kWh**)	☒ Demand Response (**Ability to Shift Load?**)	☐ Distributed Generation (**Increase Ability to Produce Clean Energy**)	☐ Increase Energy Storage (**Ability to Store Energy**)
GHG Benefits	Yes.			

213 Citation: www.biofiltro.com Data provided by Matt Tolbirt, CEO, BioFiltro.

Implementation Timeline	☒ <= 3 years	☐ 3-7 years	☐ > 7 years
Estimated Simple Payback	Cost not available to perform payback analysis.		

What is the technology?

BioFiltro BIDA© System is a Biofiltration wastewater treatment system that uses physical and biological filtration, aerobic and anaerobic medias, and nitrification and denitrification processes to produce clean water and fertilizer. The system relies on earthworms and bacteria to break down contaminants on the surface. Water trickles down through sawdust and gravel layers, resulting in high quality effluent.

How does it work?

As the worms move throughout our system in search of food, they create air channels and thus passive aerate the system. Oxygen is a key component to wastewater treatment and while most technologies require a lot of energy to push air through water, these worms are doing it naturally. As the worms eat, they poop. Worm castings are extremely rich in microbes and bacteria which work symbiotically and beneficially together to form a biofilm that grows throughout the wood shavings and rocks. A biofilm is a sticky layer comprised of billions of microbial colonies which captures, retains, and breaks down waste.

What are the benefits?

The BioFiltro processing system takes 4 hours to complete and is therefore able to process millions of gallons of wastewater a day. The process can remove more than 90 percent of the BOD (biochemical oxygen demand) and TSS (total suspended solids) from the wastewater on-site and uses up to 95 percent less energy than traditional wastewater treatment methods to deliver water that is ready for reuse, crop irrigation or apt for tertiary disinfection. BioFiltro engineers custom design each BIDA® System to cater to the needs of each client. The modular design can meet individual household needs or that of multimillion gallon per day industrial clients.

Current Status

Technology has been successfully installed and benefits documented at 39 food processors, 57 sanitary waste facilities, 12 slaughterhouses, 11 wineries, 10 dairies facilities. Interstate 5 Highway Interchange, Firebaugh, California (2016). The Interstate 5 Highway Interchange located in Fresno County (Exit 368) is home to a handful of fast food restaurants, gas stations and one hotel located in remote farm fields. After decades of using an old activated sludge system, the area needed an upgrade, so the property owners researched several options.

In 2015, I-5 Property Services Inc. opted to install a pilot BIDA® System to test the technology during the holiday season where usage of the interchange peaks due to increased road traffic over Thanksgiving and December holiday vacation. Shortly after the holidays, I-5 Property Services moved to install an 80,000 GPD BIDA® System in 2016.

- 80,000 gpd maximum daily flow design
- 3 million gallons treated
- 9 businesses served

Mostos del Pacífico grape juice concentrate and winery, Curicó, Chile, processes more than 110,000,000 tons of grapes per year. The facility previously employed a hold and haul process by contracting waste haulers to transport their discharge to a local municipal plant. As production was limited by wastewater storage capacity and transport costs rose into the hundreds of thousands, Mostos looked for an economical and comprehensive wastewater treatment provider. Within 90 days of being awarded the bid, BioFiltro commissioned a fully operable 75,000 GPD facility that included the design, construction, and operation of screens, a chemical-free DAF, and the BIDA® System. The facility was recently expanded to filter approximately 100,000 GPD and handles 100 percent of the plant´s effluent which fluctuates in BOD throughout the production season.

All large organic solids captured in the screens and DAF are treated onsite in secondary vermicomposting bins, effectively making the facility a zero-waste system.

- 90 days from signed contract to plant coming online
- 0 chemicals used in DAF system
- 0 waste hauler trucks currently in use

Technology Name	BioFiltro BIDA® System
Sector	Industrial, Agricultural
Industry Segment	Industrial: Wastewater Facilities; Food Processors; Agricultural: Slaughterhouses; Dairies; Wineries
Water Benefits	Level of Drought Resilience: High
	Type of Drought Benefit: • Increases Recycle/Reuse
Water Resources	Type of Water Resource Benefit: • Produces recycled water that can replace flood irrigation systems with more efficient irrigation delivery systems, such as sprinkler or drip systems. • Removes nitrates from process water effluent, enabling beneficial reuse without risk of increasing salt concentrations in fields and groundwater, protecting potable resources. • Produces secondary undisinfected quality effluent (irrigation-ready); can be modified for tertiary disinfection for use in urban systems.
Electric Benefits	• Reduces electric consumption (kWh) by 95% compared to traditional wastewater treatment methods. The passive aerobic process averages 0.0007 kWh/ gallon treated. • Reduces pumping hours—Pumps activate only when a facility discharges and can coordinate with intermittent irrigation schedule. Typically, only demands energy for 8 hours a day. Standard facilities operate 24 hours a day. Can be scheduled for off-peak hours.

Cost-Benefit Analysis	No explicit electric savings benefits or cost estimates were provided from information sources gathered.
Other Benefits: Health and Safety	• Alleviating aged wastewater collection and treatment infrastructure reduces frequency of regulatory permit violations and inadvertent discharge of untreated and/or nondisinfected wastewater effluent to the environment, reducing risks to people, animals and plants • Nitrification and denitrification reduce nitrate contamination of groundwater from reuse sites. • BOD and TSS removal rates >90%
Other Benefits: Environmental	Reduces GHG Emissions • Earthworm tunneling increases aeration of filtration medium, encouraging aerobic processes to produce less methane. • No sludge eliminates solids management & hauling, eliminates truck emissions • Treats water right away in four hours, so there is a 90% reduction in methane from dairy wastewater
Other Benefits: Economic	• Telemetry monitoring and annual maintenance are centralized, automating wastewater treatment and creating economies of scale for participating communities. These services reduce the need for dedicated operations and maintenance staff for small community wastewater systems, saving costs. • Modularity of system reduces costs, extends life, and reduces need for expensive, long lead-time retrofits of large centralized wastewater treatment systems, which reduces costs of wastewater collection and treatment for all customer classes • Reduction of biosolids transportation costs by up to 100%

Candidate Technology 5: Forward Osmosis, Concentrator[214]

Technology Name	**Porifera—Concentrator**			
Technology Solution(s)	☐ Water Use Efficiency	☐ Increase Water Supply	☒ Reduce Use of Potable Water for Non-Potable Uses	☐ Water Management Tools
Sector(s)	☐ Agricultural	☐ Commercial	☒ Industrial	☐ Residential
Industry Segment(s)	Industrial: Food Processing; Wastewater Treatment Facilities			
Drought Resilience	☒ High	☐ Medium	☐ Low	
Water Benefits	☐ Reduces Water Use	☐ Increases Water Supply	☒ Produces/Uses Recycled Water	☐ Reduces Water Loss
Electric Benefits	☒ Energy Efficiency (**Reduces kWh**)	☐ Demand Response (**Ability to Shift Load?**)	☐ Distributed Generation (**Increase Ability to Produce Clean Energy**)	☐ Increase Energy Storage (**Ability to Store Energy**)
GHG Benefits	Yes.			

214 Porifera website: www.porifera.com and data provided directly from Eric Desormeaux, Director of Process Development, Porifera, Inc.

Implementation Timeline	☒ <= 3 years	☐ 3-7 years	☐ > 7 years
Estimated Simple Payback	Cost not available to perform payback analysis.		

What is the technology?

Porifera Concentrator is a Low-Energy Beverage Concentration system which utilizes forward osmosis to draw water out of product streams. Nonthermal process protects and retains flavors, nutrients, and aromatics. This system competes uses Porifera's membrane process to compete with evaporators to create new products or save on waste disposal costs.

How does it work?

Porifera Concentrator draws water out of liquid product into a draw solution, which can easily be filtered with reverse osmosis and reused onsite. This technology can be used by food processors to create liquid concentrates, or by companies which truck away brines or high contaminant waste. Water fills 75 percent of liquid storage trucks, planes, ships and warehouses. By dewatering liquid products, companies can save money and energy while reducing emissions from transportation and storage of the product.

What are the benefits?

Porifera Concentrator can increase water reuse by 90 percent, while reducing energy and total costs by >70 percent compared to evaporators. It can also be used to create unique value-added products for new revenue streams.

How is it Different from Similar Technologies?

Porifera Concentrator uses a unique membrane process, module & system. Porifera Concentrator can produce new cold concentrates (for example dairy, wine, juice, berries, melons, tomato paste, antioxidants, nutrients) as well as cold concentrates that were previously only possible with thermal processes (evaporators or freeze dry) while saving more than 70 percent energy and cost savings compared to evaporators.

Current Status

Porifera has been awarded $22M in federal & state contracts, including two CEC EPIC projects with Los Gatos tomato processing facility and a wastewater project with a microbrewery in Oakland. They are still working on preparing case studies, but have released the following information about a Dairy plant installation:

Porifera implemented a system that would concentrate milk to 40 total solids (4x the original concentration). The resulting milk was higher quality (no "cooked" flavor or browning) and could be stored and transported using less energy and at lower cost. The concentrated milk can be rehydrated prior to selling with little to no effect on aromatic qualities. Compared to MVR thermal evaporation systems, forward osmosis demonstrated the following savings:

- 11,250 kg/h of 40 total solids milk concentrate
- CAPEX savings of 80 percent
- Energy savings of 44 percent
- OPEX savings of 50 percent (including membrane replacement cost)
- Customers with an available feed-stream (such as seawater) will see an additional 90 percent savings in both CAPEX and energy use.

Technology Name	Porifera Concentrator
Sector	Industrial
Industry Segment	Industrial: Food Processing, Wastewater Facilities
Water Benefits	Level of Drought Resilience: High
	Type of Drought Benefit: • Increases Recycle/Reuse
Water Resources	Type of Water Resource Benefit: • Can increase concentration of liquid product 5x while producing high purity water for onsite reuse. • Increasing water availability during droughts while increasing safety of the water supply. • Reducing water treatment and reuse costs.
Electric Benefits	• Forward osmosis filters the product stream by osmotic energy, which requires no external energy. The draw solution is concentrated through low-energy forward osmosis, producing pure water for reuse. • Reduces energy and total costs by more than 70% compared to thermal evaporative concentration. • Reduces electric consumption (kWh) by 44% compared to thermal evaporative concentration.
Cost-Benefit Analysis	No explicit electric savings benefits or cost estimates were provided from information sources gathered. There is one commercial system in North America and several pilot systems being tested worldwide.
Other Benefits: Environmental	Reduces GHG Emissions • Traditional product concentration uses thermal evaporation, which is typically powered by burning natural gas or propane. Forward osmosis eliminates this process and the emissions thereof. • Concentrating beverage products reduces the volume and weight of product for storage and transportation. This allows for distributors to use smaller vehicles and make fewer trips which saves fuel and reduces emissions.
Other Benefits: Economic	• Reduces costs of municipal water systems resulting from less groundwater pumping • Reduces costs of municipal wastewater system resulting from less wastewater being treated at the plant

Candidate Technology 6: Contaminant Detection and Removal[215]

Technology Name	Porifera - dprShield			
Technology Solution(s)	☐ Water Use Efficiency	☒ Increase Water Supply	☒ Reduce Use of Potable Water for Non-Potable Uses	☒ Water Management Tools
Sector(s)	☐ Agricultural	☒ Commercial	☒ Industrial	☐ Residential
Industry Segment(s)	**Industrial:** Wastewater Facilities; Municipal Potable Reuse **Agricultural:** Ultra-high Purity Ag Reuse			
Drought Resilience	☒ High	☐ Medium	☐ Low	
Water Benefits	☐ Reduces Water Use	☒ Increases Water Supply	☒ Produces/Uses Recycled Water	☐ Reduces Water Loss
Electric Benefits	☒ Energy Efficiency (**Reduces kWh**)	☐ Demand Response (**Ability to Shift Load?**)	☐ Distributed Generation (**Increase Ability to Produce Clean Energy**)	☐ Increase Energy Storage (**Ability to Store Energy**)
GHG Benefits	Yes, production of water will reduce the amount of GHG needed to bring more water to a given location.			
Implementation Timeline	☒ <= 3 years	☐ 3-7 years	☐ > 7 years	
Estimated Simple Payback	Cost not available to perform payback analysis.			

What is the technology?

Porifera's dprShield uses a membrane process with high-resolution dye monitoring and a reverse pressure barrier to provide unprecedented contaminant detection and removal for potable reuse.

How does it work?

Porifera's dprShield adds an additional contaminant barrier to protect public health by providing real-time monitoring to ensure that the barrier performs as designed by providing additional protection activated by the barrier breach itself.

What are the benefits?

dprShield can increase water reuse for potable reuse by >10 percent and can reduce energy and total costs by >20 percent compared to current state of the art potable reuse technology, which is significant at municipal scale. Electrical consumption savings are even greater compared to desalination technologies.

215 Porifera website: www.porifera.com and data provided directly from Porifera staff.

Technology Name	Porifera dprShield
Sector	Industrial, Agricultural
Industry Segment	**Industrial:** Wastewater Facilities, Municipal Potable Reuse **Agricultural:** Ultra-High Purity Ag Reuse
Water Benefits	Level of Drought Resilience: High
	Type of Drought Benefit: • Increases Recycle/Reuse
Water Resources	Type of Water Resource Benefit: • Direct Potable reuse provides high quality drinking water, which is especially necessary in droughts
Electric Benefits	• Energy costs are estimated to be reduced by >20% compared to current state of the art potable reuse technology, which is significant at municipal scale
Cost-Benefit Analysis	No explicit electric savings benefits or cost estimates were provided from information sources gathered. The technology is currently under pilot testing at the Orange County Water District
Other Benefits: Health and Safety	• New technology with fail-safe barrier that public and regulators can understand • Higher pathogen and emerging contaminant log removal credits
Other Benefits: Environmental	Reduces GHG Emissions • Reducing electric use and electric demand reduce production and/or purchase of marginal electric resources.
Other Benefits: Economic	• Reduces costs of municipal water systems resulting from less groundwater pumping • Reduces costs of municipal wastewater system resulting from less wastewater being treated at the plant

Candidate Technology 7: Dry Ice Blasting[216]

Technology Name	Cold Jet Dry Ice Blasting: Waterless Cleaning Mechanism			
Technology Solution(s)	☒ Water Use Efficiency	☐ Increase Water Supply	☐ Reduce Use of Potable Water for Non-Potable Uses	☐ Water Management Tools
Sector(s)	☐ Agricultural	☒ Commercial	☒ Industrial	☒ Residential
Industry Segment(s)	**Commercial:** Foodservice **Industrial:** Food and Beverage; Power Generation; Contract Cleaning; Oil and Gas; Foundry; Packaging; Textile **Residential:** All Residential			
Drought Resilience	☐ High	☒ Medium	☐ Low	
Water Benefits	☒ Reduces Water Use	☐ Increases Water Supply	☐ Produces/Uses Recycled Water	☐ Reduces Water Loss

216 Information Provided Regional Sales Manager, Cold Jet LLC.

Electric Benefits	☒ Energy Efficiency (**Reduces kWh**)	☐ Demand Response (**Ability to Shift Load?**)	☐ Distributed Generation (**Increase Ability to Produce Clean Energy**)	☐ Increase Energy Storage (**Ability to Store Energy**)
GHG Benefits	Yes, reduces the amount of chemical and physical contaminants in waste stream and makes water treatment more efficient.			
Implementation Timeline	☒ <= 3 years	☐ 3-7 years	☐ > 7 years	
Estimated Simple Payback	6 years.			

What is the technology?

Dry ice blasting is known by several names: dry ice blasting, dry ice cleaning, CO2 blasting, dry ice dusting, and even environmentally sustainable cleaning. Cold Jet dry ice blasting is an efficient and cost-effective way for industries to maximize production capability and quality. Dry ice blasting accelerates small pellets of solid carbon dioxide at dirty surfaces where the impact of the pellets and rapid change in temperature can blast nearly any type of contaminant off the surface. Dry ice blasting can be implemented to remove grime from nearly any surface. Applications include paint removal, mold cleaning, production machine cleaning and maintenance and oil removal.

How does it work?

Dry ice blasting is similar to sand blasting, plastic bead blasting or soda blasting where media is accelerated in a pressurized air stream to impact a surface to be cleaned or prepared. Instead of using hard abrasive media to grind on a surface (and damage it), dry ice blasting uses frozen carbon dioxide (CO2) "dry ice" pellets, accelerated at supersonic speeds, and creates mini-explosions on the surface to lift the undesirable item off the underlying substrate. A compressed air supply of 80 PSI/50 scfm can be used in this process. Dry ice pellets can be made on-site or supplied. Pellets are made from food grade carbon dioxide that has been specifically approved by the FDA, EPA and USDA.

What are the benefits?

Builds drought resilience

- Eliminates water consumption from a large variety of cleaning applications, which account for 10-28 percent of an industrial facility's overall water use.
- Allows dry industrial facilities to avoid using water to clean industrial machines.
- Can replace pressure washing for industrial, commercial, and home applications.

Improves Cleaning Efficiency

- Dry Ice Blasting is highly effective at scrubbing built-up grease, grime, rust, and other contaminants that would otherwise require intensive brushing. Users can reduce overall cleaning time by 75-90 percent compared to manual cleaning systems.

- Industrial facilities can use dry ice blasting to clean equipment in-place, reducing machinery downtime. Conveyor belts can be run while they are cleaned, increasing efficiency further.
- Waterless process allows for cleaning in and around delicate electronics. With conventional wet cleaning, electronics must be wrapped with waterproof materials, adding to the time and materials needed for cleaning.
- Eliminates downtime due to waiting for equipment to dry after cleaning, no concern that chemicals will pool in cavities and bolt holes.

Technology Name	Cold Jet Dry Ice Blasting: Waterless Cleaning Mechanism
Sector	Commercial, Industrial, Residential
Industry Segment	**Commercial:** Foodservice **Industrial:** Food and Beverage; Power Generation; Contract Cleaning; Oil and Gas; Foundry; Packaging; Textile **Residential:** All Residential
Water Benefits	Level of Drought Resilience: Medium
	Type of Drought Benefit: • Reduces Water Use
Water Resources	Type of Water Resource Benefit: • Eliminates water consumption from a large variety of cleaning applications, which account for 10-28% of an industrial facility's overall water use • Can replace pressure washing for industrial, commercial, and home applications • Allows dry industrial facilities to avoid using water to clean industrial machines
Electric Benefits	• Users can reduce overall cleaning time by 75-90% compared to manual cleaning systems • Industrial facilities can use dry ice blasting to clean equipment in-place, reducing machinery downtime • Conveyor belts can be run while they are cleaned, increasing efficiency further
Cost-Benefit Analysis	• No explicit electric savings benefits or cost estimates were provided from information sources gathered
Other Benefits: Health and Safety	• Safer than wet methods for cleaning electronics • Effective at blasting biofilms off of surfaces, though an additional sanitizing agent is necessary to inactivate pathogens • Dry ice pellets are non-toxic and non-hazardous, which is beneficial for the environment and reduces contamination for employees, products, and equipment • Allows dry industrial facilities to avoid using water to clean industrial machines • Can replace pressure washing for industrial, commercial, and home applications • Non-abrasive, nonflammable and nonconductive cleaning method • Clean and approved for use in the food industry

	• Allows most items to be cleaned in place without time-consuming disassembly • Can be used without damaging active electrical or mechanical parts or creating fire hazards • Can be used to remove production residue, release agents, contaminants, paints, oils and biofilms • Can be as gentle as dusting smoke damage from books or as aggressive as removing weld slag from tooling • Can be used for many general cleaning applications
Other Benefits: Environmental	Reduces GHG Emissions • Reducing electric use and electric demand reduce production and/or purchase of marginal electric resources • Cleaning medium evaporates on impact, leaving no chemical cleaning waste • Reduces the amount of chemical and physical contaminants in waste stream and makes water treatment more efficient • Contaminants are removed from the surface in a dry state, making them easier and safer to collect and dispose of when compared to liquid waste streams • Environmentally responsible and contains no secondary contaminants such as solvents or grit media
Other Benefits: Economic	• Reduces costs of municipal water systems resulting from less groundwater pumping • Reduces costs of municipal wastewater system resulting from less wastewater being treated at the plant

Current Status

Technology has been successfully implemented in a range of cleaning applications, including the following:

- **Ghirardelli Case Study**: To avoid any chance of nut contamination, Ghirardelli would spend up to 500-man hours to clean their production machines between product runs. Traditional cleaning methods included manually scraping with brushes and scrapers, which was time consuming, tedious, and required the company shut down production and allocate extensive resources.

  Ghirardelli deployed three Cold Jet Aero 40 systems and reduced their clean-up time by more than 60 percent. By reducing downtime, Ghirardelli could increase the number of production cycles on the equipment. They also reduced the number of resources required such as water, chemicals, and cleaning tools. The company was interested in deploying dry ice cleaning in other departments and possibly other facilities as well.

- **Bakery Case Study**: Originally, the plant used a combination of pressure washing and detailed handwashing. The process was labor intensive, taking a 50-200 man-hours just to clean the bread cooler. Similar scenarios occurred when cleaning the bread proofer and baggers, which also required at least two hours of set-up time to wrap the electrical components. The use of pressure washers required crew members to collect and

dispose of the wastewater, and the equipment had to dry completely before being reassembled.

After implementing the Cold Jet Aero system, cleaning the bread cooler took just 12 man-hours Cleaning one of the plant's bagger machines with dry ice took less than an hour for two people, while cleaning an identical machine with water took over four hours for a crew of four. The facility estimated that by reducing the amount of people and time necessary to clean the equipment, they were able to recoup 24-30 hours per person per week, which could be allocated to other cleaning and maintenance projects.

Candidate Technology 8: Above Ground Irrigation System[217]

Technology Name	**Certa-Set Yelomine Piping: PVC Irrigation Piping**			
Technology Solution(s)	☒ Water Use Efficiency	☐ Increase Water Supply	☒ Reduce Use of Potable Water for Non-Potable Uses	☐ Water Management Tools
Sector(s)	☒ Agricultural	☐ Commercial	☒ Industrial	☐ Residential
Industry Segment(s)	**Agricultural:** Crop Irrigation **Industrial:** Mining			
Drought Resilience	☐ High	☒ Medium	☐ Low	
Water Benefits	☒ Reduces Water Use	☐ Increases Water Supply	☐ Produces/Uses Recycled Water	☐ Reduces Water Loss
Electric Benefits	☒ Energy Efficiency (**Reduces kWh**)	☐ Demand Response (**Ability to Shift Load?**)	☐ Distributed Generation (**Increase Ability to Produce Clean Energy**)	☐ Increase Energy Storage (**Ability to Store Energy**)
GHG Benefits	Yes, production of water will reduce the amount of GHG needed to bring more water to a given location.			
Implementation Timeline	☒ <= 3 years	☐ 3-7 years	☐ > 7 years	
Estimated Simple Payback	30 years.			

What is the technology?

Certa-Set® is an above-ground, aluminum replacement solid-set irrigation system, made from proprietary impact resistant Yelomine compound modifiers and UV (ultraviolet) inhibitors. These modifiers and inhibitors provide higher impact strength over an extended period and allow product to be used in aboveground, exposed applications as well as in underground or buried applications. The piping is a UV coated PVC that is a 100 percent leak free during charge up and charge down periods. The Certa-Set system is capable of being 100 percent mechanized

217 California Department of Food and Agriculture project description retrieved from: https://www.cdfa.ca.gov/oefi/sweep/docs/2015_Selected_Projects.pdf; "California Drought Charge True Cost of Water", San Francisco Chronicle, https://www.sfchronicle.com/opinion/article/California-drought-Charge-true-cost-of-water-6319943.php; Norum, E., *A Study of Operating Efficiencies Comparing Aluminum Pipe Systems to Certa-Set PVC Irrigation Piping*, The Center for Irrigation Technology California State University, Fresno, February 2004.

and has been shown to reduce labor costs, increase irrigation efficiency, and increase yields and profits over conventional irrigation methods.

Certa-Set® PVC piping systems can replace existing aluminum irrigation sets and are ideally designed for use in row crops such as carrots and turf grass applications. The system works particularly well in drag, mechanical move and side-shift operations. Agricultural growers can benefit from the system's leak-proof and corrosion-resistant design.

How does it work?

The product's pipe and couplings have precision engineered grooves that, when aligned, allow a spline to be inserted. This results in a continuous restraint with evenly distributed loading that locks the pipe and coupling together. Flexible elastomeric O-rings in the coupling provide a hydraulic pressure seal. Joints can be easily disassembled when system reconfiguration is needed.

Additionally, the product contains impact modifiers for higher impact strength over extended periods, and ultraviolet inhibitors that allow the pipe to be used in exposed above-ground locations allow for superior flow rates and greater pumping efficiencies compared to other non-metal pipe options.

What are the benefits?

Builds drought resilience

- Reduces potable water demand up to 9 percent through leak reduction during each irrigation cycle.
- Reduces amount of irrigation water, which reduces demand for potable water supplies (drinking water resources, including surface and groundwater).

Supports Electric Reliability

- **Reduces electric consumption (kWh**): Product reduces energy consumption by reducing the charge up and charge down times of each irrigation cycle. As the time needed to pump a required amount of water is reduced, kWh savings are achieved.

Technology Name	Certa-Set Yelomine Piping: PVC Irrigation Piping
Sector	Agricultural, Industrial
Industry Segment	**Agricultural:** Crop Irrigation **Industrial:** Mining
Water Benefits	Level of Drought Resilience: Medium • Certa-Lok Yelomine pipe is a widely adopted technology in California's Central Valley. According to the Kern River Watershed Coalition Authority's November 2016 Update, Yelomine piping is used by 66% of irrigators in the Chanac Creek region. As 34% of irrigators have still not adopted this technology, there is potential to capture more water savings in the Ag sector. However, the annual water saved per acre is low.

	Type of Drought Benefit: • Reduces Water Use • Reduces potable water demand up to 9% through leak reduction during each irrigation cycle • Reduces amount of irrigation water, which reduces demand for potable water supplies (drinking water resources, including surface and groundwater)
Water Resources	Type of Water Resource Benefit: • Because water is used more efficiently, there is less demand for potable water used in non-potable settings.
Electric Benefits	• Reduces electric consumption (kWh) Product reduces energy consumption by reducing the charge up and charge down times of each irrigation cycle. As the time needed to pump a required amount of water is reduced, kWh savings are achieved
Cost-Benefit Analysis	• Total Costs: 150,000/142 acres = $1056/acre • Annual Energy Cost Savings = $30/acre • Annual Water Savings = .285 acre-ft, $17 cost per acre ft = $4.84/acre • Payback—30.3 years • EUL: 20 based on plastic sewer piping
Other Benefits: Health and Safety	• Alleviating aged wastewater collection and treatment infrastructure reduces frequency of regulatory permit violations and inadvertent discharge of untreated and/or nondisinfected wastewater effluent to the environment, reducing risks to people, animals and plants
Other Benefits: Environmental	Reduces GHG Emissions • Reducing electric use and electric demand reduce production and/or purchase of marginal electric resources
Other Benefits: Economic	• Reduces costs of municipal water systems resulting from less groundwater pumping • Reduces costs of municipal wastewater system resulting from less wastewater being treated at the plant

Candidate Technology 9: Novel Membrane[218]

Technology Name	**Novel Membrane**			
Technology Solution(s)	☒ Water Use Efficiency	☒ Increase Water Supply	☐ Reduce Use of Potable Water for Non-Potable Uses	☐ Water Management Tools
Sector(s)	☐ Agricultural	☐ Commercial	☒ Industrial	☐ Residential
Industry Segment(s)	Wastewater Treatment			
Drought Resilience	☒ High	☐ Medium	☐ Low	
Water Benefits	☒ Reduces Water Use	☒ Increases Water Supply	☐ Produces/Uses Recycled Water	☐ Reduces Water Loss

218 Source: Grant Request Form on www.energy.gov.

Electric Benefits	☒ Energy Efficiency (**Reduces kWh**)	☐ Demand Response (**Ability to Shift Load?**)	☐ Distributed Generation (**Increase Ability to Produce Clean Energy**)	☐ Increase Energy Storage (**Ability to Store Energy**)
GHG Benefits	Yes. reducing electric use and electric demand reduce production and/or purchase of marginal electric resources.			
Implementation Timeline	☐ <= 3 years	☒ 3-7 years	☐ > 7 years	
Estimated Simple Payback	Cost not available to perform payback analysis.			

What is the technology?

Novel membrane technology can minimize fouling of membrane surfaces in wastewater treatment operations; thus, increasing water recovery and lowering energy demand. Membrane fouling can be substantially reduced, and the flux rate increased using proposed surface-modified amphiphilic, anti-adhesive membrane for water treatment. The technology can be successfully used for treatment of various types of feed water (for example surface water, backwash water, organic spiked water).

How does it work?

The technology is skid mounted and includes minor modifications to tie into hydraulic, piping, and electrical systems at an existing microfiltration water treatment facility. The novel membrane proposes to replace existing hydrophilic membranes with amphiphilic membranes, a procedure similar to routine scheduled membrane replacements, and installation of a 480v motor connected to the pilot membrane unit feed water pump, as well as installation of equipment necessary to test and evaluate benefits, including increased energy efficiency, reduced greenhouse gas emissions, and reduced operating costs. The total footprint of the technology installations will be approximately 600 square feet.

What are the benefits?

Builds drought resilience

- The use of locally available water resources through cost effective reclamation results in drought resiliency
- Preliminary estimates indicate, at a per capita water use of 125 gpd, the conserved water can provide an annual water supply to a population of approximately 58,000 people.

Supports Electric Reliability

- Reduces electric consumption (kWh): Preliminary estimate assuming 40 percent improvement in efficiency during MF membrane treatment and 20 percent improvement in energy efficiency RO treatment at 10 & 50 percent market penetration indicates annual electricity savings of 8.7 million and 47 million kWh.

Technology Name	Novel Membrane
Sector	Industrial
Industry Segment	Wastewater Facilities
Water Benefits	Level of Drought Resilience: High
	Type of Drought Benefit: • Increases water supply • Preliminary estimates indicate, at a per capita water use of 125 gpd, the conserved water can provide an annual water supply to a population of approximately 58,000 people.
Water Resources	Type of Water Resource Benefit: • Because water is used more efficiently, there is less demand for potable water used in non-potable settings.
Electric Benefits	• Preliminary estimate assuming 40% improvement in efficiency during MF membrane treatment and 20% improvement in energy efficiency RO treatment at 10 & 50% market penetration indicates annual electricity savings of 8.7 million and 47 million kWh.
Cost-Benefit Analysis	• Although energy and water savings data were estimated, no explicit cost estimates were provided from information sources gathered to perform a cost-benefit analysis.
Other Benefits: Health and Safety	• No documentation was found to show other health or safety benefits.
Other Benefits: Environmental	Reduces GHG Emissions • Reducing electric use and electric demand reduce production and/or purchase of marginal electric resources
Other Benefits: Economic	• Reduces costs of municipal wastewater system resulting from less wastewater being treated at the plant

Candidate Technology 10: Biological Reactor[219]

Technology Name	BioForce Aerobic Biological Reactor for Biosolids			
Technology Solution(s)	☐ Water Use Efficiency	☒ Increase Water Supply	☒ Reduce Use of Potable Water for Non-Potable Uses	☐ Water Management Tools
Sector(s)	☒ Agricultural	☐ Commercial	☒ Industrial	☐ Residential
Industry Segment(s)	**Agricultural:** Dairy Farms and Crop Farming **Industrial:** Wastewater Treatment Facility			
Drought Resilience	☒ High	☐ Medium	☐ Low	
Water Benefits	☒ Reduces Water Use	☒ Increases Water Supply	☐ Produces/Uses Recycled Water	☐ Reduces Water Loss
Electric Benefits	☒ Energy Efficiency	☐ Demand Response	☒ Distributed Generation (**Increase Ability**	☐ Increase Energy Storage

219 Data provided BioForce technical staff.

	(Reduces kWh)	(Ability to Shift Load?)	to Produce Clean Energy)	(Ability to Store Energy)
GHG Benefits	Yes. Up to 90% water demand reduction, which reduces the number of trucks required to transport biosolids by 90%.			
Implementation Timeline	☒ <= 3 years	☐ 3-7 years	☐ > 7 years	
Estimated Simple Payback	3.3 years			

What is the technology?

The BioForce Aerobic Biological reactor for biosolids technology converts any organic waste into renewable energy and biochar. Biochar is charcoal used as a soil amendment and is a valuable byproduct of pyrolysis and can be used in many ways. This includes being an absorber in functional clothing, insulation in the building industry, as carbon electrodes in super-capacitors for energy storage, food packaging, wastewater treatment, air cleaning, silage agent or feed supplement, for drinking water filtration, sanitation of human and kitchen wastes, and as a composting agent. Biochar is a stable solid, rich in carbon, and can endure in soil for years. Biochar thus has the potential to help mitigate climate change via carbon sequestration.

How does it work?

The BioForce Aerobic Biological reactor for biosolids technology proposes to:

- Replace traditional biosolids drying technologies such as gravity belt thickeners and screw presses,
- Reduce energy input and environmental risk for management of biosolids, and
- Prepare biosolids for energy generation, either in anaerobic digesters or BFT pyrolysis reactors.

The technology proposes to achieve these objectives using a two-step process. First, by creating optimal conditions for bacterial growth. The exponential growth of bacteria within the reactor releases heat, which dries the biosolids. If the organic waste is too wet, it will need to go through bio drying first to remove most of the water using the bacteria only and no chemicals. Accelerated composting can occur by loading the system with 20 percent solid and 80 percent dry solid using biomass where no energy is needed or used to remove the moisture.

Once dry, step 2 involves the pyrolysis. Pyrolysis can be defined as the thermal decomposition of organic material through the application of heat without the addition of extra air or oxygen. Through this process, that takes place at temperatures between 660 and 1,650 degrees Fahrenheit, 3 co-products are obtained: syngas (for clean energy generation) bio-oil and char, which together is a sustainable soil amendment.

The pyrolysis process uses this principle to produce renewable energy from any organic waste via an energy recovery system (pyrolysis reactor) that makes the process sustainable and efficient where significant water savings are achieved for end users, and in certain applications, avoid the need for digesters.

BioForce's BFT P-Five Pyrolysis Reactor

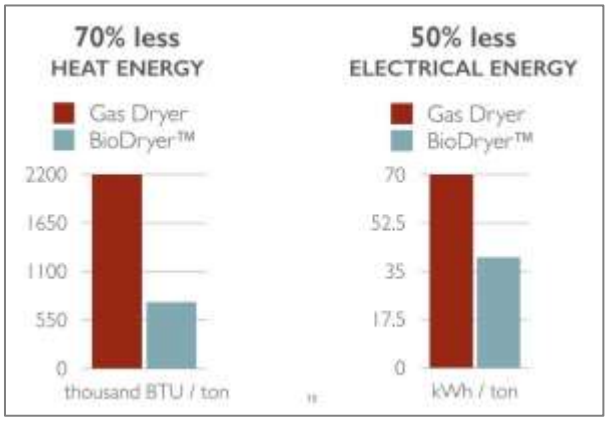
What are the benefits?

Builds drought resilience

- Addition of biochar to soils decreases bulk density, increases total pore volume and increases available water content in a wide variety of sandy soils, which are common in Tulare County.
- Biochar increases the drought resistance of fungal and bacterial communities within soil due to faster recovery from disturbances.

Supports Electric Reliability

- Reduces electric consumption (kWh): Preliminary estimates indicate the proposed technology can reduce electric energy consumption by 50 percent over conventional electric dryer systems.



Electric Energy Savings over Conventional Electric Drying Systems

- Increases renewable energy production—Pyrolysis produces syngas, a clean, renewable fuel that can be burned for energy. The energy savings of BFT's biodryer and energy production of syngas can reduce energy required for biosolids management by up to 100 percent.

Technology Name	Aerobic Biological Reactor for Biosolids
Sector	Agricultural, Industrial
Industry Segment	**Agricultural:** Dairy Farms, Crop Farming **Industrial:** Wastewater Facilities
Water Benefits	Level of Drought Resilience: High
	Type of Drought Benefit: • Reduce Use of Potable Water for Non-Potable Uses Preliminary • Reduces Water Use and Demand • Increases Water Supply by mitigating groundwater contamination
Water Resources	Type of Water Resource Benefit: • Because water is used more efficiently, there is less demand for potable water used in non-potable settings.
Electric Benefits	• Technology proposes to reduce electric consumption (kWh/ton) by 50% over conventional gas dryers. • Increases renewable energy production—Pyrolysis produces syngas, a clean, renewable fuel that can be burned for energy. The energy savings of BFT's biodryer and energy production of syngas can reduce energy required for biosolids management by up to 100%.
Cost-Benefit Analysis	• Costs: A smaller scale system for farming applications estimates at $300,000. • Savings: A 100 kW conventional dryer system would be replaced with a new pyrolysis reactor/dryer that consumes 25 kW. Operating at 8,000 hours per year would equate to an annual savings estimate of 600,000 kWh per year. • Simple Payback: 3.3 years = [$300,000 / (600,000 kWh savings) *($0.15/kWh)
Other Benefits: Health and Safety	• Pyrolysis eliminates pathogens, pharmaceuticals, and chemicals of emerging concern in biosolids. • Volume reduction reduces overflow risk of sludge beds and prevents surface and groundwater contamination.
Other Benefits: Environmental	Reduces GHG Emissions • Reducing electric use and electric demand reduce production and/or purchase of marginal electric resources • Up to 90% volume reduction, which reduces the number of trucks required to transport biosolids by 90%. • Efficient capture and treatment of biosolids at the source reduces escaped methane emissions • Biochar has a high carbon content and doesn't biodegrade, so it permanently sequesters carbon within soil, increasing soil carbon content by 34% • Biochar Reduces CO2, CH4, and N2O flux of the soil, reducing agricultural greenhouse gas emissions • The pyrolysis machine has been designed to achieve the maximum production of gaseous material via a special flameless reactor, which allows a lower combustion temperature, resulting into low NOx emissions.

Technology Name	Aerobic Biological Reactor for Biosolids
Other Benefits: Economic	• Reduces costs of municipal wastewater system resulting from less wastewater being treated at the plant. • Modularity of systems reduces costs, extends life, and reduces need for expensive, long lead-time retrofits of large centralized wastewater treatment systems, which reduces costs of wastewater collection and treatment for all customer classes • Potential creation of new revenue sources from biochar and syngas allow facilities to invest in more upgrades without relying on rate increases.

Current Status

The technology has been successfully installed and benefits documented at (1) facility:

- Silicon Valley Clean Water (2015). In September 2015, BioForce Tech signed a contract with Silicon Valley Clean Water (WWTP) for the energy recovery and biochar production of 7,000 tons of biosolids per year. The biochar production is estimated to be around 700 tons per year.

  2017—Manufacturer received permits for a full-scale pyrolysis plant to transform biosolids into energy and biochar.

Candidate Technology 11: Primary Wastewater Treatment[220]

Technology Name	Clear Cove On-Site Primary Wastewater Treatment			
Technology Solution(s)	☒ Water Use Efficiency	☐ Increase Water Supply	☒ Reduce Use of Potable Water for Non-Potable Uses	☐ Water Management Tools
Sector(s)	☒ Agricultural	☐ Commercial	☒ Industrial	☐ Residential
Industry Segment(s)	**Agricultural:** Dairy Farms and Crop Farming **Industrial:** Wastewater Treatment Facility, Food and Beverage Processing			
Drought Resilience	☒ High	☐ Medium	☐ Low	
Water Benefits	☒ Reduces Water Use	☐ Increases Water Supply	☒ Produces/Uses Recycled Water	☐ Reduces Water Loss
Electric Benefits	☒ Energy Efficiency (**Reduces kWh**)	☒ Demand Response (**Ability to Shift Load?**)	☒ Distributed Generation (**Increase Ability to Produce Clean Energy**)	☐ Increase Energy Storage (**Ability to Store Energy**)
GHG Benefits	Yes. The ClearCapture technology will result in significant Greenhouse Gas (GHG) reduction by reducing the load on the municipal wastewater treatment plant which typically utilize an aerobic process that consumes significant energy and produces significant GHG emissions.			

220 [1] Data provided ClearCove staff. [2] "NYSERDA Demonstration Study Report" retrieved from https://www.nyserda.ny.gov/-/media/Files/EERP/Commercial/Sector/Municipal-Water-Wastewater-Facilities/ClearCove-Harvester.pdf. [3] Altstadt Brewery Video retrieved from https://www.youtube.com/watch?v=5F3eKS5qVXo. [4] ClearCove Systems ClearCapture Product Video retrieved from http://www.clearcovesystems.com/clearcapture-product-video/.

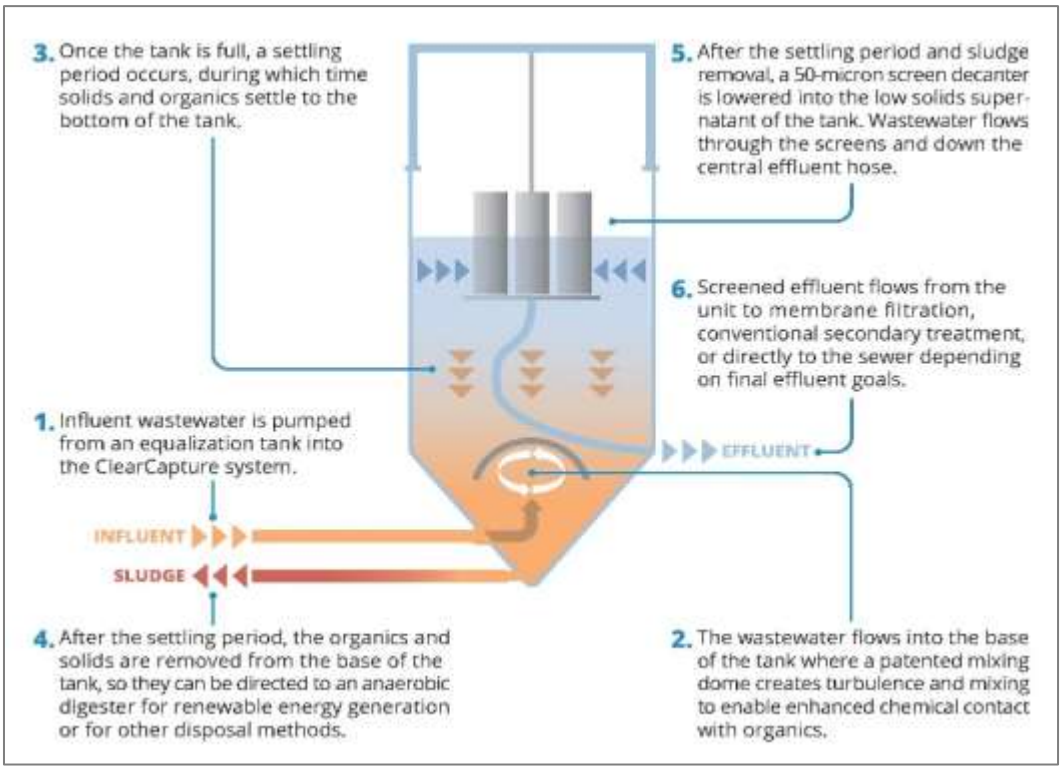
Implementation Timeline	☒ <= 3 years	☐ 3-7 years	☐ > 7 years
Estimated Simple Payback	1.6 years.		

What is the technology?

The ClearCove technology is based on a simple, non-biological, physical-chemical process, encompassing settling and screening to provide enhanced capture of organics and solids versus conventional technologies. ClearCove delivers its technology to the Food & Beverage (F&B) market via its ClearCapture™ system. The ClearCapture technology enables Ultrafiltration and Reverse Osmosis membranes downstream which allows F&B processors to recover up to 80+ percent of their process wastewater to reuse quality without the use of biology.

How does it work?

The Clear Cove ClearCapture's technology uses little-to-no biology by removing the biology from wastewater operations, Food and Beverage producers can realize considerable financial and energy savings. Moreover, they can spare themselves the hassle of dealing with troublesome bugs, which enables them to do what they do best: produce Food and Beverage offerings. The figure below provides a six-step process on how the technology works.



On-site primary wastewater treatment six step process

Who are the targeted adopters?

Targeted adopters for the technology are F&B processors that generate a wastewater stream, ClearCove currently targets the following including but not limited to dairy processors, breweries, wineries, fruit/vegetable processing, soft drinks, seafood, meat processing, juice, and snack food processors.

What are the benefits?

The ClearCapture technology offers several benefits to F&B processors, including:

- **Energy Savings**: The ClearCapture technology consumes approximately 50 percent less energy than conventional solutions for complete wastewater treatment down to reuse levels.
- **Water Reuse**: The ClearCapture technology enables F&B facilities to recover up to 90 percent of their process wastewater to potable reuse levels. This in turn reduces the facilities' water demand by up to 90 percent.
- **Energy Production**: Due to the ClearCapture technology being a physical chemical process, the organics captured are of significantly higher methane potential than those that are degraded and captured in a biological process.
- **Capital Savings**: The ClearCapture technology is skid mounted and highly modular resulting in a lower capital investment than conventional technologies that typically require significant concrete tank construction.
- **GHG Impact**: The ClearCapture technology will result in significant Greenhouse Gas (GHG) reduction by reducing the load on the municipal wastewater treatment plant which typically utilize an aerobic process that consumes significant energy and produces significant GHG emissions.
- **Highly Automated**: The ClearCapture system is a highly automated system that can run unattended, requiring significantly less attention than conventional systems which typical require a full-time operator.
- **Reduced O&M**: The ClearCapture system requires significantly less O&M than conventional systems. The system utilizes common coagulants versus costly polymers, resulting in approximately 50 percent less chemical cost. The use of coagulants instead of cationic polymers also enables the ClearCapture system to utilize physical membranes downstream.

What are the costs/risks?

The costs of the ClearCove technology, while less than conventional solutions, include the capital investment for equipment and installation as well as the energy and chemical costs associated with operating the system. Risks associated with the system are minimal as the process is a physical/chemical system and is not susceptible to upset or failure like conventional biological solutions.

How it could be applicable to the region?

The ClearCove technology is applicable to the region as the area with its high density of F&B processors and combined with the needs for both water and energy efficiency. The ClearCove technology enables the opportunity for resource recovery in the form of water reuse, renewable energy generation, energy consumption reduction and GHG reduction.

Technology Name	Aerobic Biological Reactor for Biosolids
Sector	Agricultural, Industrial
Industry Segment	**Agricultural:** Dairy Farms, Crop Farming **Industrial:** Wastewater Facilities
Water Benefits	Level of Drought Resilience: High
	Type of Drought Benefit: • Reduce Use of Potable Water for Non-Potable Uses Preliminary • Reduces Water Use and Demand
Water Resources	Type of Water Resource Benefit: • The ClearCapture technology enables F&B facilities to recover up to 90% of their process wastewater to potable reuse levels. This in turn reduces the facilities' water demand by up to 90%. • Because water is used more efficiently, there is less demand for potable water used in non-potable settings.
Electric Benefits	• **Energy Savings:** The ClearCapture technology consumes approximately 50% less energy than conventional solutions for complete wastewater treatment down to reuse levels. • **Reduces electric demand (kW):** uses 1 x ¼ hp pump 15 minutes per hour to treat process water effluent; processing time can be scheduled during off-peak hours. • **Energy Production:** Due to the ClearCapture technology being a physical chemical process, the organics captured are of significantly higher methane potential than those that are degraded and captured in a biological process. The technology proposes to increase renewable energy production (methane production) by 240-520% through non-biological (chemical and physical) removal of the biosolids. Thereby, preserving the energy value that is typically degraded by biological processes prior to digestion. The technology proposes to generate 2.2 GWh/year of electricity via microturbines with produced biogas.
Cost-Benefit Analysis	• **Costs:** A smaller scale system for food and beverage manufacturing applications estimates at $500,000. • **Savings:** Recovering up to 90% of process water alone estimates to approximately $300,000 in operational cost savings alone. Electric savings from using a smaller fractional VFD hp pump motor for approximately 15 minutes for every hour of use compared to conventional 3 hp motor operating continuously results in an estimated energy savings of 50% from baseline conventional solutions. • **Simple Payback:** 1.6 years = [$500,000 / ($300,000 water savings + 21,000 kWh savings) *($0.15/kWh)
Other Benefits: Health and Safety	• 99% coliform removal • Up to 100% TSS removal

Technology Name	Aerobic Biological Reactor for Biosolids
	• Over 99% COD removal • Up to 98% BOD removal • Removal of other organics, for example, phosphorous
Other Benefits: Environmental	Reduces GHG Emissions • The ClearCapture technology will result in significant Greenhouse Gas (GHG) reduction by reducing the load on the municipal wastewater treatment plant which typically utilize an aerobic process that consumes significant energy and produces significant GHG emissions. • Compact footprint: the most space-efficient offering in the market today
Other Benefits: Economic	Reduces costs of municipal wastewater system resulting from less wastewater being treated at the plant. • **Capital Savings:** The ClearCapture technology is skid mounted and highly modular resulting in a lower capital investment than conventional technologies that typically require significant concrete tank construction. • **Highly Automated:** The ClearCapture system is a highly automated system that can run unattended, requiring significantly less attention than conventional systems which typical require a full-time operator. • **Reduced O&M:** The ClearCapture system requires significantly less O&M than conventional systems. The system utilizes common coagulants versus costly polymers, resulting in approximately 50% less chemical cost. The use of coagulants instead of cationic polymers also enables the ClearCapture system to utilize physical membranes downstream. • Opex is up to 50% lower versus conventional technologies (due to a highly automated system) • Capex is 25% lower than conventional wastewater treatment technology

Candidate Technology 12: Ozone Laundry[221]

Technology Name	NuTek Ozone Laundry Support System			
Technology Solution(s)	☒ Water Use Efficiency	☐ Increase Water Supply	☐ Reduce Use of Potable Water for Non-Potable Uses	☐ Water Management Tools
Sector(s)	☐ Agricultural	☒ Commercial	☒ Industrial	☐ Residential
Industry Segment(s)	**Commercial:** Hotels, Resorts, Nursing Homes, Healthcare Facilities, Athletic Clubs, Prisons, Central Laundries, and Schools **Industrial:** Textile and Light Industrial Manufacturing			
Drought Resilience	☐ High	☒ Medium	☐ Low	
Water Benefits	☒ Reduces Water Use	☐ Increases Water Supply	☐ Produces/Uses Recycled Water	☐ Reduces Water Loss
Electric Benefits	☒ Energy Efficiency (**Reduces kWh**)	☒ Demand Response (**Ability to Shift Load?**)	☐ Distributed Generation (**Increase Ability to Produce Clean Energy**)	☐ Increase Energy Storage (**Ability to Store Energy**)

221 Data provided Nutek Ozone staff.

GHG Benefits	Yes. By eliminating the need for hot water for a sizable percentage of linen, reducing the number of wash cycles, and reducing drying times, the OLSS can significantly impact a facility's carbon footprint by drastically reducing the amount of carbon dioxide and other greenhouse gases into the atmosphere.		
Implementation Timeline	☒ <= 3 years	☐ 3-7 years	☐ > 7 years
Estimated Simple Payback	1.5 years.		

What is the technology?

Standard industrial clothes washers on the market today consume 3.1 gallons per pound of clothes. High-efficiency clothes washers, holding Energy Star certification, aim to reduce water use by 45 percent, with proposed efficiencies of 1.8 gallons per pound of clothes. The NuTek Ozone Laundry Support System uses the natural disinfecting properties of ozone gas to increase the efficiency of cleaning agents. This allows for users to reduce water and energy use tied to on-premise clothes washers and increase savings.

How does it work?

The NuTek Ozone Laundry Support System captures oxygen gas from the air and uses electricity to trigger a reaction to create ozone or O3 gas. With the use of the patented Passive Injection Technology, the ozone is injected into the unit during a wash cycle. The O3 gas particles produce cleaner, whiter, softer clothes with a multifaceted approach:

- Envelop clothing, killing 99.99 percent of bacteria as tested by the CDC.
- Open weaves of fabric to easily loosen soils from fabrics.
- React with chemicals in cleaning agents to boost efficiency.
- Extracts the maximum volume of water and chemicals, leaving clothes free of excess water.

Applications for Tulare County

The technology would primarily target the industrial and commercial sectors in Tulare County. Hotels, resorts, nursing homes, healthcare facilities, athletic clubs, prisons, central laundries, and schools are all potential customers that would benefit from this technology. The multifarious benefits of NuTek OLSS would aid in the movement towards drought resilience, electric reliability, greenhouse gas emission reduction, and environmental risk mitigation in Tulare. Large agriculture-focused commercial and industrial sectors in Tulare are looking to join the movement, and NuTek's OLSS systems appear to be a good fit.

What are the benefits?

Technology Name	Aerobic Biological Reactor for Biosolids
Sector	Agricultural, Industrial
Industry Segment	**Agricultural:** Dairy Farms, Crop Farming **Industrial:** Wastewater Facilities
Water Benefits	Level of Drought Resilience: High
	Type of Drought Benefit: • Reduces Water Use and Demand • The system enables target adopters to reduce water usage associated with clothes washing by 35% by utilizing fewer wash and rinse cycles. In addition, with the disinfecting properties of ozone, hot water consumption will be reduced by 90-95% for light to medium soiled linens. As a byproduct, wastewater emission will be reduced. This unique technology is one part of the movement towards drought resilience in the commercial and industrial sectors in Tulare
Water Resources	Type of Water Resource Benefit: • Because water is used more efficiently, there is less demand for potable water used in non-potable settings.
Electric Benefits	• **Energy Savings:** The ozone penetrates the fabrics and partially opens the weave, creating more space between fibers allowing for water, soil, and cleaning agents to flow in and out of fabrics, thus increasing extraction efficiency. As a result, drying times will be reduced by up to 50%. Along with reduced drying times is the elimination of energy associated with water heating. Ozone replaces the need for heated water in the washing process with its disinfecting properties.
Cost-Benefit Analysis	• Due to the additional technology associated with NuTek Ozone Laundry Support Systems, the initial cost is higher than conventional on-premise laundry systems. Current prices, including installation, shipping, and training range from $15,400 to $37,400. However, with high water and energy savings, the return on investment for the OLSS systems are competitively short. • According to several case studies, an average return on investment is 4.1 months with local rebates and energy savings incentives, and less than 18 months without a rebate (please see case studies below).

Technology Name	Aerobic Biological Reactor for Biosolids
Other Benefits: Health and Safety	• Looking at the chemistry behind ozone-detergent interactions, the ozone acts as a catalyst for laundry detergent, improving its effectiveness due to the weave-opening and disinfecting properties. This results in a 20%-30% reduction in chemical use per wash cycle. • As tested at Accuratus labs, ozone is the most powerful oxidant for sanitizing surfaces with a bacterial disinfecting efficiency of 99.99%. • When looking at the life-cycle processing of ozone, no chemicals are used in the direct production. Ozone is produced for OLSS under similar conditions to the natural process. Oxygen gas is flowed through a chamber while being exposed to UV light, causing a chemical reaction, and creating ozone. • Similarly, after ozone is used, it rapidly decomposes into oxygen gas, thus, the product has no negative environmental or regulatory risks. • Lastly, a recent all state memo issued by the Center for Medicare & Medicaid Services (CMS) has recognized ozone cleaning as an acceptable method of processing laundry.
Other Benefits: Environmental	Reduces GHG Emissions • By eliminating the need for hot water for a sizable percentage of linen, reducing the number of wash cycles, and reducing drying times, the OLSS can significantly impact a facility's carbon footprint by drastically reducing the amount of carbon dioxide and other greenhouse gases into the atmosphere. When multiplied by millions of pounds of laundry across thousands of On-Premise Laundries in Tulare, ozone becomes a major contributor to reducing greenhouse gas emissions.
Other Benefits: Economic	• There are four areas of cost savings with the product: water savings, energy savings, extending linen life, and local incentive programs. Across previous installations, the product has qualified for custom rebates and incentives from local utility providers totaling between 34%-70% of total project costs. • More importantly, the OLSS provides ongoing annual energy savings by reducing water, electric, and gas bills year after year. • The manufacturer has worked with Accuratus Labs to study the effect of ozone on a variety of linens over an extended period. The findings show that the product extends linen life by 23%, saving thousands of dollars spent annually on linen replacements. Tied with this is the elimination of costs associated with expensive and harsh fabric softeners which are replaced with the use of ozone.

Case Studies

The NuTek OLSS has a proven track-record of water savings, electricity and gas savings, linen lifetime extension, and chemical costs savings. Units have been installed across hotels, resorts, and prisons across California, while awaiting the opportunity to enter nursing homes and healthcare facilities with their new Sustainable Healthcare Solutions division. With current systems, OLSS has seen annual savings between $2,183 to $45,770 per year. The following are case-studies depicting cost-benefits:

- **DoubleTree by Hilton, Anaheim, California**: Projected electricity savings: $9,104.51, and projected annual savings with the OLSS: $36,559.41, with a total project price of $29,900.00. The ROI for this system is 122 percent.
- **Santa Barbara County Jail, Santa Barbara, California**: The jail processes 2,000 lbs. of laundry every day to service an average of 1,200 inmates. The pre-ozone cost to wash per load was $5.07. The post-ozone cost to wash per load is $1.60. Energy savings of $3.47 per load x 624 loads per month = $2,165.28 per month, or $25,983.36 per year. The installation of NuTek's OLSS reduced natural gas consumption by 88.1 percent, water use by 18.8 percent, chemical, electrical and sewer costs by 12-18 percent.
- **Lowes Coronado Bay, Coronado Bay, California**: Gas, water and electricity savings per load of towels post ozone is $8.60 per load. Gas savings for washers, gas savings for dryers and electric savings per load of sheets is $3.28 per load. Gas, water & electricity savings for rugs and hand towels is $1.40 per load. Total monthly energy savings equals $2,183.22, per NUS Direct Consulting.
- **Doubletree Fess Parker Resort, Santa Barbara, California**: Annual savings in natural gas for washers = $12,350, natural gas for dryers = $5,136, water savings = $9,313 and electricity for both washers & dryers = $1,979 per year. Ozone equipment payback in 12 months.
- **Sheraton Majestic Hotel, Anaheim, California**: Annual water and natural gas savings = $36,204, natural gas for dryer's savings = $9,565,87, total annual energy savings = $45,770.87 with a pay back in 7.6 months.

Candidate Technology 13: Atmospheric Water Generator[222]

Technology Name	**Atmospheric Water Generator**			
Technology Solution(s)	☐ Water Use Efficiency	☒ Increase Water Supply	☐ Reduce Use of Potable Water for Non-Potable Uses	☐ Water Management Tools
Sector(s)	☐ Agricultural	☒ Commercial	☒ Industrial	☒ Residential
Industry Segment(s)	**Commercial:** Offices, Hotels, Resorts, Nursing Homes, Healthcare Facilities, Athletic Clubs, Prisons and Schools **Industrial:** Remote Mines, Oil Rigs, Greenhouses **Residential:** All Residential			
Drought Resilience	☐ High	☒ Medium	☐ Low	
Water Benefits	☐ Reduces Water Use	☒ Increases Water Supply	☐ Produces/Uses Recycled Water	☐ Reduces Water Loss
Electric Benefits	☒ Energy Efficiency (**Reduces kWh**)	☒ Demand Response (**Ability to Shift Load?**)	☒ Distributed Generation (**Increase Ability to Produce Clean Energy**)	☐ Increase Energy Storage (**Ability to Store Energy**)

222 Data provided by multiple manufacturers.

GHG Benefits	Yes., this technology provides on-site drinking water, avoiding the lead time, high costs and high GHG impacts of delivering critical potable water supplies to remote communities during emergencies, such as the recent multi-year drought.		
Implementation Timeline	☒ <= 3 years	☐ 3-7 years	☐ > 7 years
Estimated Simple Payback	Cost not available to perform payback analysis.		

What is the technology?

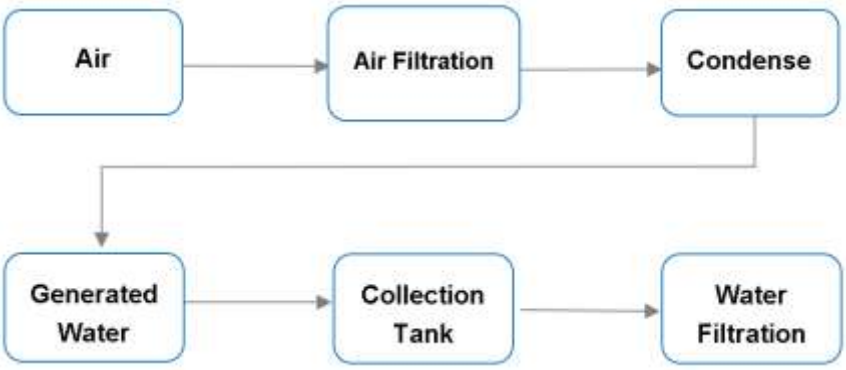
Atmospheric Water Generators (AWG) are an emerging technology used for on-site production of potable water. The technology is focused on giving potable water to those who lack freshwater during emergency situations. This technology explores the possibility of using a dehumidification system run by solar thermal energy to (1) pre-treat feed air stream for air conditioning units and reduce latent heat, consequently reducing electrical power consumption and (2) condense atmospheric moisture and use it as an additional renewable source of water and further enhance the sustainability and independence of first-aid cabins.

How does it work?

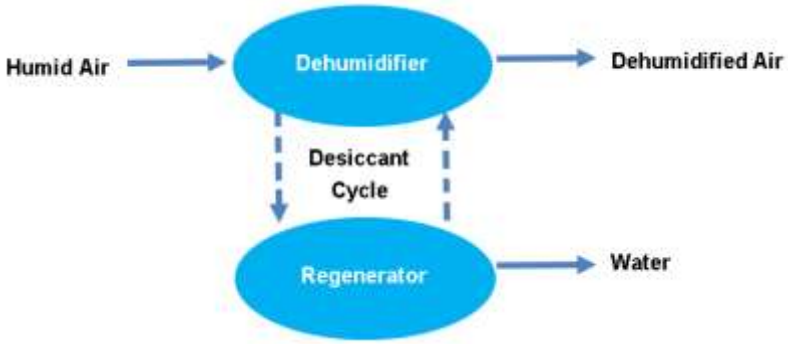
AWG devices filter and condense moisture in the air by cooling air below its dew point, producing water. There are three types of AWGs: cooling condensation, wet desiccation, and Peltier cooling. Cooling condensation and wet desiccation are the most widely used today.

The technology, however, is strongly limited by the environmental conditions required for operation. Most products in the market, require a minimum 30 percent humidity, moderate temperatures, and a large amount of energy for optimal operation. Most companies offset the large energy requirements by partnering their products with high-efficiency solar panels. Thus, AWGs partnered with solar panels are entirely self-sufficient, making it the ideal alternative to high-cost water deliveries. A notable mention for AWGs is Sun-to-Water, one of the first companies to utilize wet desiccation, boasting an operating cost of $0.04 - $0.08 per gallon.

Most technology developers use mature refrigeration technologies in packaged units to condense and collect moisture. Large scale operations use wet desiccation, utilizing salts for moisture extraction. If the water is intended for human consumption, some units include ultraviolet or other disinfection technologies. Some also add minerals to improve the taste of the water. In the pre-commercial stage, the market is saturated with start-ups, with multiple companies claiming the same patents.



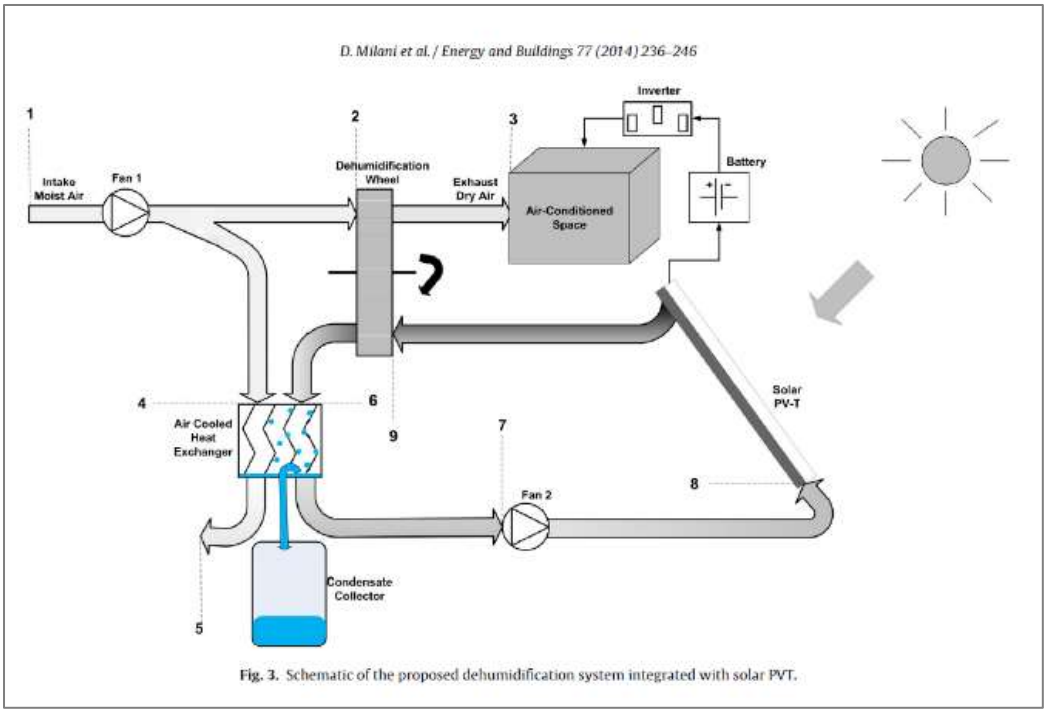
Operating schematic for cooling condensation atmospheric water generators



Operating schematic for wet desiccation atmospheric water generators

Bundling AWG with Solar Photovoltaics (PVT)

The process will intake fresh air and split into two streams. The major stream goes into the desiccant wheel (stream 2) and the minor steam goes to a heat exchanger (steam 4) where it exchanges enthalpy with the regeneration stream (steam 6) and condenses water. The humidity set-point on the wheel is lowered to force the dehumidifier to work at its full capacity at all times. The major air (stream 2) enters the dehumidifier at a certain state (usually relatively cool and moist compared to the outlet).



Atmospheric Water Generator Process Streams

As water absorbs onto the desiccant, the heat of sorption is released and warms up the surrounding air. When the process air leaves the dehumidifier, it is often drier and warmer than its entry status. Water vapor molecules are deposited on the dehumidification wheel to begin to accumulate until saturation. The wheel is rotating at very slow rate to increase residual time for water vapor molecules. Once that part of the wheel is saturated it will ultimately reach the regeneration phase (point 9). In the regeneration phase, the saturated portion of the wheel is exposed to a hot dry air stream that comes from a heat source, supplied by the hybrid PVT system.

This technology was tested in Sydney, Abu Dhabi and London for their dissimilar climates. Abu Dhabi possessed the highest rate of potential water collection, that reached up to 18.5 kL a year. Sydney generated 13.8 kL a year while London generated up to 10 kL of water a year. Most of energy required can be met by the thermal gain of the solar hybrid PVT array during the day. However, the photovoltaic panels mounted on top of the first aid cabin is not enough to meet its energy demand, requiring constant energy from an additional source.

Economic Drivers

The industry of atmospheric water generators is new in the United States. The new technology provides economic and environmental benefits at the residential, commercial, and industrial scale. Financial incentives must be put in place to encourage adoption from single-family homes and multi-family housing units. With economies of scale, as production increases and competitors enter the market, full life-cycle costs will be decrease, as maintenance and retrofitting costs are minimal. Units equipped with solar panels will increase initial cost, which

will increase the economic barrier to entry, but will drastically lower operational costs. If utilized solely for emergency applications, solar-powered AWGs are not recommended due to the lower production capacity and higher costs. For continual use, solar-powered units are highly recommended. Due to the early market position of AWG technology, no cost-benefit analyses have been conducted. A pilot program in Tulare County would provide data for a full cost-benefit analysis.

What are the benefits?

Technology Name	Atmospheric Water Generator (AWG)
Sector	Commercial, Industrial, Residential
Industry Segment	**Commercial:** Offices, Hotels, Resorts, Nursing Homes, Healthcare Facilities, Athletic Clubs, Prisons and Schools **Industrial:** Remote Mines, Oil Rigs, Greenhouses **Residential:** All Residential
Water Benefits	Level of Drought Resilience: Medium
	Type of Drought Benefit: • Increases Water Supply • On-site production of small quantities of potable water. • The ability to produce critical drinking water supplies "from air" would be very beneficial to residents that remain dependent on private wells (not connected to municipal water supplies).
Water Resources	Type of Water Resource Benefit: Because potable water is produced, there is less demand for potable water used for both potable and non-potable settings.
Electric Benefits	**Renewable Energy:** 100% off-grid power and water production for residential and commercial buildings: solar or wind power and 100% off-grid water production, storage and dispensing for remote mines, oil rigs, greenhouses, villages without plumbing infrastructure and other similar facilities.
Cost-Benefit Analysis	Although energy and water savings data were estimated, no explicit cost estimates were provided from information sources gathered to perform a cost-benefit analysis.
Other Benefits: Health and Safety	• Filters the air with Anti-Bacterial filter • Destroys and removes all bacteria and impurities.
Other Benefits: Environmental	Reduces GHG Emissions • A green solution for water sustainability • Fully replaces the need for bottled water or water purifier on faucets. • Extracts moisture from the air to produce pure drinking water • Provides on-site drinking water, avoiding the lead time, high costs and high GHG impacts of delivering critical potable water supplies to remote communities during emergencies, such as the recent multi-year drought.
Other Benefits: Economic	• Pure water production and purification 24/7 • Reduce social costs of waiting, lack of hygiene, illness, social unrest.

Candidate Technology 14: Disinfection[223]

Technology Name	Shield 1500 (Puralytics)			
Technology Solution(s)	☐ Water Use Efficiency	☒ Increase Water Supply	☒ Reduce Use of Potable Water for Non-Potable Uses	☐ Water Management Tools
Sector(s)	☐ Agricultural	☐ Commercial	☒ Industrial	☐ Residential
Industry Segment(s)	**Industrial:** Manufacturing, Wastewater Treatment Facilities			
Drought Resilience	☐ High	☒ Medium	☐ Low	
Water Benefits	☐ Reduces Water Use	☒ Increases Water Supply	☒ Produces/Uses Recycled Water	☐ Reduces Water Loss
Electric Benefits	☒ Energy Efficiency (**Reduces kWh**)	☒ Demand Response (**Ability to Shift Load?**)	☒ Distributed Generation (**Increase Ability to Produce Clean Energy**)	☐ Increase Energy Storage (**Ability to Store Energy**)
GHG Benefits	Yes.			
Implementation Timeline	☒ <= 3 years	☐ 3-7 years	☐ > 7 years	
Estimated Simple Payback	Cost not available to perform payback analysis.			

What is the technology?

The patented Puralytics ® process employs LEDs to excite our proprietary nanotechnology mesh which drives light-activated treatment processes including an advanced oxidation process (AOP). The Shield achieves advanced disinfection, detoxification and contaminant degradation; it can be used in industrial treatment settings, manufacturing process or waste treatment. Emerging contaminants (personal care products & pharmaceuticals), herbicides and pesticides, pathogens (bacteria, virus, protozoa) and industrial chemicals (petrochemicals, toxins) are all destroyed in the treatment process. Multiple Shields may be used to achieve volume or treatment level requirements.

The unit is flexible in configuration, has a small footprint, and it is easy to integrate and operate. In addition, it has low pressure drop and minimal maintenance requirements. There are no chemicals additives and zero discharge. They are fully manufactured in the USA. Puralytics has developed a next generation advanced oxidation process, AOP PLUS, using only light energy to activate an advanced nanotechnology coated mesh. Water is purified through simultaneous photochemical reactions, destroying volatile organic chemicals, pesticides, pharmaceuticals; while also sterilizing bacteria, viruses, and other pathogens. There are no chemical additives and 100 percent of the water is purified.

223 Puralytics website: https://puralytics.com/.

How does it work?

Puralytics' ® core technologies are advanced oxidation process (AOP) reactors using a proprietary catalyst material and light energy to generate hydroxyl radicals to purify water. The nanomaterial is not consumed or broken down, minimizing chemicals and eliminating water waste associated with traditional chemical and physical water treatment technologies. Contaminants are destroyed instead of concentrated, minimizing the disposal problems associated with traditional water treatment technologies. Conventional AOP technology was only developed four decades ago but is already widely used for destroying contaminants. The Puralytics version using photochemical oxidation, generates powerful hydroxyl radicals which are established to:

- Destroy volatile organic chemicals
- Destroy pesticides, pharmaceuticals and other chemicals
- Destroy or inactivate pathogens

The AOP PLUS also delivers additional oxidative power created through the Nano particle photocatalytic reaction used in the Puralytics AOP PLUS process. This higher level oxidative energy degrades additional hard to remove pollutants and contaminants which other AOPs and granular activated carbon cannot remove and can be used in to meet difficult to achieve regulatory or compliance standards for a wide range of pollutants.

The light and nanomaterial combine 5 photochemical processes delivering: disinfection, trapping of heavy metals through adsorption, breaking apart organic contaminants. Puralytics treatment modules or stand-alone systems are scalable in treatment level and in flow, from millions of gallons per day to less than 1 gallon per minute.

What are the benefits?

Database Field	Field Description
Technology Name	Shield 1500 (Puralytics)
Sector	Commercial, Industrial, Residential
Industry Segment	**Commercial:** Healthcare Facilities **Industrial:** Wastewater Facilities, Food and Beverage Processing, Bioscience, and Research Laboratories
Water Benefits	Level of Drought Resilience: Medium
	Type of Drought Benefit: • Increases Water Supply • Produces/Uses Recycled Water
Water Resources	Type of Water Resource Benefit: • Because potable water is produced, there is less demand for potable water used for both potable and non-potable settings. • Water Recovery: 100% • Water Production: 0.5-3.9 L/min | 200–1500 gallons per day 0.3- 1 GPM • Pressure Drop: 2–7 psi @ 200-1500 gpd

Database Field	Field Description
	• The Shield is designed to last 1 yr. or 547,500 gallons (2,072,512 Liters) with continuous operation before cartridge replacement is recommended.
Electric Benefits	• **Electricity Power Consumption:** 570 Watts • **Electricity Savings:** The technology produces up to 1500 gallons of water per day. It has 33% lower unit energy use. • **Other Enhancements Include:** lower pretreatment requirements and active electronics cooling system to allow operation in hotter environments. Finally, it is compatible with much broader pumping options (for off-grid applications) and it has 150% higher flow capacity but similar performance on most contaminants.
Cost-Benefit Analysis	• Cost not available to perform cost-benefit analysis.
Other Benefits: Health and Safety	• Safe: UVA Wavelengths used are safe and avoid bromate and nitrite formation • Sustainable: No Mercury UV lamps to replace (or break) each year • Secure: No chemicals needed, simple cartridge replacement • The Shield was designed to achieve 99.9999% bacteria, 99.99% virus, 99.9% protozoa, and > 70% reduction in any specific organic or heavy metal at 3.94 lpm (specifically, the microbiological targets are zero units found in standard tests which start with the log values of the targeted removal). By adjusting the flow rate, the reduction rate can be increased or decreased for a specific contaminant type. Shield units can be operated in parallel to increase throughput or contaminant reduction.
Other Benefits: Environmental	<u>Reduces GHG Emissions</u> • Simple: Without the complexity of other AOPs like chemical feed, pressurized ozone or hydrogen peroxide • Small footprint • 100% water recovery, no concentrated effluent or backflush stream. Absolutely chemical free processing. Destruction of contaminants in water means no contaminants wind up in a landfill or other waste stream.
Other Benefits: Economic	• Scalable: Other AOPs are not simple or inexpensive systems. • Up to 90% lower unit consumables cost and reduced maintenance time. • Flexible configuration (modular and scalable) • Easy integration and operation • Minimal maintenance requirements

Candidate Technology 15: Smart Metering[224]

Technology Name	Self Help Engagement Tools: Smart Metering Technologies (SMT)			
Technology Solution(s)	☒ Water Use Efficiency	☐ Increase Water Supply	☐ Reduce Use of Potable Water for Non-Potable Uses	☒ Water Management Tools

224 *2017 DNV GL Universal Audit Tool Impact Evaluation—Study, Searching for the Crucial Component of Home Energy Report Programs*—E-Source, Urban water conservation through customized water and end-use information, Science Direct.

Technology Name	Self Help Engagement Tools: Smart Metering Technologies (SMT)			
Sector(s)	☒ Agricultural	☒ Commercial	☒ Industrial	☒ Residential
Industry Segment(s)	**Agricultural:** All Agricultural Facilities **Commercial:** All Commercial Facilities **Industrial:** All Industrial Facilities **Residential:** All Residential			
Drought Resilience	☐ High	☒ Medium	☐ Low	
Water Benefits	☒ Reduces Water Use	☐ Increases Water Supply	☐ Produces/Uses Recycled Water	☐ Reduces Water Loss
Electric Benefits	☒ Energy Efficiency (**Reduces kWh**)	☐ Demand Response (**Ability to Shift Load?**)	☐ Distributed Generation (**Increase Ability to Produce Clean Energy**)	☐ Increase Energy Storage (**Ability to Store Energy**)
GHG Benefits	Yes, reduced water usage means less GHG emissions will be needed to transport water.			
Implementation Timeline	☒ <= 3 years	☐ 3-7 years	☐ > 7 years	
Estimated Simple Payback	< 1 year			

What is the technology?

Water utilities and public agencies around the world use information campaigns to encourage residential water conservation. A variety of communication engagement channels are used to inform homeowners of ways to save. The communication engagement channel of informational delivery (for example paper versus online) is likely to have implications for its reach. Similarly, the content of water-use information and its format may influence impacts on consumption behaviors. However, in the water sector, comparatively less attention has been on the communication of the detailed water-use information to customers.

Self-Help Engagement Tools (engagement tools) educate utility consumers about their water and energy use with a level of analysis suited to the customers' needs and abilities. These engagement tools come in various forms comprising of online universal audit tools (UAT) and portals, home energy reports (HER), feedback postcards, smart metering technologies (SMT), home displays, leaflets, bill inserts and mail-in surveys.

SMTs introduce new opportunities to collect more detailed information on resource consumption practices and patterns than was previously possible under conventional metering. The opportunity exists to convey this information both to the utility and the consumer to inform and guide water management (Boyle et al., 2013).

How does it work?

Smart metering technology (SMT) is paired with end-use analysis to provide more detailed information on household consumption. SMT is an innovative measurement technology that offers potential to contribute for more efficient usage of electricity, gas, and water.

Within the water sector, residential meters have traditionally been read up to once per quarter, yielding no more than four data points per meter per year (Britton et al., 2008). By contrast, smart water meters record the flow of water consumption every set number of seconds (for example every 15 or 60 s). The technology therefore opens the door to significantly greater data resources, and the possibility of understanding water consumption according to time of use within the day, taking also variations in weather and seasonal. The smart meters will collect data every set number of seconds instead of at four data points per meter per year like traditional meters.

SMTs can be combined with other communication channels, strategies and tactics such as HER, UAT or HWU to increase water and energy efficiency and conservation efforts. Home Water Updates (HWU) cards or Home Energy Reports (HER) issued to targeted participants show a pie chart of customer specific water usage compared to an average of other participating neighbors. The back of the card shows the breakdown of customer water usage and customized tips to save water based on each activity (that is showers, toilets, outdoor, leaks, washing machines). UAT provides residential customers with advice on energy efficiency, insight into areas of high energy use, and tips and suggestions for saving both energy and money based on responses to an online survey regarding household appliances, occupancy, and other dwelling characteristics. There is an analogous version of the tool for business customers.

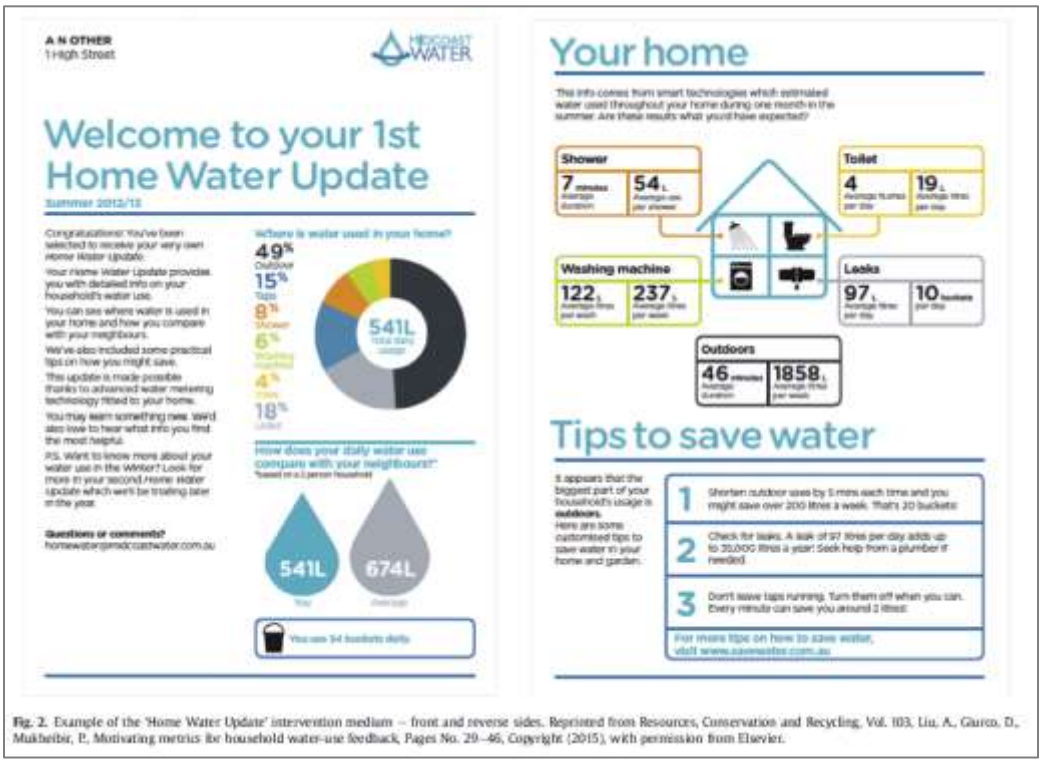
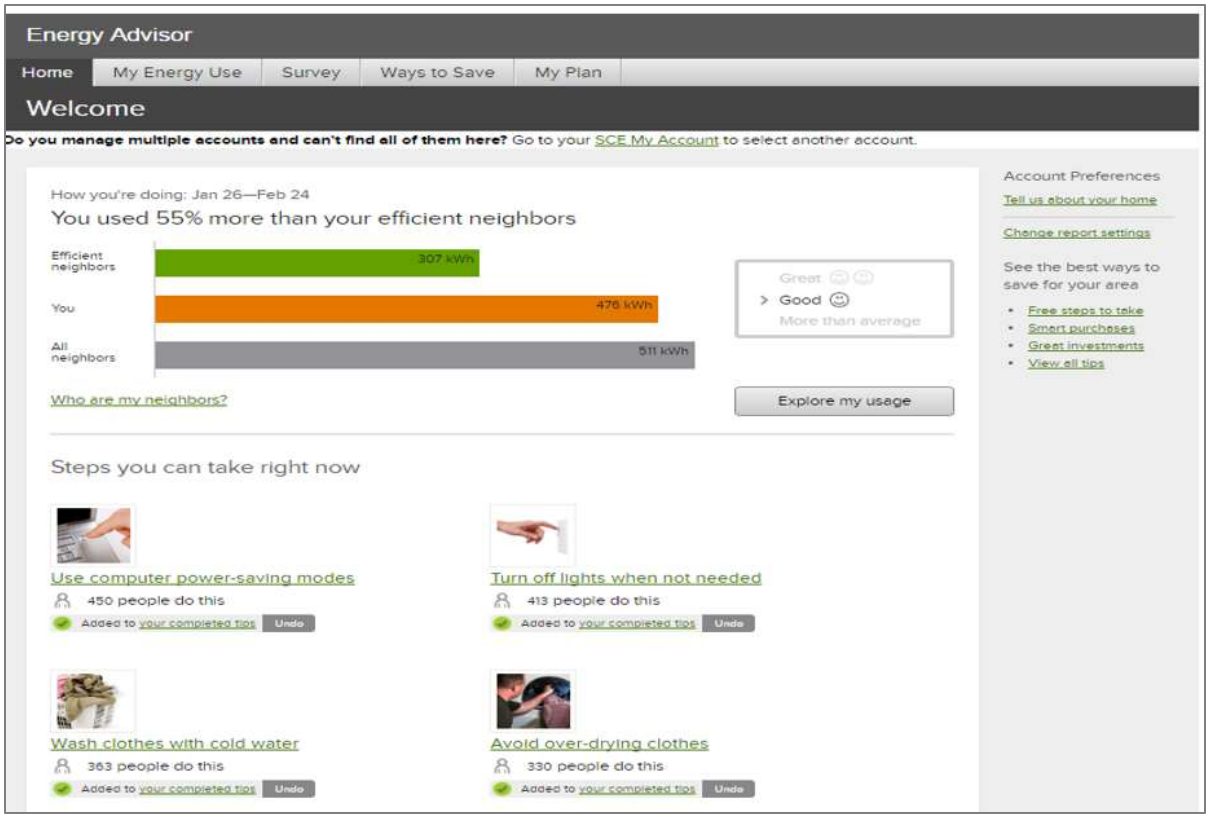


Fig. 2. Example of the 'Home Water Update' intervention medium – front and reverse sides. Reprinted from Resources, Conservation and Recycling, Vol. 103, Liu, A., Giuca, D., Mukheibir, P., Motivating metrics for household water-use feedback, Pages No. 29–46, Copyright (2015), with permission from Elsevier.

Sample Home Water Update (HWU) Customer Intervention Report



Sample Customer Engagement Online UAT

What are the benefits?

Database Field	Field Description
Technology Name	Self Help Engagement Tools: Smart Metering Technologies (SMT)
Sector	Agricultural, Commercial, Industrial, Residential
Industry Segment	**Agricultural:** All Agricultural Facilities **Commercial:** All Commercial Facilities **Industrial:** All Industrial Facilities **Residential:** All Residential
Water Benefits	Level of Drought Resilience: Medium
	Type of Drought Benefit: Reduce Water Use
Water Resources	Type of Water Resource Benefit: • Results from an Australian study showed a positive impact between 5 and 10% water savings. • The study showed that HWUs have a high program reach and appeal, with all participants having reporting engaging with their HWU cards. • Results from the study showed that the intervention group consuming 8% less than the control group. • After viewing the HWUs, consumption of the intervention group reduced by 20.3% while the control group reduced by 12.7%.
Electric Benefits	**Electricity Savings:** A 2017 DNV GL impact evaluation study on California's Universal Audit Tool (UAT) indicates that electric savings estimate to range between 1% to 4% from baseline conditions (70 kWh up to 271 kWh) after UAT engagement.

Cost-Benefit Analysis	**Costs:** $6.82 up to $15.85 per survey. (E-Source Study) **Savings:** 70 kWh up to 271 kWh per survey. (DNV GL Study) **Simple Payback:** 0.58 years up to 0.98 years = [$6.82 / (70 kWh) *($0.10/kWh)] = 0.98 = [$15.85 / (271 kWh) *($0.10/kWh)] = 0.58
Other Benefits: Health and Safety	No specific health and safety benefits were identified from the research conducted.
Other Benefits: Environmental	Reduces GHG Emissions • Reduced water usage results in less GHG emissions due to water transportation. • Reducing electric use and electric demand reduce production and/or purchase of marginal electric resources.
Other Benefits: Economic	Relatively low-cost research environment to explore the provision of detailed household water-use feedback.

Candidate Technology 16: Smart Irrigation[225]

Technology Name	**Smart Irrigation**			
Technology Solution(s)	☒ Water Use Efficiency	☐ Increase Water Supply	☐ Reduce Use of Potable Water for Non-Potable Uses	☒ Water Management Tools
Sector(s)	☒ Agricultural	☒ Commercial	☐ Industrial	☒ Residential
Industry Segment(s)	**Agricultural:** Crop Farming, Dairies **Commercial:** Offices, Hotels, Resorts, and Schools **Residential:** All Residential			
Drought Resilience	☒ High	☐ Medium	☐ Low	
Water Benefits	☒ Reduces Water Use	☐ Increases Water Supply	☐ Produces/Uses Recycled Water	☒ Reduces Water Loss
Electric Benefits	☒ Energy Efficiency (**Reduces kWh**)	☒ Demand Response (**Ability to Shift Load?**)	☐ Distributed Generation (**Increase Ability to Produce Clean Energy**)	☐ Increase Energy Storage (**Ability to Store Energy**)
GHG Benefits	Yes, reduced water usage means less GHG emissions from electricity generation and water transportation.			
Implementation Timeline	☒ <= 3 years	☐ 3-7 years	☐ > 7 years	
Estimated Simple Payback	< 1 year.			

Landscape Irrigation Background

Landscape irrigation accounts for approximately one-third of all residential water use nationwide (EPA 2008). In a study to evaluate and quantify residential water use, Mayer et al. (1999) found that outdoor water use was 35 percent higher for homes with inground sprinkler

225 "Smart new evapotranspiration based controllers cut landscape water use by 20%-50%." *Urban Farmer Store*. http://www.urbanfarmerstore.com/smart-new-evapotranspiration-based-controllers-cut-landscape-water-use-by-20-50/.

systems than for homes without. The same study revealed that homes with irrigation systems controlled by an automatic timer had 47 percent more outdoor water use than those without. A similar study of monthly residential irrigation totals in central Florida found that timer-based irrigation systems controlled by homeowners applied on average 2.4 times the calculated net irrigation requirement (Haley et al. 2007).

To reduce water peak demand, some municipalities have adopted outdoor watering restrictions (for example, odd–even watering days) with stiff penalties for homeowners found in violation. During periods of extended drought, restrictions limiting irrigation to once or twice per week are common; however, the effectiveness of such policies at reducing overall water use depends on citizen adherence and how strictly the restrictions are enforced (Ozan and Alsharif 2013). Several towns, such as Cary, North Carolina, have also implemented tiered rate structures, in which unit charges for water increase with use (Goodwin and Cefalo 2010). Rain sensors, which bypass irrigation following rainfall events, are required in many communities (Cardenas-Lailhacar and Dukes 2008), and in some cases smart irrigation controllers are being encouraged or even required as an effort to further conserve water.

What is the technology?

Smart Irrigation Technologies comprise of 1) evapotranspiration (ET) based controllers, which adjust irrigation schedules based on estimated reference evapotranspiration and (2) soil moisture sensor-based controllers, which function based on soil moisture measured in the root zone. Proper installation, programming, and maintenance of smart irrigation technologies maximize water savings and reduce water usage and smart irrigation retrofits should be targeted toward systems that historically overirrigate.

How does it work?

Evapotranspiration (ET) is the amount of water that is lost from the soil through evaporation and plant use. **ET irrigation controllers** re-adjust themselves automatically as often as needed without manual reprogramming by using three sources of information:

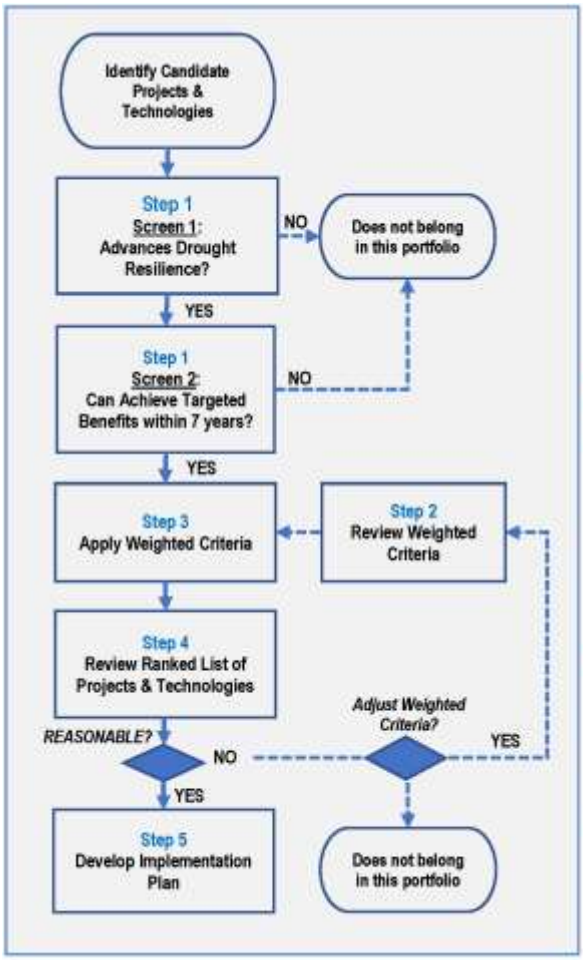
1. Built in logic has solar radiation values for every micro-climate, permanently stored onboard in memory, by postal zip code or latitude.
2. Entered data about each zone to be watered: soil type, plant type, irrigation type (sprinklers or drip), and slope.
3. Real-time data from on-site sensors or wireless E.T. weather data service enabling fast response to unexpected storms or heat waves.

Soil Moisture Sensor uses capacitance to measure the water content of soil (by measuring the dielectric permittivity of the soil, which is a function of the water content). Sensors are inserted into the soil, and the volumetric water content of the soil is reported in percent.

What are the benefits?

Database Field	Field Description
Technology Name	Smart Irrigation Technologies)
Sector	Agricultural, Commercial, Industrial, Residential
Industry Segment	**Agricultural:** Crop Farming, Dairies **Commercial:** Offices, Hotels, Resorts, and Schools **Industrial:** Wastewater Treatment Facilities **Residential:** All Residential
Water Benefits	Level of Drought Resilience: Medium
	Type of Drought Benefit: • Reduce Water Use
Water Resources	Type of Water Resource Benefit: • Per a 2011 North Carolina field study, smart irrigation technologies did result in beneficial changes in water-use behavior. • On average, the smart technologies reduced weekly irrigation by 21%
Electric Benefits	• **Electricity Savings:** Embedded energy savings due to less pumping can be realized from smart irrigation technologies. Depending on sector and applications annual embedded electricity savings range from 1 kWh up to 20 kWh per soil moister sensor or smart irrigation controller.
Cost-Benefit Analysis	**Soil Moisture Sensor Costs:** $7 up to $40 per soil moisture sensor **Smart Irrigation Controller Costs:** $70 up to $300 per controller **Energy Savings:** 1 kWh up to 20 kWh per sensor or smart irrigation controller. **Water Savings**: On average, the smart technologies reduced weekly irrigation by 21%. California water energy nexus deemed measures estimate annual water savings between 4,000 gallons ($132 annual cost savings) and 14,000 gallons ($463 annual cost savings) per year of water savings attributed to smart irrigation technologies. **Soil Moisture Sensor Simple Payback:** 0.5 years up to 0.61 years = [$7 / (70 kWh) *($0.10/kWh) + ($132)] = 0.05 = [$40 / (271 kWh) *($0.10/kWh) + ($463] = 0.08 **Smart Irrigation Controller Simple Payback:** 0.05 years up to 0.08 years = [$70 / (70 kWh) *($0.10/kWh) + ($132)] = 0.50 = [$300 / (271 kWh) *($0.10/kWh) + ($463] = 0.61
Other Benefits: Health and Safety	No specific health and safety benefits were identified from the research conducted.
Other Benefits: Environmental	Reduces GHG Emissions • Reduced water usage results in less GHG emissions due to water transportation. • Reducing electric use and electric demand reduce production and/or purchase of marginal electric resources.
Other Benefits: Economic	Relatively low-cost research environment to explore the provision of detailed household water-use feedback.

APPENDIX J:
Technology Scoring Tools



TOOL PURPOSE

To provide an objective, structured framework for evaluating and prioritizing candidate projects and technologies in context of an organization's mission, vision, goals, objectives, management priorities, financial and staff resources, risk management criteria, and organizational capabilities.

TOOL STRUCTURE

Step 1: Screen Candidate Projects

Screen #1: Does this project or technology meet the primary goal?

Screen #2: Can this project or technology achieve the targeted benefits within the required timeframe?

Step 2: Develop Weighted Scoring Criteria

Identify Key Criteria that will determine the relative ranking of candidate projects or technologies and apply weights to the various criteria.

Step 3: Score and Rank Candidate Projects

Organize candidate projects and technologies by "Type";[1] use Weighted Scoring Criteria to score each candidate project or technology.

Step 4: Review Ranked List of Candidate Projects and Technologies

Review list in order of highest to lowest scores.

- If ranked list appears reasonable, proceed to development of Implementation Plan.
- If ranked list does not appear reasonable, adjust Weighted Scoring Criteria and re-score.

[*Note: An iterative process is often needed to calibrate a new scoring tool.*]

Step 5: Develop Implementation Plan

Develop plan for implementing projects and technologies that appear to provide high potential benefits within the organization's investment and risk management policies.

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[1] In this example, the projected timeframe to achieve benefits was used to organize projects.

- Priority 1: Near Term (<= 3 years)
- Priority 2: Medium Term (> 3 and <= 7 years)

Projects and technologies that are expected to take > 7 years to achieve the targeted benefits were not scored.

Customizing Weighted Criteria

The examples provided in this appendix are illustrations only. The specific criteria used and their relative weights should be customized to each individual or organization's specific goals and objectives for an activity of this kind.

The sample scoresheet provided on the next page seeks to estimate values for two factors:

- **Benefits** attempt to evaluate the ability of any particular project or technology to support or advance California's resource, economic and environmental priorities.
- **Adoption Challenges** attempt to understand the types of challenges that targeted adopters will need to address in order to successfully implement the proposed project or technology.

The above two factors are relevant to program design:

An understanding of the benefits communities, local governments, and the state could realize through technologies helps to advance meaningful dialogues about why policymakers, regulators, legislators, community and business leaders, and other key stakeholders should encourage and support adoption.

An understanding of primary adoption challenges associated with specific technologies enable tailoring programs to address the types of barriers that adopters are likely to encounter.

Note that the criteria, weights and sample scoresheets are provided herein for illustrative purposes only. The criteria and weights to be applied must be tailored to the specific goals and objectives of the individual or organization(s) that have need to prioritize their resources and investments.

The example provided herein is focused primarily on the relative merits of candidate projects and technologies that can build ***drought resilience***.

Drought resilience requires strategies that significantly (a) reduce water use and increase efficient use of existing water supplies, and (b) increase production and use of recycled water and other "new" sources of water (for example, treatment of brackish water). In this context:

Atmospheric Water Generators (AWGs) score poorly. While they are very valuable in providing emergency potable water in areas where water supplies have been compromised or do not exist, the very small amounts of water that can currently be produced by AWGs and their high cost (comparable to that of purchased bottled water) is not a good fit for drought resilience.

Conversely, ***Food & Beverage Water Recycling/Reuse*** has demonstrated reductions of 80-90+% in the Food & Beverage (F&B) industry's demand for potable water.

Of these two technologies, Food & Beverage Water Recycling/Reuse is thus a much better fit with the goal of building drought resilience. It would not, however, be able to provide emergency water supplies. If the portfolio goal was to identify technologies that could produce emergency water, AWG would score higher.

Structuring the Score Sheet

There is no limit to the number of criteria that can be included, although the scoring process becomes much more difficult with the number of criteria.

Similarly, weights can be applied at multiple levels; but again, too much complexity may thwart one of the objectives for this type of process, which is to ensure transparency and objectivity.

Further, there may be more than one scoresheet—for example, different types of technologies with very different purposes may very well have different criteria (for example, technologies that address drought resilience vs. electric reliability).

Calibration

Especially if this is the first time that this score sheet is being used, calibration is usually needed.

After the first round of scoring (a sample can be used to calibrate the criteria and weights), the portfolio team reviews the relative ranking of various projects and technologies to determine whether the goals and objectives of the scoring process were met. If the purpose was to develop a portfolio of technologies that have high potential to advance drought resilience, a scoresheet that ranks AWG higher than F&B should be scrutinized and revised as needed to assure the appropriate result.

This is just a Tool

The process of collectively identifying and ascribing weights to evaluation criteria helps to levelize participants' knowledge and understanding of the portfolio's goals and objectives, and the portfolio developer's needs and interests. If the tool does not seem to be producing a rational outcome, change the criteria and weight and re-score some of the candidate technologies. This is usually an iterative (and sometimes frustrating) process; but with each iteration, new insights are gained as to the types of criteria that should be included and their relative importance to the evaluation process.

A sample scoresheet designed to rank candidate drought resilient technologies has been provided, along with illustrative scoring of two technologies with very different characteristics: Atmospheric Water Generators (AWGs) and Food & Beverage Water Recycling/Reuse.

SAMPLE SCORESHEET: DROUGHT RESILIENCE

BENEFITS			ADOPTION CHALLENGES		
Weight %	Score 0-5	Y Axis	Weight %	Score 0-5	X Axis
DROUGHT RESILIENCE			COSTS		
	0-5	↑ Water Supplies		0-5	% of Annual Budget
	0-5	↑ Water Quality		0-5	Est. Payback (# years)
	0-5	↑ Water Use Efficiency		0-5	Funding Availability
	0-5	↑ Water Recycling/Reuse		0-5	Timeline to Secure Funding
35%	Wtd. AVG	Avg Score * Weight%	25%	Wtd. AVG	Avg Score * Weight%
ELECTRIC RELIABILITY			REGULATORY & ENVIRONMENTAL RISKS		
	0-5	↓ Electric Consumption (kWh)		0-5	↑ Permit Violations
	0-5	↓ Electric Demand (kW)		0-5	↑ Threats to Species & Ecosystems
	0-5	↑ Clean/Renewable Distributed Energy Production (kWh/kW)		0-5	
	0-5	↑ Demand Response (kW)		0-5	
25%	Wtd. AVG	Avg Score * Weight%	25%	Wtd. AVG	Avg Score * Weight%
ENVIRONMENTAL RESPONSIBILITY			OPERATING RISKS		
	0-5	↓ GHG Emissions		0-5	↑ Operating complexity
	0-5	↑ Carbon Sequestration		0-5	↑ Risk of outages
	0-5	↑ Biogas Production, Capture & Use		0-5	Requires changes to other systems
	0-5	↓ Adverse Impacts on Ecosystems		0-5	Requires specialized staff or training
15%	Wtd. AVG	Avg Score * Weight%	20%	Wtd. AVG	Avg Score * Weight%
SOCIO-ECONOMIC IMPACTS			ECONOMIC RISKS		
	0-5	↑ Jobs (Local & Statewide)		0-5	↓ Revenues
	0-5	↓ Water &/or Energy Costs		0-5	↑ Operating Costs
	0-5	↑ Quality of Life for Local Residents		0-5	↑ R&R[2] Frequency and Costs
	0-5	↓ Reduces Risks to Public Health & Safety		0-5	Difficulty of obtaining funding
15%	Wtd. AVG	Avg Score * Weight%	20%	Wtd. AVG	Avg Score * Weight%
OTHER RESOURCE & ENVIRONMENTAL BENEFITS			TECHNOLOGY RISKS		
	0-5	↑ Natural Gas Efficiency		0-5	Technology Obsolescence[3]
	0-5	↑ Renewable Natural Gas		0-5	
	0-5	↓ Disadvantaged Communities		0-5	
	0-5			0-5	
10%	Wtd. AVG	Avg Score * Weight%	10%	Wtd. AVG	Avg Score * Weight%
100%	Total Weight must add to 100%		100%	Total Weight must add to 100%	

SCORES

5 = High	2 = Medium-Low
4 = Medium-High	1 = Low
3 = Medium	0 = None

[2] "R&R" as used herein refers to "Repairs and Replacements"; i.e., the level and frequency of costs that will be incurred to maintain the system in good working order throughout its estimated useful life.

[3] Technology Obsolescence as used herein is defined as the risk that a technology will cease to be the most effective or cost-effective choice during its intended useful life.

SCORING EXAMPLE 1

Candidate Technology: Atmospheric Water Generator (AWG)

Technology Description:
Condenses water from humidity in ambient air; combined with ultrafiltration (reverse osmosis), produces high quality emergency potable drinking water on-site.

Key Technology Attributes:

Costs/Risks	Benefits
▪ Uses substantial quantities of energy to produce small quantities of potable water, resulting in a high quality product that is comparable in cost to purchasing bottled water. ▪ Since the technology condenses moisture in air to produce water, local humidity may be reduced (unknown as to whether in enclosed areas, reductions in humidity would be sufficient to cause some discomfort).	▪ Produces potable water at remote sites in quantities sufficient to meet essential human needs for drinking and cooking. ▪ AWGs have been proven effective in providing small quantities of potable water to meet essential human needs in remote locations, especially areas impacted by extreme events that damaged water infrastructure and/or polluted water resources; they are also used by the military when posted in remote locations that do not have ready access to safe drinking water.

Technology Readiness:
AWGs have been proven to work but the high amount of electricity needed to produce potable water is a deterrent to widescale commercialization. It has been demonstrated effective in areas impacted by natural disasters and other extreme events, and is also used by the U.S. military in remote locations.

Research continues into strategies for substantially increasing the efficiency of electric use and also combining AWGs with clean, distributed generation (especially solar PV with battery energy storage).

Zero Mass Water

One innovative product that bears watching is Zero Mass Water's "Source Hydropanels" that draw ambient air via solar powered fans to condense and collect water vapor. The collected water is then mineralized for taste and disinfected with ozone. One system (comprised of 2 solar PV panels in a single array) costs about $2,000. Depending on the amount of solar radiation and humidity, one system can produce between 4-10 liters (1 to 2.6 gallons per day).

Source Hydropanels have been installed and demonstrated effective in 10 countries with highly variable climates, some with humidities as low as 10%.

Zero Mass Water is showing that AWG in combination with solar PV with batteries can produce potable water in small quantities in remote areas that have neither safe drinking water or electric power.

Source: Zero Mass Water's website.

ATMOSPHERIC WATER GENERATOR

Weighted Score	Score	Factor	Basis for Score
		DROUGHT RESILIENCE	
@ 35% = 0.0875	1	↑ Water Supplies	Creates very small quantities of potable water.
	0	↑ Water Quality	N/A
	0	↑ Water Use Efficiency	N/A
	0	↑ Water Recycling/Reuse	N/A
	0.25	**Avg Score**	***~ 2 gpd potable water per single residential unit.***
		ELECTRIC RELIABILITY	
@ 25% = 0.125	0	↓ Electric Consumption (kWh)	Does not reduce electric consumption.
	0	↓ Electric Demand (kW)	Does not reduce electric demand.
	1	↑ Clean/Renewable Distributed Energy Production (kWh/kW)	When combined with Solar PV, increases clean/renewable distributed energy production.
	1	↑ Demand Response (kW)	May have some Demand Response benefit if could be operated only during hours when the grid is experiencing over-generation.
	0.5	**Avg Score**	***This technology is designed to produce emergency potable water, not to provide electric benefits.***
		ENVIRONMENTAL RESPONSIBILITY	
@15% = 0	0	↓ GHG Emissions	Does not reduce GHG emissions.
	0	↑ Carbon Sequestration	Does not increase carbon sequestration.
	0	↑ Biogas Production, Capture & Use	Does not increase biogas production, capture and use.
	0	↓ Adverse Impacts on Ecosystems	Does not reduce adverse impacts on ecosystems.
	0	**Avg Score**	***This technology is not expected to provide environmental benefits.***
		SOCIO-ECONOMIC IMPACTS	
@ 15% = 0.3375	3	↑ Jobs (Local & Statewide)	Could increase jobs if a market is created for this product and at least some of the manufacturing, assembly, installation, and/or maintenance is performed in California.
	0	↓ Water &/or Energy Costs	Would not decrease water &/or energy costs.
	3	↑ Quality of Life for Local Residents	Could increase the quality of life for local residents, especially those that reside in remote local areas where wells are totally dry.
	3	↓ Reduces Risks to Public Health & Safety	Could reduce health and safety risks due to lack of potable water in remote communities where wells are totally dry.
	2.25	**Avg Score**	Could help to provide emergency potable water in sufficient quantities for drinking and cooking; insufficient water production to meet for all sanitation needs (e.g., personal hygeine and flushing toilets).
		OTHER RESOURCE AND ENVIRONMENTAL BENEFITS	
@10% = 0.17	0	↑ Natural Gas Efficiency	Does not increase natural gas efficiency.
	0	↑ Renewable Natural Gas	Does not increase production of renewable natural gas.
	5	↓ Disadvantaged Communities	Could directly benefit residents of Disadvantaged Communities where wells have gone dry and there is no other source of water.
	1.67	**Avg Score**	The primary advantage of this technology is its ability to provide small quantities of potable water in remote areas distant from water resources. It could also be used to supply potable water for essential human purposes (drinking and cooking) in areas where water quality has become contaminated and there is no other reliable source of clean and safe water.
0.72	**Wtd. Average Score: BENEFITS**		

SAMPLE ADOPTION CHALLENGES SCORE SHEET: ATMOSPHERIC WATER GENERATOR

Weighted Score	Score	Factor	Basis for Score
		COSTS	
@ 25% = 0.875	3	% of Annual Budget	The First Cost is typically significant (akin to buying new kitchen appliances). Operating costs, primarily for purchase of electricity, are relatively high.
	5	Est. Payback (# years)	Given that: (a) First and Operating costs are relatively high for units that do not self-produce electricity, and (b) the quantity of water produced is very small, the payback period tends to be long, even when using the price of bottled water as the basis for valuing the product (water).
	3	Funding Availability	The funding level tends to be significant for most residents or small businesses.
	3	Timeline to Secure Funding	The costs to acquire and operate these systems likely exceed the ability of residential customers and small businesses to directly purchase these systems without a loan or other financial assistance.
	3.5	**Avg Score**	***This score varies widely with the type of AWG system and technology, and the individual resident's financial circumstance. The scores shown here are provided solely to illustrate the scoring process and the rationale that was applied to develop these scores.***
		REGULATORY AND ENVIRONMENTAL RISKS	
@ 25% = 0	0	↑ Permit Violations	This technology would not increase permit violations, as long as the water quality is deemed safe. (Note: *In California, residents that self provide their own water are not subject to water quality regulations*[4].)
	0	↑ Threats to Species & Ecosystems	No apparent threat to species or ecosystems (except that taking humidity out of the air could reduce the amount of humidity that may be uncomfortable for some people and/or animals, especially if the unit is operated within an enclosed area).
	0	**Avg Score**	***This technology is not expected to adversely impact regulatory compliance or the environment.***
		OPERATING RISKS	
@20% = 0.15	1	↑ Operating complexity	Operating complexity appears minimal for most systems.
	1	↑ Risk of outages	Risk of outages appears minimal for most systems.
	1	Requires changes to other systems	This technology would not require changes to other systems, but it would require a fair amount of electricity that may require some electric system upgrades.
	0	Requires specialized staff or training	Most residents could probably perform the minimal maintenance needed (e.g., replacing filters).
	0.75	**Avg Score**	***This technology employs mature, well proven technologies in a new way, with the result that operating risks appear minimal.***
		ECONOMIC RISKS	
@ 20% = 0.35	0	↓ Revenues	Does not reduce revenues.
	3	↑ Operating Costs	The additional cost of electricity could be significant for some.
	1	↑ R&R Frequency and Costs	Costs for O&M appear minimal.
	3	Difficulty of obtaining funding	The difficulty of obtaining funding will be specific to the adopter's financial circumstance.
	1.75	**Avg Score**	***Without Solar PV, electric costs may be prohibitive for some adopters.***

[4] "It is the responsibility of the well owner to ensure that their domestic well water is safe, since the State of California does not regulate domestic well water quality." State Water Resources Control Board website: https://www.waterboards.ca.gov/gama/well_owners.shtml (viewed May 6, 2018).

Weighted Score	Score	Factor	Basis for Score
TECHNOLOGY RISKS			
@10% = 0.3	3	Technology Obsolescence	***Ongoing R&D among many market entrants targets increased water production efficiency, reduced electric consumption, and reduced capital costs. Consequently, it seems likely that more economic and efficient units will be available prior to the end of an AWG unit's useful life. However, as long as purchased AWG units continue producing high quality water throughout the projected payback period upon which the investment decision was made, concerns about technology risks need not deter adoption.***
1.675	Wtd. Average Score: ADOPTION CHALLENGES		

SCORING EXAMPLE 2

Candidate Technology: Food & Beverage Water Recycling/Reuse

Technology Description:
Several technologies are available today that enable cost-effective on-site recycle/reuse of Food and Beverage (F&B) process water. One very interesting technology uses proven physical-chemical processes to efficiently remove solids from F&B process water effluent. When combined with advanced filtration and disinfection, a high quality water resource is produced.

Key Technology Attributes:

Strong fit with State policy goals

This technology helps to achieve the following state policy priorities:

1. Increases long-term drought resilience by:
   a. Increasing recycled water production and use;
   b. Reducing potable water demand by reducing water purchases, surface and/or groundwater withdrawals (by the adopter and/or by its municipal water and wastewater utilities).
2. Increases electric reliability through a combination of energy efficiency, demand reduction, and the potential to increase renewable distributed generation (bioelectricity).
3. Improves environmental quality and climate action by:
   a. Reducing GHG emissions; and
   b. Reducing adverse impacts of effluent discharges on species and ecosystems.
4. Increases biogas production, capture and use.

Significant resource, economic and environmental benefits accrue to all key stakeholders

STAKEHOLDER	RESOURCE	ECONOMIC	ENVIRONMENTAL
ACTOR			
Adopter	▪ New water resource (recycled) ▪ Reduce water purchases ▪ Increase biogas production	▪ Reduce water ▪ Reduce WW discharge costs	▪ Reduce GHG emissions ▪ If discharges effluent to the environment: reduces quantity and improves quality
IMPACTED STAKEHOLDERS			
Water Utility	Reduced water demand	Reduced cost of water resources, demand on water infrastructure, electric use, and capital and operating costs	Reduced environmental impacts attributable to water pumping, treatment and delivery
Wastewater Utility	Reduced WW treatment load	Reduced demand on WW infrastructure, electric use, and capital and operating costs	Reduced environmental impacts attributable to wastewater collection, treatment and discharge
Electric Utility	Reduced electric demand (kWh and kW) attributable to water and WW; potential increase in renewable resource (bioelectricity)	Reduced demand for electric resources and on electric infrastructure, reduced capital and operating costs	Reduced environmental impacts attributable to electric generation and delivery
Gas Utility	Potential increase in renewable gas production		

The resource and economic benefits realized by each impacted utility (water, wastewater, electric, and gas) would flow to their respective ratepayers.

Manageable costs and risks

One technology solution evaluated for this project produced substantial resource and economic benefits that resulted in estimated paybacks less than 3 years. There are few risks, and the primary operating risk – that the technology might fail, resulting in untreated effluent – can be managed by discharging any untreated effluent to the wastewater utility during the system outage.

Technology Readiness:

Physical/Chemical treatment is a proven technology. Although products in this category are undergoing continual improvement, the basic technology is not likely to become obsolete in the foreseeable future. Much more R&D is also being conducted on the water purification portion of these systems that uses a fair amount of electricity. Many market entrants are seeking new ways to perform ultrafiltration that is energy efficient and requires less frequent replacement of the filters.

SAMPLE BENEFITS SCORE SHEET:
FOOD & BEVERAGE WATER RECYCLING/REUSE

Weighted Score	Score	Factor	Basis for Score
		DROUGHT RESILIENCE	
@ 35% = 1.75	5	↑ Water Supplies	Enables Recycle/Reuse of Substantial Quantities of Water (80-90+% of F&B process water has been documented).
	5	↑ Water Quality	Water purification (ultrafiltration and disinfection) creates a high quality recycled water resource. Depending on the level of treatment, effluent can be treated to levels comparable to that of potable water.
	5	↑ Water Use Efficiency	By substantially increasing on-site recycle/reuse, demand for potable or "fresh" water is reduced by the amount of water recycled/reused.
	5	↑ Water Recycling/Reuse	This technology helps to meet California's recycled water policy goals.
	5	**Avg Score**	***Drought resilience can be significantly enhanced by substantially increasing both the quantity and the quality of recycled water production and use.***
		ELECTRIC RELIABILITY	
@ 25% = 0.6875	2	↓ Electric Consumption (kWh)	Direct: Reduces the amount of electricity needed to treat comparable wastewater (WW) quantities and quality vs. conventional centralized biological wastewater treatment. Indirect (Embedded): Avoids electric consumption that would otherwise have been needed to produce the water that is now being saved by using recycled water instead (e.g., electricity saved from avoided surface or groundwater pumping, treatment, and distribution).
	3	↓ Electric Demand (kW)	Direct: Reduces electric demand associated with avoided use of blowers and other high electric intensity equipment and processes that would have been needed for conventional WW treatment. Indirect: Reduces the amount of electric demand not needed to produce, treat and distribute the water that is now being saved.
	4	↑ Clean/Renewable Distributed Energy Production (kWh/kW)	Separating/collecting biosolids at the beginning of WW treatment (vs. at the end, as is typical during conventional WW treatment) preserves the energy value of the biosolids and increases biogas production. The incremental biogas can be used to produce renewable distributed bioelectricity and/or other valuable energy products. Biogas increases of 300+% have been documented.)
	2	↑ Demand Response (kW)	Depending on the volume of WW to be treated, treatment can sometimes be deferred during periods of high electric demand.
	2.75	**Avg Score**	***Electric benefits are significant when measured on a holistic basis: i.e., the quantity of electric energy and demand that can be saved by replacing conventional WW treatment plus "embedded" kWh and kW saved by substantially reducing potable water demand.***
		ENVIRONMENTAL RESPONSIBILITY	
@15% = 0.4125	5	↓ GHG Emissions	Direct: Increases capture and opportunity for beneficial use of biogas, thereby reducing GHGs emitted throughout the WW treatment cycle). Indirect: Reduces electricity related GHGs attributable to avoided electric consumption for both water production, treatment and distribution, and for wastewater treatment.
	0	↑ Carbon Sequestration	Does not increase carbon sequestration.
	4	↑ Biogas Production, Capture & Use	Increases biogas production, capture & use.
	2	↓ Adverse Impacts on Ecosystems	May have beneficial impacts on ecosystems: ▪ If the quality of any treated effluent discharged to the environment is improved, and/or ▪ If the volume of treated effluent discharged to the environment is reduced.

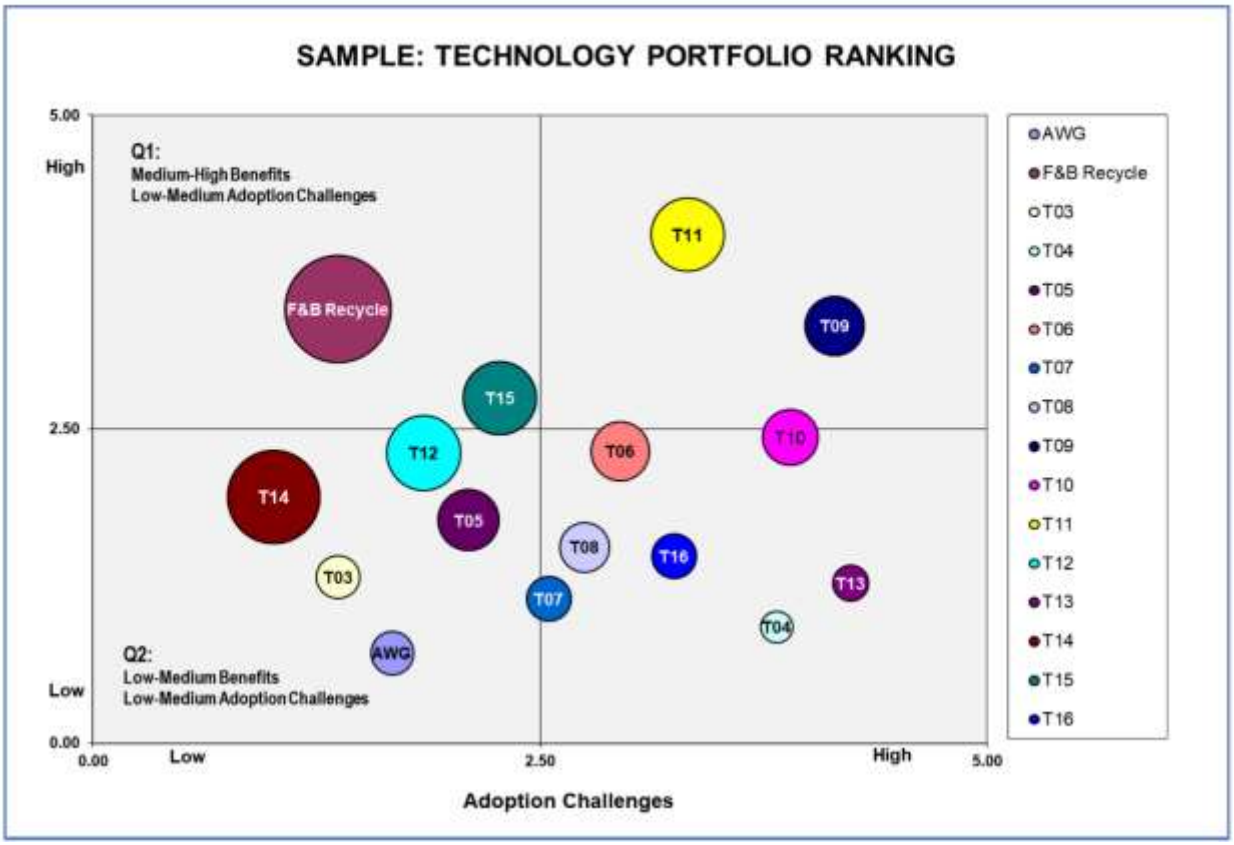
Weighted Score	Score	Factor	Basis for Score
			Note: *Depending on the unique circumstances of the affected ecosystems, impacts may or not be deemed beneficial.*
	2.75	**Avg Score**	***The primary anticipated benefits are reductions in GHG emissions and increased biogas production; some benefits may also accrue to ecosystems but it depends on the ecosystem's unique circumstances.***
SOCIO-ECONOMIC IMPACTS			
@ 15% = 0.375	3	↑ Jobs (Local & Statewide)	Could increase jobs if markets are created for these products and at least some of the manufacturing, assembly, installation, and/or maintenance is performed in California.
	4	↓ Water &/or Energy Costs	Technology Adopter: Reduces purchased water costs. Electric Utility: May realize cost reductions due to net reduction of electric demand (kWh and kW), and potential increases in renewable distributed generation (e.g., bioelectricity) that enable deferring or reducing investments in new electric resources and/or infrastructure. Water/WW Utilities: Customer-side investments that reduce water demand and either defer or reduce need for municipal water and WW capital improvements can reduce both capital and operating costs. Ratepayer Benefits: Reduced electric, water and WW utilities' costs are passed onto the respective ratepayers.
	2	↑ Quality of Life for Local Residents	Increasing recycle/reuse could increase the quality of life for local residents by substantially relieving pressure on existing surface and groundwater resources, making more water available for residential users.
	1	↓ Reduces Risks to Public Health & Safety	On-site recycle/reuse of industrial process water may reduce risks to public health and safety (e.g., where discharges may have been made to natural waterways that were not in compliance with regulatory discharge permit requirements). A modest score of "1" was used to indicate that there could be a benefit, but it need not necessarily be so in all cases.
	2.5	**Avg Score**	***The primary anticipated socio-economic benefits of these technologies are increased jobs and decreased costs of water, energy, and WW treatment.***
OTHER RESOURCE AND ENVIRONMENTAL BENEFITS			
@10% = 0.233	0	↑ Natural Gas Efficiency	Does not increase natural gas efficiency.
	2	↑ Renewable Natural Gas	Increases biogas production that can be used to produce renewable natural gas, one of the state's resource goals. However, the biogas can be used for other purposes, including heating and production of bio-electricity – increased production of biogas does not necessarily mean that production of renewable natural gas will increase. Consequently, a conservative score of "2" was ascribed to this benefit.
	3	↓ Disadvantaged Communities	May benefit residents of Disadvantaged Communities (DACs) whose wells have gone dry by (a) increasing production of recycled water which could be used for non-potable purposes by residents of DACs, and/or (b) reducing competition for limited surface and groundwater supplies.
	2.33	**Avg Score**	***The primary additional benefits of these technologies are (a) potential drought resiliency benefits to DACs, and (b) the potential to increase production of renewable natural gas.***
3.455	**Wtd. Average Score: BENEFITS**		

SAMPLE ADOPTION CHALLENGES SCORE SHEET: FOOD & BEVERAGE WATER RECYCLING/REUSE

Weighted Score	Score	Factor	Basis for Score
		COSTS	
@ 25% = 0.9375	3	% of Annual Budget	In general, the technologies described herein require substantial capital investments (>$100,000) that will require senior management approval. Therefore, although the relative magnitude of the financial investment decision depends on the adopter's unique financial circumstance, a median score of "3" was provided to indicate that procurement of these systems will likely need to be planned for and scheduled. Financing may also be needed.
	5	Est. Payback (# years)	The systems that were considered when scoring these technologies indicated paybacks < 3 years, which is viewed as financially feasible by most organizations.
	4	Funding Availability	The ability to obtain funding depends on the financial strength of the adopter. In general, especially with an anticipated payback < 3 years and fairly modest annual operating costs, we believe that most financially viable organizations are likely able to obtain funding.
	3	Timeline to Secure Funding	The timeline to obtain funding depends on many factors specific to the adopter's financial circumstance, business, cash flows, assets, etc. A modest score of "3" was used or this illustration.
	3.75	**Avg Score**	***In general, although these technologies appear to have a fairly quick payback, the magnitude of the initial investment will likely require scheduling the investment and obtaining funding.***
		REGULATORY AND ENVIRONMENTAL RISKS	
@ 25% = 0	0	↑ Permit Violations	No increases in permit violations are expected. In fact, it is more likely that discharge permit violations would decrease as a result of treating process water effluent to higher standards before discharging to the environment.
	0	↑ Threats to Species & Ecosystems	Similarly, these technologies are not expected to adversely impact species and ecosystems. They may in fact have a beneficial impact by improving the quality of effluent discharges and reducing the volume of industrial effluent discharged to the environment.
	0	**Avg Score**	***These technologies are not expected to adversely impact regulatory compliance or the environment.***
		OPERATING RISKS	
@20% = 0.20	1	↑ Operating complexity	The technologies described herein are deemed fairly simple to operate.
	1	↑ Risk of outages	The frequency of outages is deemed minimal. Further, in the event that one or both portions of the systems (the wastewater treatment portion or the advanced filtration/disinfection portion) were to fail, the effluent could be discharged to the local municipal WW treatment plant.
	1	Requires changes to other systems	Changes to other systems are minimal, and the footprint of the combined systems is relatively small.
	1	Requires specialized staff or training	Relatively little training is required to operate these systems, and no specialized staff are expected to be required.
	1.0	**Avg Score**	***Operating risks for these technologies are relatively low.***
		ECONOMIC RISKS	
@ 20% = 0.134	0	↓ Revenues	These systems are not expected to adversely impact the adopter's revenues. If the targeted benefits are achieved, these technologies may actually reduce the adopter's costs, increasing their competitive position in their market(s) and potentially increasing revenues. In addition, if the adopter also creates valuable products from increased biogas production, new revenue streams may be developed.

Weighted Score	Score	Factor	Basis for Score
	1	↑ Operating Costs	The adopter's operating costs for the new system(s) are expected to be more than fully offset by substantial reduced costs for discharges to municipal WW treatment systems and avoided water purchases.
	1	↑ R&R Frequency and Costs	R&R frequency and costs for these system(s) are expected to be modest.
	0.67	**Avg Score**	***Economic risks of these systems are expected to be modest.***
		TECHNOLOGY RISKS	
@10% = 0.1	**1**	Technology Obsolescence	***Physical/Chemical treatment is a proven technology. Although products in this category are undergoing continual improvement, the basic technology is not likely to become obsolete in the foreseeable future. Much more R&D is being conducted on the water purification portion of these systems that uses a fair amount of electricity. Many market entrants are seeking new ways to perform ultrafiltration that is energy efficient and requires less frequent replacement of the filters that are fairly costly. Consequently, it seems likely that more economic and efficient units will be available prior to the end of a system's useful life. However, with such a short payback period, technology risks are fairly low.***
1.3715	**Wtd. Average Score: ADOPTION CHALLENGES**		

SAMPLE OUTPUT: BUBBLE DIAGRAM



APPENDIX K: Comprehensive Valuation of Multiple Benefits

Valuation of Distributed Water Resources

Appropriate valuation of water benefits created through customer-side distributed water resources is crucial to a successful Water PPP program.

There are many different approaches to valuing water savings: short or long-run average cost, marginal cost, or "market" prices. The California Public Utilities Commission (CPUC) explored the relative merits of these and other methodologies during two rulemakings: the 2013-2014 Energy Efficiency Portfolios[226] Water-Energy Nexus Rulemaking[227] and decided to value water resources on the same basis as customer energy programs, the avoided cost of the long-run marginal supply.[228]

Energy Embedded in Water, or "Embodied Energy"

The most significant outcome from the CPUC's deliberations in May 2012 with respect to the state's water-energy nexus was its decision to recognize "embodied energy", or "energy embedded in water." The CPUC agreed with stakeholders' testimony that the sum of energy inputs to water that avoided (saved) by saving water should be included when computing incentives for energy efficiency programs.[229] Recognition of energy inputs to water and wastewater both upstream and downstream of an energy customer's site is a departure from prior CPUC policies that favored a very conservative measurement that recognized only on-site energy benefits. The CPUC's primary caveat was that since unregulated energy utilities do not pay into the regulatory public purpose program surcharge[230] that funds customer energy efficiency projects, only energy provided by the state's regulated energy utilities would be included in the embodied energy computation.

The Statewide Perspective is Appropriately Holistic

As a regulator with specific jurisdictional boundaries, the CPUC was unable to consider a more holistic approach that values all benefits that accrue to the state and its residents when water and/or energy are saved. Those discussions ensued through the Water-Energy Nexus

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226 *Order Instituting Rulemaking to Examine the Commission's Post-2008 Energy Efficiency Policies, Programs, Evaluation, Measurement, and Verification, and Related Issues*. CPUC Rulemaking 09-11-014. November 20, 2009.

227 *Order Instituting Rulemaking into Policies to Promote a Partnership Framework between Energy Investor Owned Utilities and the Water Sector to Promote Water-Energy Nexus Programs*. CPUC Rulemaking 13-12-011. Filed December 19, 2013.

228 *Decision Regarding Tools for Calculating the Embedded Energy in Water and an Avoided Capacity Cost Associated with Water Savings*. CPUC Rulemaking 13-12-011. Decision 15-09-023, September 17, 2015.

229 *Decision Providing Guidance on 2013-2014 Energy Efficiency Portfolios and 2012 Marketing, Education, and Outreach*. CPUC Rulemaking 09-11-014. Decision 12-05-015, May 10, 2012.

230 Then known as the "Public Goods Charge", or "PGC".

Rulemaking during which the CPUC adopted a water avoided cost model that emulated existing energy avoided cost methodologies for CPUC jurisdictional energy efficiency programs.

Regulatory protocols such as the CPUC's energy avoided cost model are structured to achieve specific goals and objectives within the regulator's jurisdiction. The CPUC's regulatory policies and protocols governing valuation of energy savings were structured to encourage customer adoption of energy efficiency while protecting energy ratepayers from over-compensating customers for these types of investments. For the reasons cited, the CPUC's computation of energy embedded in water, or embodied energy, does not consider all avoided energy inputs to save water—only those that can be proven to have been provided by investor-owned energy utilities subject to the CPUC's jurisdiction.

In that context, valuable resource benefits are not recognized through regulatory programs that are inhibited from according value to all resource benefits gained for the state. The ability to accord value to all benefits could make the difference between a project that is implemented, vs. one that is not. Customer projects that may have been able to contribute substantially towards achieving the state's ambitious resource, environmental, and economic policy goals may not be implemented if a project is deemed not cost-effective for the customer that needs to make the investment.

While individual state agencies may not be able to recognize benefits comprehensively, the state can and should develop its own metrics that value resource and environmental benefits of specific actions, whether the actions are taken by utilities or their customers, to enable more effective investments of public funds.

Recognition of all value streams created by distributed water resources is essential to the success of a Water PPP program. Without it, there is no basis for providing financial incentives to water users to make drought resilient choices that benefit all ratepayers. The example below illustrates why a holistic methodology for measuring and recognizing both water and energy benefits is crucial to optimizing state investments.

> Example 1: A large water customer purchases and installs a packaged wastewater treatment system with advanced filtration and disinfection at its manufacturing facility. The system collects and treats process water effluent to levels needed for reuse at its facility, which is a high quality recycled water that can be used for all beneficial purposes authorized by the SWRCB, except for drinking water.
>
> Table J-1 shows the flow of costs and benefits among the water customer and its water, wastewater, and energy utilities. In this example, the customer's electric use actually increases since the customer's "base case"—do not purchase and install the system: continue to discharge wastewater to the municipal sewer—would have not required any electricity at the customer's facility.

Table K-1: Costs and Benefits of Customer-Side Distributed Water Resources

<table>
<tr><th></th><th>Water Customer</th><th>Water Utility</th><th>Wastewater Utility</th><th>Electric Utility</th><th>“The Public”</th></tr>
<tr><td colspan="5">Costs</td><td></td></tr>
<tr><td>Equipment Cost</td><td>X</td><td></td><td></td><td rowspan="3">Increased electric consumption and demand by Customer</td><td rowspan="3">GHG Emissions could increase if more electricity is used by the Customer than is saved by its Water and Wastewater Utilities</td></tr>
<tr><td>Electric Purchases for Wastewater and Recycled Water System</td><td>X</td><td></td><td></td></tr>
<tr><td>Other Operating Costs</td><td>X</td><td></td><td></td></tr>
<tr><td colspan="5">Benefits</td><td></td></tr>
<tr><td>Site Water Consumption</td><td>Reduced Purchase Costs</td><td>Reduced Water Demand and Associated Avoided Costs of Water Supplies, Water Infrastructure, Energy & Other Operating Costs</td><td rowspan="2">Reduced Wastewater Flows and Associated Avoided Costs of Wastewater Infrastructure, Energy & Other Operating Costs</td><td>Reduced Electric Demand and Associated Avoided Costs of Electricity, Electric Infrastructure, and Operating Costs Associated with Water</td><td rowspan="2">1—Increased Drought Resilience

2 - Reduced GHG Emissions Associated with Reduced Electric Use by Water and Wastewater Utilities</td></tr>
<tr><td>Site Discharges to Municipal Wastewater Treatment Facility</td><td>Reduced Wastewater Discharge Fees</td><td></td><td>Reduced Electric Demand and Associated Avoided Costs of Electricity, Electric Infrastructure, and Operating Costs Associated with Wastewater</td></tr>
</table>

Under this scenario, the customer bears the costs of purchasing, installing, operating and maintaining the new system. Economic values would accrue to the customer through reduced water purchases from the water utility and reduced cost of wastewater service from the wastewater utility. Whether the adoption decision was “cost-effective” depends on the perspective of each of the impacted entities.

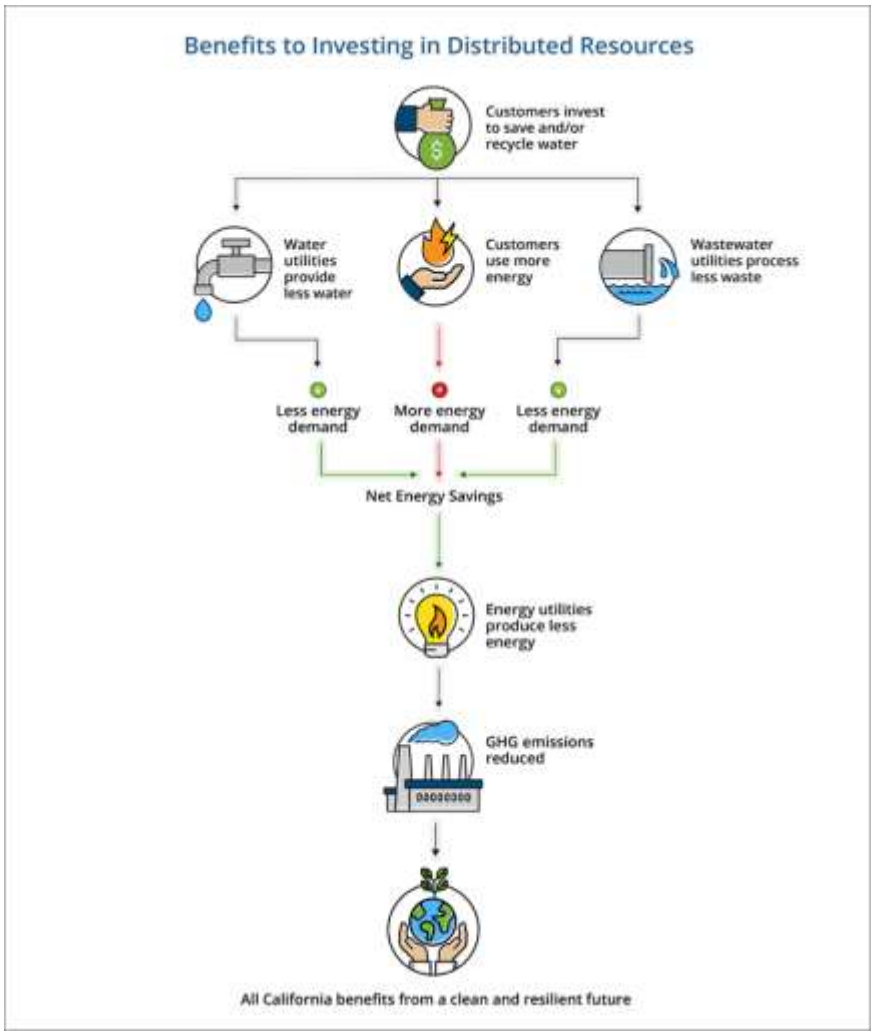
1. Customer:
   - Costs: The customer incurs capital and operating costs by purchasing and installing the new equipment. The customer also increases its electric requirements by the amount of electricity needed to operate the new equipment.
   - Benefits: The customer receives economic benefits through water savings (reduced purchases of water from its water utility) and reduced wastewater fees (reduced discharges to the municipal wastewater system due to recycling and reuse its process water effluent).

   Absent (a) any additional considerations, such as regulatory compliance, water quality, environmental impacts, and/or other factors not considered in this scenario; and (b) grants, subsidies or incentives that may be available; the Customer's investment decision will depend on the relationship of its incremental costs to the benefits the Customer expects to achieve.
2. Water Utility:
   - Costs: No additional costs are incurred by the water utility.
   - Benefits: Costs of water service will be reduced by (a) the amount of water that is no longer needed by the Customer, and (b) the pro rata portion of avoided or deferred costs of capital repairs, replacements, and enhancements, and reduced operating costs (energy and other).
3. Wastewater Utility:
   - Costs: No additional costs are incurred by the wastewater utility.
   - Benefits: Costs of wastewater service will be reduced by the pro rata portion of avoided or deferred costs of capital repairs, replacements, and enhancements, and reduced operating costs (energy and other).
4. Electric Utility:
   - Costs: Additional electricity is used by the Customer for the new equipment that increases the costs of procuring and delivering electricity. To the extent that the incremental electric demand exceeds the electric utility's capacity, capital investments may be needed.
   - Benefits: Costs of electric service will be reduced by (a) the amount of electricity and demand that is no longer needed by the Customer's Water and Wastewater Utilities, and (b) the pro rata portion of avoided or deferred costs of capital repairs, replacements, and enhancements, and reduced operating costs.
5. "The Public":
   - Costs: If incremental electric use by the Customer exceeds the amount of electricity saved by the Customer's Water and Wastewater Utilities, greenhouse gas emissions could increase on a net basis, triggering need for costs for GHG emissions mitigation.
   - Benefits: The public benefits from reduced drought risk and increased water supply availability. The public also benefits from reduced GHG emissions, if more electricity is saved than is used by the Customer.

Most state programs are presently managed from a single perspective, whether it's the water, wastewater or energy utility, or the California Climate Plan developed and administered by the Air Resources Board (ARB). The current single agency perspective results in sub-optimal decisions from the perspective of statewide benefits.

In order to assure that public investments are optimized to the greatest possible extent, a comprehensive statewide metric is needed that can be applied consistently by all state programs. The metric should recognize the multiple resources produced by any strategy or technology. Adjustments may still need to be made if there are specific legislative restrictions on authorized purposes for which certain public funds can be applied. That could potentially be addressed by allocating preference percentages; for example, if public funds are specifically designated for "drought resilience", water benefits could account for 70 percent of the score, leaving the remaining 30 percent for recognition of additional important state benefits.

Figure K-1: Multiple Benefits Created by Distributed Water Resources



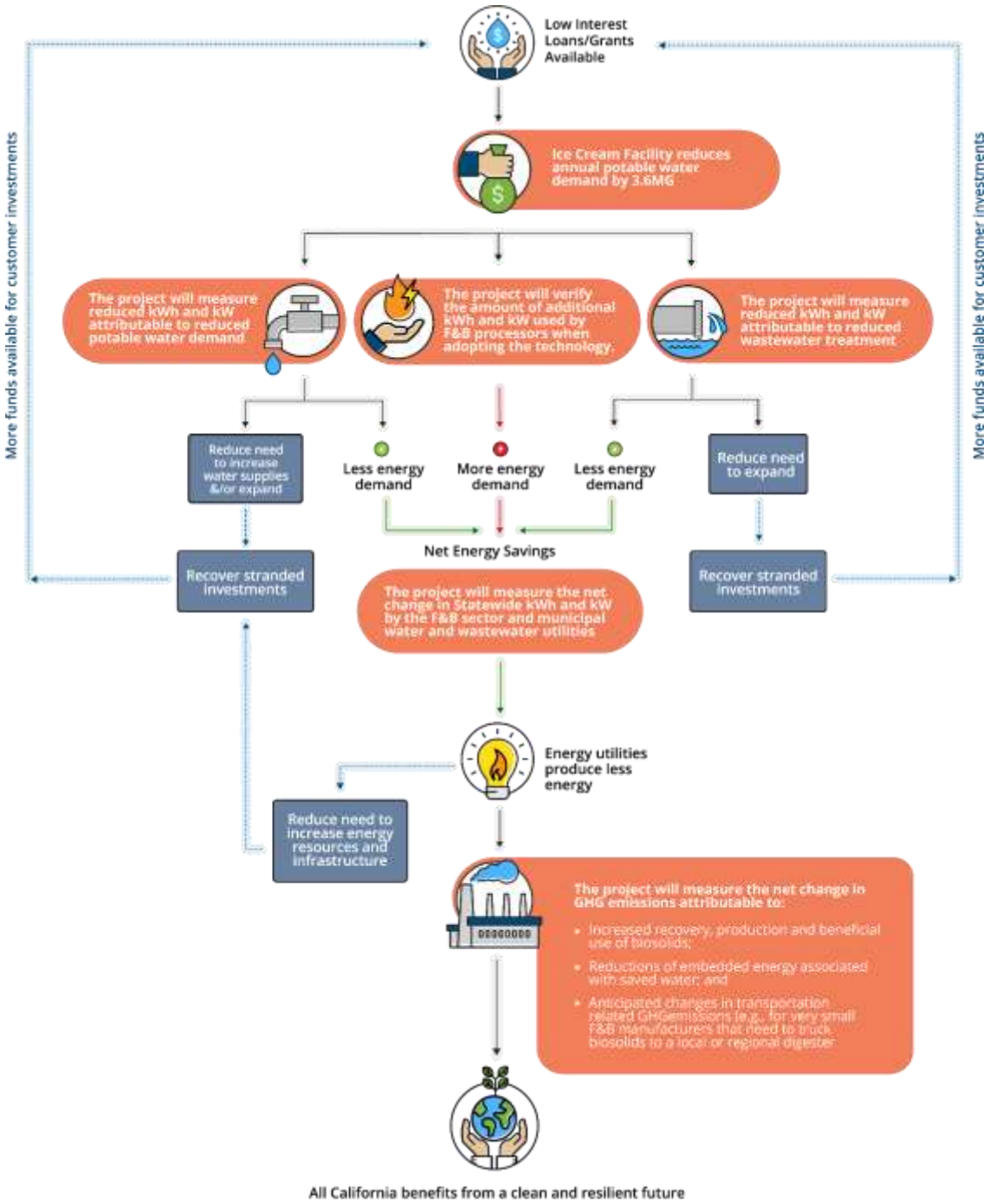
Evaluated solely from a single resource, single customer site perspective, California's current policies dissuade customers from investing in distributed resources.

- When water users invest in onsite collection, treatment, and recycle/reuse of their own wastewater, they increase electric use at their site since they are now performing functions that would otherwise be performed by centralized municipal water and wastewater treatment facilities. Customer-side water treatment, recycle and reuse projects thus become ineligible for electric efficiency incentives.
- This single resource, single-site impact model ignores the true benefits to the State:
  - A water user makes an investment to treat, recycle, and reuse its own wastewater, substantially reducing its potable water demand and reducing municipal wastewater treatment.
  - The water utility reduces its energy use by reducing the amount of water it needs to supply, treat, and deliver.
  - The wastewater utility reduces its energy use by reducing wastewater collection and treatment; and, where applicable, also reduces energy associated with production and delivery of recycled water.
- Greenhouse gas emissions are reduced by the amount of statewide electric savings.

The net impacts for the State are thus positive.

Optimizing State investments requires a holistic perspective: what are the total NET benefits to the State?

Figure K-2: Comprehensive Approach to Valuing Multi-Benefit Projects



<u>EXAMPLE</u>: An ice cream manufacturer installs equipment to treat process wastewater on-site for direct recycle/reuse.

APPENDIX L: Accelerated Compliance with New Codes and Standards

California has some of the most aggressive codes and standards for water efficient plumbing fixtures and appliances. Many programs have been implemented by state agencies, water and energy utilities, and industry associations to encourage residential water users to adopt fixtures and appliances that either meet or exceed the new codes.

Programs specifically designed to increase and accelerate customer adoption of new, more efficient fixtures and appliances is important because California's Title 20 Appliance Efficiency Regulations apply to sellers, not to water users.[231] Specifically, California's Title 20 Appliance Efficiency Regulations requires sellers of fixtures, appliances, and equipment to certify that fixtures and appliances that are "sold or offered for sale" in California comply with then-current code. In this manner, the state assures that new fixtures and appliances purchased in California will meet or exceed current code.

Until recently, there was no requirement for water users to upgrade fixtures and appliances before the end of their "useful life". For many water users, "useful life" is generally defined as the length of time (typically measured in number of years) that any particular fixture or appliance continues to function or operate in a manner that meets each water user's criteria as to what constitutes "functioning" or "operating".

In 2009, Senate Bill 407 [Padilla, 2009] required that single family residences offered for sale on or after January 1, 2017 be equipped with water efficient plumbing fixtures that are compliant with then-current California codes. The law requires sellers or transferors of single family residences to sign a disclosure attesting to such compliance, or disclosing non-compliance. Effective January 1, 2019, sellers or transferors of multi-family residential properties and commercial properties must similarly comply. In addition, multi-family and commercial properties that require building permits and meet certain criteria (sum of concurrent permits by same applicant increase floor space in a building by more than 10 percent, and/or total construction costs estimated in the building permit exceed $150,000) are required to bring all plumbing fixtures up to code. The duty for enforcement of multi-family and commercial property compliance was delegated to local building departments.

> Exceptions to the requirements for multi-family and commercial properties were granted to local governments that had enacted ordinances prior to July 1, 2009 that required retrofit of noncompliance plumbing fixtures.

Energy Commission staff estimated annual water savings from 2015 and 2016 code changes to indoor water fixtures (toilets, urinals, faucets and faucet aerators, and showerheads) would save

231 California Energy Commission. *2015 Appliance Efficiency Regulations*. Publication Number CEC–400–2015–021.

about 12.2 billion gallons per year. The associated annual savings of electricity and gas attributable to reduced hot water consumption from these efficient fixtures were estimated at 303 GWh and 46 Mtherm respectively. Using the CEC's emission factors[232], annual greenhouse gas emission reductions were estimated at 3.5 million tons (1,756 tons).

Table L-1: Estimated Statewide Annual Savings from Title 20 Water Efficiency Standards

California Title 20 Changes to Water Efficiency Standards	Estimated Annual Savings			
	Water (MG)	Electricity (GWh)	Gas (Mtherm)	GHGs (eCO_2)
2015 Appliance Efficiency Regulations (effective January 1, 2016)				
Toilets, Residential (1.28 gpf)	808	8	n/a	58,880
Toilets, Commercial	96	1	n/a	
Urinals (0.125 gpm wall-mounted, 0.5 gpm others)	308	3	n/a	12,290
Faucets, Residential Lavatory: 1.5 gpm eff. Sept. 1, 2015; 1.2 gpm eff. July 1, 2016	2,450	62	8	1,807,370
Faucets, Kitchen (1.8 gpm)	3,290	83	11	
Faucets, Public Lavatory (0.5 gpm)	1,420	14	6	
Subtotal 2015 Appliance Efficiency Regulations	**8,370**	**171**	**25**	**1,878,540**
2016 Showerheads (Tier 1: 2.0 gpm)	2,432	83	12	
2018 Showerheads (Tier 2: 1.8 gpm)	1,448	49	8	
Subtotal Showerhead Regulation Changes	**3,880**	**132**	**20**	
Estimated Annual Savings	**12,250**	**303**	**45**	**3,511,151**

Sources: Compiled from [1] California Energy Commission. *Staff Analysis of Water Efficiency Standards for Toilets, Urinals and Faucets*. Publication Number CEC–400–2015–021; [2] California Energy Commission. *Staff Analysis of Water Efficiency Standards for Showerheads*. Publication Number CEC-400-2015-027.

The projected annual savings are expected to be much higher when the existing stock of noncompliant plumbing fixtures are projected to be exhausted (referred to as "full turnover"): during Year 2038 for toilets, urinals and faucets, and during Year 2039 for showerheads. Presuming no other changes to California's water efficiency standards occur over that period, estimated annual savings are 127.4 billion gallons of water, 2,999 GWh of electricity, and 425 million therms of natural gas. The projected greenhouse gas emissions reductions from these energy savings are 36.1 million tons of CO_2 equivalents per year.

232 California Energy Commission. *Energy Aware Planning Guide*. February 2011. Publication Number CEC-600-2009-013.

Table L-2: Estimated Annual Statewide Savings from Title 20 Water Efficiency Standards

California Title 20 Changes to Water Efficiency Standards	Estimated Annual Savings at Full Turnover				
	Projected Year	Water (MG)	Electricity (GWh)	Gas (Mtherm)	GHGs (tons eCO_2)
Toilets, Urinals and Faucets	2038	88,590	1,677	223	19,882,898
Showerheads	2039	38,802	1,322	202	16,216,946
Total Estimated Annual Savings		**127,392**	**2,999**	**425**	**36,099,844**

Sources: Compiled from [1] California Energy Commission. *Staff Analysis of Water Efficiency Standards for Toilets, Urinals and Faucets*. Publication Number CEC–400–2015–021; [2] California Energy Commission. *Staff Analysis of Water Efficiency Standards for Showerheads*. Publication Number CEC-400-2015-027.

The Incremental Value of Accelerated Code Compliance

Notably, although substantial resources and environmental benefits would be achieved during the first full year of implementation, these expected annual benefits are dwarfed by the anticipated annual benefits in 2038, when "full turnover" is expected.

> *"Full Turnover" occurs when installed fixtures and appliances of the type subject to the Title 20 changes have finally been changed out and meet "today's" code. The projected value at "full turnover" does not include potential additional savings that may accrue over the 20 year period due to future changes to Title 20.*

Table L-3: Incremental Annual Statewide Value of Early Title 20 Water Fixtures Changeouts

California Title 20 Changes to Water Efficiency Standards	Estimated Annual Savings at Inception vs. "Full Turnover"				
	Projected Year	Water (MG)	Electricity (GWh)	Gas (Mtherm)	GHGs (tons eCO_2)
First Full Year	2018	12,250	303	45	3,511,151
At "Full Turnover"	2038	127,392	2,999	425	36,099,844
Incremental Annual Value of Early Changeouts		**115,142**	**2,696**	**380**	**32,588,693**

Sources: Compiled from [1] California Energy Commission. *Staff Analysis of Water Efficiency Standards for Toilets, Urinals and Faucets*. Publication Number CEC–400–2015–021; [2] California Energy Commission. *Staff Analysis of Water Efficiency Standards for Showerheads*. Publication Number CEC-400-2015-027.

For many water users, "useful life" is the length of time that a fixture or appliance continues to function or operate in a manner that meets each water user's criteria as to what constitutes "functioning" or "operating". Incentives could accelerate changeouts to more efficient fixtures "today."

> *Many 1.5 gpm showerheads are already available, both online and in retail stores, some with flow restrictors that can dial flows to as low as 0.5 gpm. Project staff obtained prototypes of 1.0 gpm units that are under development, and procured and tested other units with variable flows less than 1.0 gpm.*

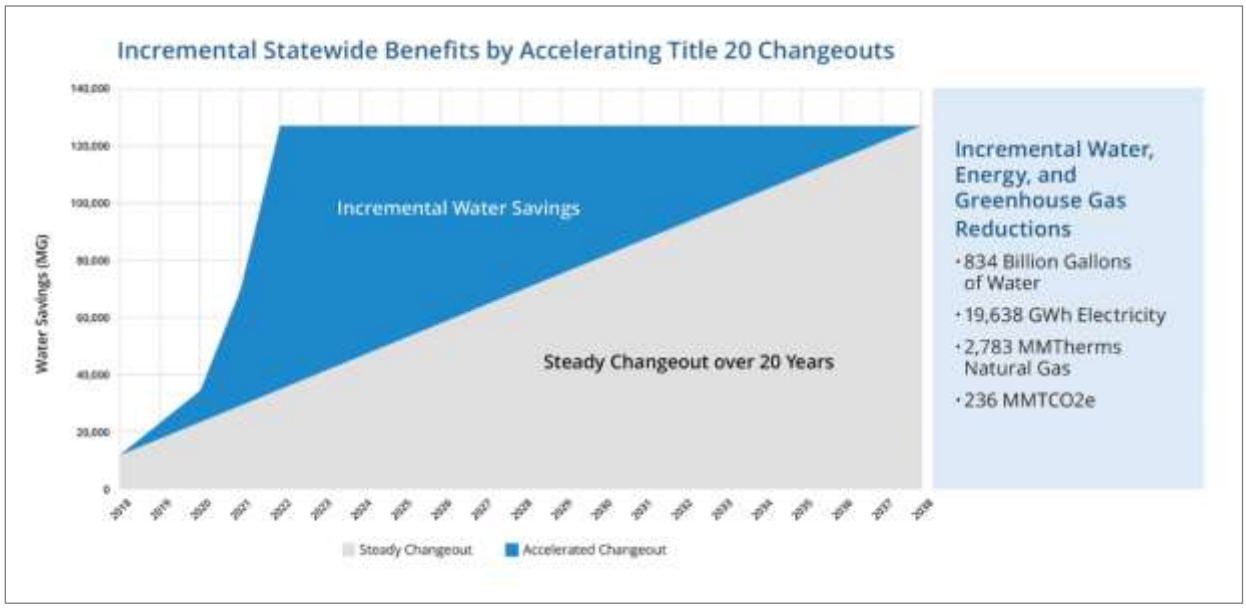
Although California does not yet require residential lavatory faucets to use 0.5 gpm aerators, retailers already sell these fixtures to generally positive reviews, especially from parents that stated these aerators substantially reduce water waste.[233]

The difference between projected annual benefits in 2018 and 2038 is staggering, and leads to a natural conclusion:

The incremental water, energy and GHG benefits at "full turnover" are too significant to defer.

Figure L-1 shows the incremental water, energy and greenhouse gas benefits that could be achieved if all water fixtures could be brought up to current Title 20 code within 5 years, instead of 20. The estimated incremental benefits do not include additional benefits that could accrue if additional code upgrades are made to Title 20 over the 20 year period.

Figure L-1: Incremental Annual Statewide Benefits by Accelerating Title 20 Changeouts



Key Findings

1. Annual savings of water, electricity and natural gas, and associated greenhouse gas reductions increase by a factor of about ten, once the existing inventory of noncompliant plumbing fixtures is fully exhausted (that is, all noncompliance plumbing fixtures are replaced with fixtures that comply with codes effective as of 2018).
2. The incremental benefits should be targeted for achievement as soon as possible.

Recommendations

1. Substantially enhance financial and technical assistance to encourage residential and non-residential water users to upgrade their plumbing fixtures to current or future code prior to

233 Source: Customer reviews of 0.5 low flow faucet aerators on amazon.com and other purchasing sites. One manufacturer received an average score of 4.4 out of 338 reviews that praised the water savings and reduced water waste. One package of six 0.5 aerators cost less than $10 including shipping.

the end of their useful lives (that is, encourage early retirements of existing plumbing fixtures that are not in compliance with 2018 codes).

2. Provide incentives to manufacturers and distributors to bring above code choices to Californians.

APPENDIX M: Disadvantaged Communities

Many state and federal grant programs express preference for funding projects that benefit "disadvantaged communities." The definition as to what exactly constitutes a disadvantaged community (DAC) for purposes of any particular funding or grant program—and how that definition is applied—is left to the grant administrator, subject to any specific requirements that may have been stipulated by the funding source(s).

Lack of a consistent methodology for defining a "Disadvantaged Community" (DAC) among California state agencies leads to confusion, sometimes thwarting or diminishing the benefits intended for eligible DACs. Confusion increases when different state agencies interpret and apply these definitions differently for various types of state funded programs.

California Policy Overview

In 2006, the passage of the California Global Warming Solutions Act (AB 32) required California to reduce greenhouse gas (GHG) emissions to 1990 levels by 2020. To achieve these targets, the California Air Resources Board (ARB) was charged with developing a Scoping Plan.[234] The first Plan was approved in 2008 and ARB identified the Cap-and-Trade Program as an approach to reduce greenhouse gas (GHG) emissions. The Scoping Plan is updated every 5 years with the most current revision released November 2017, which takes into account SB 32—setting a new GHG emission reduction target of 40 percent below 1990 levels by 2030.[235]

Multiple new laws and regulations have been enacted that require Greenhouse Gas Reduction Funds to be allocated to—or for the benefit of—disadvantaged communities (DAC). These include the following bills:

- ***Senate Bill 535*** directed 25 percent of the proceeds to fund projects that provide benefits to DACs with a minimum of 10 percent of the funds for projects within DACs. Under SB 535, the California Environmental Protection Agency (CalEPA) is also given the responsibility of identifying DACs based on geographic, socioeconomic, public health and environmental hazard criteria.[236]
- ***Assembly Bill 1550*** amended the law so that 25 percent of the funds are used directly in DACs identified by CalEPA. Another 5 percent of the funds must be used to assist low-income communities or households within half a mile of a DAC.[237]

234 California Air Resources Board. *AB 32 Scoping Plan.* California Environmental Protection Agency Air Resources Board. 6 October 2017.

235 Senate Bill 32, 2015-2016 Regular Session, Chapter 249, 2016.

236 Senate Bill 535, 2011-2012 Regular Session, Chapter 830, 2012.

237 Assembly Bill 1550, 2015-2016, Regular Session, Chapter 369, 2016.

The CalEPA utilized the California Environmental Screening Tool (CalEnviroScreen) 2.0 to implement SB 535. The tool was developed with public input through multiple workshops in 2014 and ultimately ranks California's 8,000 census tracts to determine which are considered disadvantaged. Cal/EPA Secretary Matt Rodriquez said: "By identifying California communities with the greatest cumulative exposure to pollution, we can be more effective in directing limited state resources to where they are needed most."

Federal Definitions

The problem is that the term "disadvantaged communities" has been used by both the federal government and state agencies for many years with an entirely different definition. Prior to CalEnviroScreen, the tool most used to identify communities targeted for specialized assistance was income, in part for consistency with federal assistance programs that co-fund some state programs.

Federal water safety assistance programs for small and disadvantaged communities:[238]

(c) Eligible entities. An eligible entity under this section—

(1) is—

(A) a public water system;

(B) a water system that is located in an area governed by an Indian Tribe; or

(C) a State, on behalf of an underserved community; and

(2) serves a community—

(A) that, under affordability criteria established by the State under section 300j–12(d)(3) of this title, is determined by the State—

(i) to be a disadvantaged community; or

(ii) to be a community that may become a disadvantaged community as a result of carrying out a project or activity under subsection (b); or

(B) with a population of less than 10,000 individuals that the Administrator determines does not have the capacity to incur debt sufficient to finance a project or activity under subsection (b).

Federal Community Facilities Direct Loan & Grant Program[239]

Priority point system accords special preference to:

- Small communities with a population of 5,500 or less
- Low-income communities having a median household income below 80 percent of the state nonmetropolitan median household income.

238 Excerpt from 42 U.S. Code The Public Health and Welfare, Subchapter XII—Safety of Public Water Systems, § 300j–19a - *Assistance for small and disadvantaged communities.*

239 U.S. Department of Agriculture and Rural Development website: https://www.rd.usda.gov/programs-services/community-facilities-direct-loan-grant-program.

DAC Definitions Used by State Agencies

Table M-1 lists some of the DAC definitions used by various state agencies for different purposes.

Table M-1: Disadvantaged Community Definitions

Defining Entity	Definition
California Air Resources Board (Cap-and-Trade Auction Proceeds)	Utilizes CalEPA's CalEnviroScreen designated census tracts but also includes geographic criteria of "half-mile zones around these disadvantaged community census tracts" that are applicable to some projects.[240]
California Energy Commission (CEC)	Utilizes CalEnviroScreen to guide EPIC investments in "Disadvantaged Communities" in accordance with Senate Bill 535 (De León).[241]
The Safe Drinking Water Act & Water Code Section 79505.5 (Proposition 1)	A community with an annual median household income (MHI) that is less than 80% of the statewide annual MHI. The SWRCB determines DAC eligibility on the basis of an entire water agency's MHI. The Department of Water Resources (DWR) allows determination of eligibility for DAC status at the level of individual parcels within a water agency's service.
Drinking Water State Revolving Funds	"Small Disadvantaged Community means a community with a population of less than 20,000, and either: (1) a community Median Household Income (MHI) of less than eighty percent (80%) of the statewide MHI; or (2) a community sewer rate of more than four percent (4%) of the community's MHI."

Below are examples of how some state programs apply these definitions.

1. Proposition 1. California Water Code Section 79702 employs a further definition: An "'Economically distressed area' means a municipality with a population of 20,000 persons or less, a rural county, or a reasonably isolated and divisible segment of a larger municipality where the segment of the population is 20,000 persons or less, with an annual median household income that is less than 85 percent of the statewide median household income, and with one or more of the following conditions as determined by the department: (1) Financial hardship. (2) Unemployment rate at least 2 percent higher than the statewide average. (3) Low population density."[242] DWR has created a mapping tool for determining whether or not any particular community falls within an "economically distressed area" (EDA). Some grant assistance within Water Bond Proposition 1 has been specifically designated for qualified EDAs.
    a. The SWRCB decided that for purposes of its Drinking Water State Revolving Fund program (DWSRF), eligibility for DAC grants will be made at the level of a small public

240 California Air Resources Board Website: https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/535investments.htm.

241 California Energy Commission Website: http://www.energy.ca.gov/commission/diversity/definition.html and CPUC's website: http://www.cpuc.ca.gov/discom/.

242 California Water Code § 79702 and Department of Water Resources (DWR) website: http://wdl.water.ca.gov/irwm/grants/resources_eda.cfm.

water system's entire service area. The decision to apply the DAC designation to a public water system's entire service area was not specified by legislation.

b. The California Department of Water Resources (CDWR) determines DAC applicability on a project specific basis; that is, if a project is deemed to benefit a DAC area within a water agency's service area, the project may be eligible. The Air Resources Board (ARB) uses a similar project specific determination for communities that are DAC sub-sets of any particular jurisdiction (for example, of a municipality or of a water agency).

Another complication was introduced with a new category of "disadvantaged community, an "Economically Distressed Area (EDA)": For purposes of Proposition 1, communities with an MHI less than 85 percent of statewide MHI could qualify for certain types of assistance.

2. CPUC Rulemaking 15-03-010 was opened in March 2015 To Identify Disadvantaged Communities in the San Joaquin Valley and Analyze Economically Feasible Options to Increase Access to Affordable Energy in those Disadvantaged Communities. A Phase 1 Decision was issued May 15, 2017 that ordered a study to be conducted. The study will be reviewed during Phase II. This Rulemaking was established to implement California Public Utilities Code Section 783.5 [Assembly Bill 2672 Perea, 2014] that stipulated the following criteria:
   - At least 25 percent of residential households with electrical service are enrolled in the California Alternate Rates for Energy (CARE) program.
   - The DAC has a population greater than 100 persons within its geographic boundary.
   - The geographic boundary of a DAC is no further than seven miles from the nearest natural gas pipeline.
3. The Tulare Lake Basin Disadvantaged Community Water Study was funded by Proposition 1. The study uses the DAC definition established by Proposition 84: a community whose median household income is 80 percent or less than the statewide median household income.[243]

The CalEnviroScreen Tool

CalEnviroScreen is a mapping tool that "identifies California communities that are most affected by many sources of pollution, and where people are often especially vulnerable to pollution's effects." The tool draws from environmental, health, and socioeconomic information to create scores for each census tract in California. The areas with higher scores (for example 100 percent) have higher pollution burdens and—as mentioned above—communities with a score of 75 percent or higher are designated as DACs.

The Tool was developed as part of the CalEPA's 2004 Environmental Justice Action Plan. This plan asked for the development of guidance to analyze the impacts of multiple pollution sources in California communities. CalEnviroScreen version 1.0 was thus released in 2013 after

243 Provost & Pritchard Consulting Group. *Tulare Lake Basin Disadvantaged Community Water Study—Annual Report, November 2016.*

12 public workshops with version 2.0 released in 2014. The below table describes the factors that were used to determine "disadvantaged" scores under CalEnviroScreen version 2.0.

Table M-2: CalEnviroScreen Indicators[244]

CalEnviroScreen Indicators	Description	Data Sources
Ozone (Air Quality)	Exposure Indicator: Amount of the daily maximum 8-hour ozone concentration over the California 8-hour standard (0.070 ppm), averaged over three years (2009 to 2011).	Air Monitoring Network, California Air Resources Board (CARB)
Drinking Water Contaminants	Exposure Indicator: Drinking water contaminant index for selected contaminants.	Drinking Water Systems Geographic Reporting Tool, California Environmental Health Tracking Program, California Department of Public Health (CDPH), Public Water System Location Data, Safe Drinking Water Information System, U.S. Environmental Protection Agency, Water Quality Monitoring Database, CDPH, Domestic Well Project, Groundwater Ambient Monitoring and Assessment (GAMA) Program, State Water Resources Control Board, Priority Basin Project, GAMA Program, State Water Resources Control Board and U.S. Geological Survey
Pesticide Use	Exposure Indicator: Total pounds of selected active pesticide ingredients (filtered for hazard and volatility) used in production-agriculture per square mile.	Pesticide Use Reporting, California Department of Pesticide Regulation (DPR)
Groundwater Threats	Environmental Effects Indicator: Sum of weighted scores for sites within each census tract.	GeoTracker Database, State Water Resources Control Board (SWRCB)
Poverty	Socioeconomic Factors Indicator: Percent of the population living below two times the federal poverty level (5-year estimate, 2008-2012).	American Community Survey, U.S. Census Bureau
Unemployment	Socioeconomic Factors Indicator: Percent of the population over the age of 16 that is unemployed and eligible for the labor force. Excludes retirees, students, homemakers, institutionalized persons except prisoners, those not looking for work, and military personnel on active duty (5-year estimate, 2008-2012).	American Community Survey, U.S. Census Bureau

244 Rodriguez, Matthew and George Alexeff. *California Communities Environmental Health Screening Tool, version 2.0* (CalEnviroScreen 2.0). CalEPA and OEHHA. August 2014.

Application of the CalEnviroScreen Tool

Though most grant guidelines still refer to the 2.0 version, the most recent version—CalEnviroScreen 3.0—was released in January 2017 and incorporates more recent data for all the indicators and adds two new indicators. Below are the updates as outlined in the CalEPA and OEHHA's Update to the California Communities Environmental Health Screening Tool Report.[245]

- Updates to all the indicators based on recent information.
- Improvements to indicator calculations that more accurately reflect environmental conditions or population vulnerability.
- Addition of a cardiovascular disease indicator.
- Addition of a new socioeconomic indicator that addresses housing costs across the state.
- Updates to the scoring method that balances separate contributions of major components of the score.
- Removal of the age indicator since it did not provide a good measure of children and elderly vulnerability.

The California Environmental Protection Agency (Cal/EPA) acknowledged CalEnviroScreen's weakness with respect to delivery of community assistance programs:

> "*The term community has numerous definitions ranging from a neighborhood within a city, to a small town or unincorporated area. In some cases, communities have been identified as an entire region. A few public comments pointed out that the use of census tracts as a proxy for a community might not give an accurate snapshot of an area where people associate with some type of commonality.*"[246]

Changes in DAC Designations, CalEnviroScreen 2.0 vs. 3.0

Some stakeholders question the basis for changing DAC designations merely because the census tract scores produced by CalEnviroScreen 3.0 are slightly different than those produced by version 2.0. This leads to even more questions about the relative merits of relying solely upon census tract level scores to design and develop programs that should be implemented at the level of an entire local government jurisdiction.

For example, when comparing the Tulare County data used from the Census Bureau for CalEnviroScreen's 2.0 and 3.0 tools, it is shown that 2,977.79 square miles were taken away from 3.0; however, as noted above the 2010 census boundaries are still being used.

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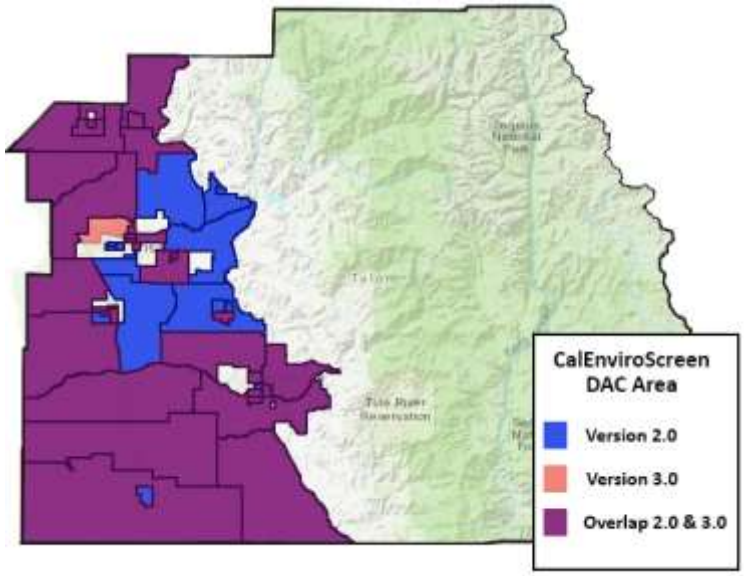
245 CalEPA and OEHHA. *Update to the California Communities Environmental Health Screening Tool CalEnviroScreen 3.0*, January 2017.

246 California Environmental Protection Agency. *Designation of Disadvantaged Communities Pursuant to Senate Bill 535 (DE LEÓN).* April 2017.

Figure M-1 shows the differences between each version in Tulare County: Blue=2.0, Red=3.0, Purple=overlap of the two.

Figure M-1: Tulare County Result of CalEnviroScreen 2.0 vs. 3.0



Sources: CalEnviroScreen 2.0 and 3.0

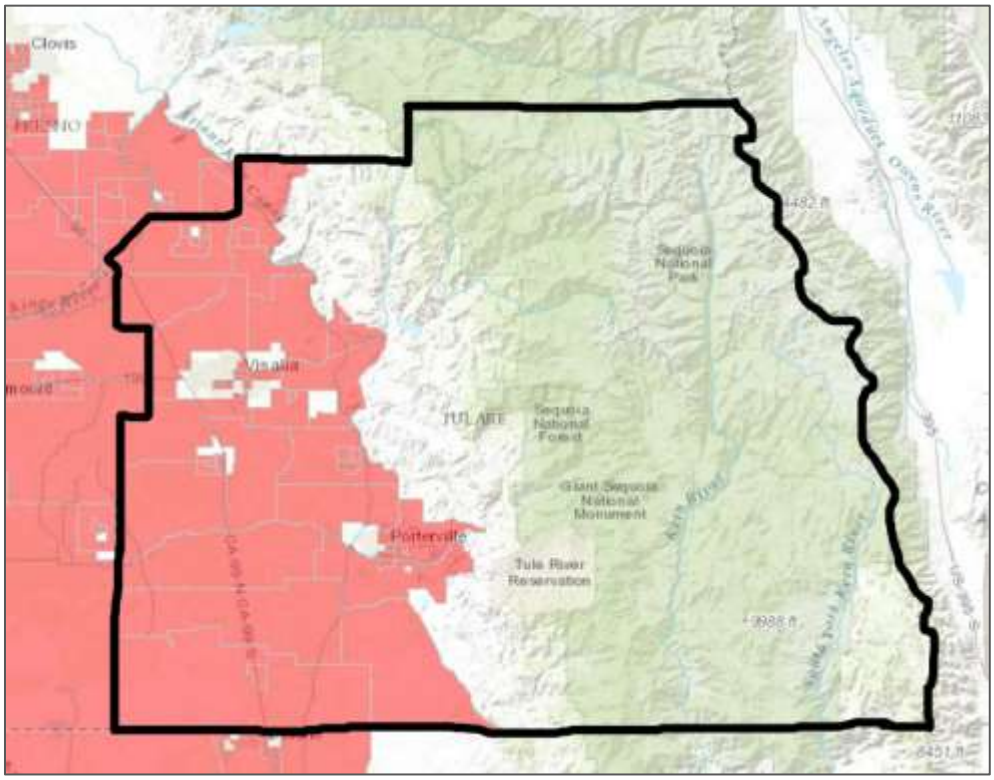
Based on the new 3.0 indicators, many communities that were eligible under 2.0 are now not eligible for DAC status. In Tulare County, the eligible population declined 24 percent from 277,219 in version 2.0, to 211,613 in version 3.0.

Fairness and Equity

Multiple stakeholders within Tulare County have expressed their concerns about participating in programs that rely strictly upon the census-tract methodology in determining DACs for eligibility. In particular, local governments articulated concerns about fairness and equity to their customers, constituents and stakeholders when census tract level designations are used to design and implement programs that provide assistance to some of their constituents, but not to others that may live directly across the street.

Tulare County's populated areas are mostly "DAC" as determined by the CalEnviroScreen tool. However, very small patches of light gray (non-DAC) tracts remain.

Figure M-2: Disadvantaged Communities within Tulare County



Red shaded areas are scored as "DACs", unshaded areas are not. Most of Tulare County's population lives in the western third of the county, from the plains to the foot of the hills. Most of the populated areas are DACs in accordance with CalEnviroScreen 2.0.

During workshops conducted in Fresno by the Air Resources Board, participants "shared concerns over the size of the Central Valley census tracts not adequately representing rural communities."[247] Also, although the tool itself was updated with new indicators and information, it is still based upon the Census tract boundaries from the Census Bureau, which were last updated in 2010.[248]

The most important criterion that is being missed during determination as to which communities will be deemed "disadvantaged" for which purposes is the intent of the specific funding source. The MHI indicator is clearly intended to be focused on economic factors. CalEnviroScreen is designed to focus on environmental factors, but includes economic factors, complicating its application.

Many Tulare County governmental officials pointed out the inconsistency between an environmental indicator of pollution that presumes one block is "disadvantaged" from an environmental perspective for a particular program, while a block across the street that is

247 Ibid.

248 CalEPA and OEHHA. *Update to the California Communities Environmental Health Screening Tool CalEnviroScreen 3.0*. January 2017.

subject to the same types of environmental pollution (air emissions, contaminated water supplies, etc.) does not qualify for the same assistance.

This challenge became very apparent to one member of the project team, Syzergy, that is a sub-grantee on a Department of Water Resources Water-Energy Grant. This grant is funded with Greenhouse Gas Reduction Fund (GGRF), and therefore has a goal of reducing greenhouse gases. However, when approaching local governments for assistance offering free above-code showerheads and faucet aerators to their constituents, many of the local governments declined to directly offer these benefits on the basis that it wouldn't be fair to tell their constituents that only people residing within certain census tracts would be eligible to receive these free fixtures.

The key questions remain:

1. If the primary intent of a program is to bring state assistance to communities that have been adversely impacted by environmental factors, such as air and water quality, why would environmental assistance programs employ a methodology at a census tract level that excludes specific tracts that are surrounded by communities that meet the threshold as "environmentally disadvantaged"?
2. Given that Tulare County continues to experience high levels of air and water pollution; and further, that these types of pollutants are not contiguous with census tract boundaries, why would the number of people in the county eligible for assistance in alleviating these pollutants decline in version 3.0?

At a minimum, program administrators should be accorded the latitude to make better judgments about how these definitions are applied to any particular program. If assistance is clearly targeted to specific tracts, then a census tract definition is appropriate. However, when assistance aims to alleviate environmental pollution that impacts entire communities throughout an entire region, program eligibility should be determined on a basis consistent with the problem that is targeted for remedy.

Recommendations

1. Expand DAC Designation to include all DACs designated by CalEnviroScreen 2.0 and/or 3.0 and all future tool updates until such a time as an entire local jurisdiction is no longer predominantly comprised of DACs.
2. Expand DAC Reach Beyond Census Tract Boundaries. When the goal is to provide drought resilience, increase energy reliability, reduce air and/or water pollution, and other types of benefits that do not strictly follow census tract boundaries, state program managers should be permitted to determine how best to implement their programs in a manner that achieves the program's goals and objectives.
3. Develop Consistent State Definitions and Metrics for Various Types of Targeted Benefits for "DACs". There are too many disparate definitions as to what exactly "defines" a DAC. The guidelines and metrics should be appropriate for each state program's goals and objectives.

Examples:

a. If a program is intended to deliver economic benefits solely to low income residents, it is appropriate to use income. One caution, however: both federal and state programs rely on the most recent census (currently 2010) to determine income. In some areas, the census data may be too high; in others, it may be too low.

b. If a program is intended to bring economic benefits to a region, the geographic area should be expanded to include the entire region.

c. If a program is designed to remedy environmental problems such as air quality and groundwater contamination, the entire geographic region(s) impacted by those pollutants should be included.

d. Similarly, if a program is intended to build drought resilience throughout a region, the entire region must be eligible to participate.

e. On the other hand, if the purpose of a program is to remediate a specific hazard, the area impacted by that hazard should be targeted.

4. **Use Different Names that Describe the Targeted Benefits**. Since the term "disadvantaged communities" is embedded in both federal and state legislation, it will be difficult to change it. However, there is no reason that the programs delivering the benefits need to be called "Disadvantaged"—programs can be branded to convey the positive impacts that they are intended to bring.

   For example: Instead of "Low Income" or "Economically Disadvantaged" Communities:

   a. "Developing Communities"

   b. "Progressive Communities"

   These types of decisions should be delegated to the implementing program managers.

APPENDIX N:
Tulare County's Water-Energy Nexus

The "water-energy nexus" has received a lot of attention since Energy Commission staff issued a report, "California's Water-Energy Relationship",[249] in support of the *2005 Integrated Energy Policy Report.*

Prior to this report, there was a general recognition that water and energy are related. The most recognized relationship in California was hydropower—production of electricity from moving water. What distinguished the 2005 staff report from all other prior studies was the recognition that significant quantities of energy are used to "produce" water (for example, by pumping groundwater), to pump water across the state, to treat and distribute water to "end users" (customers), and to collect, treat, and either dispose of or recycle wastewater. Additional energy is used by customers during use or consumption of water (for example, for pumping or heating water, for cooling, for cleaning, and a wide variety of other purposes).

Energy Embedded in Water, or Embodied Energy

The Energy Commission staff's estimate of water-related energy use was significant—as much as 20 percent of all electric use in the state—piquing the interest of state policymakers about the potential to save substantial quantities of energy by saving water.

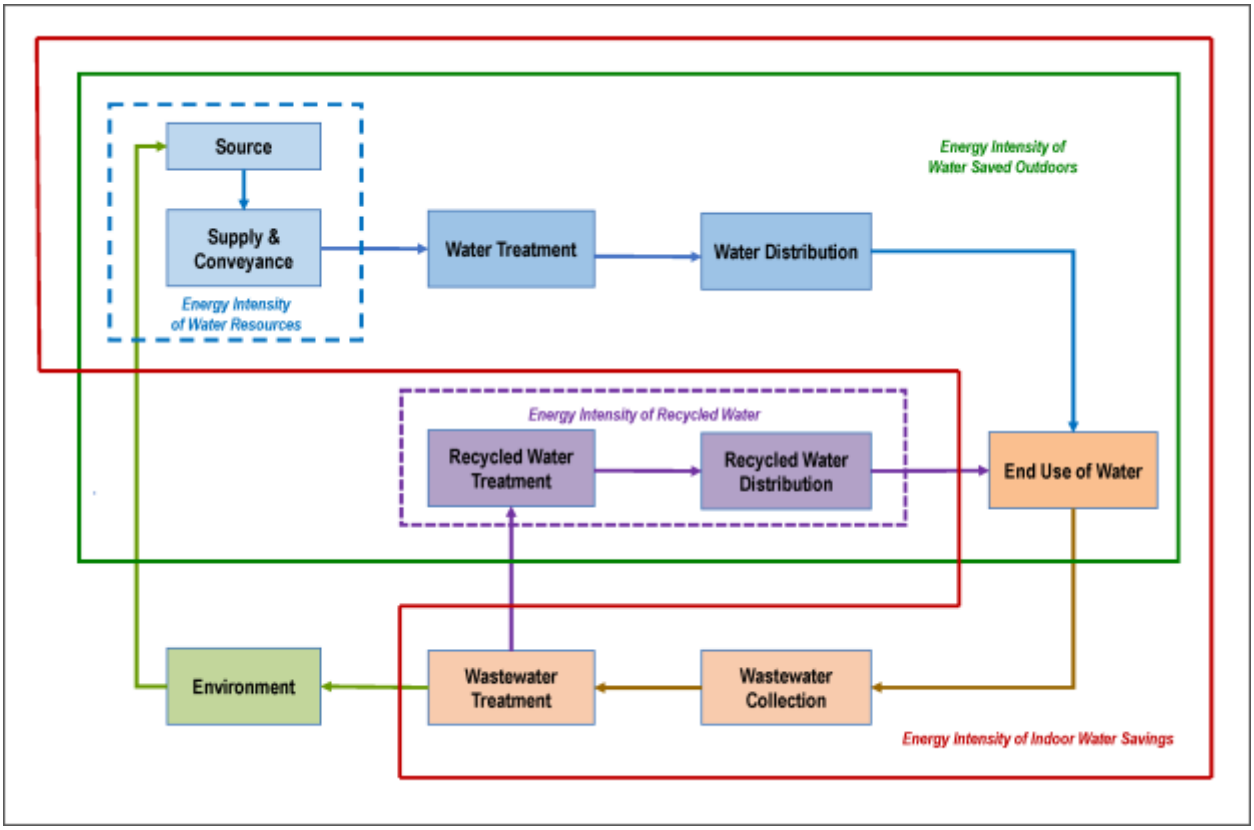
To evaluate opportunities to avoid (thereby "saving") energy inputs to water, Energy Commission staff proposed a "Water Use Cycle" framework for documenting energy inputs to water by system or function, and then estimating the average amount of energy "embedded" in a unit of water at various points in the water use cycle. The average amount of embedded energy, typically expressed as kWh or therms per acre-foot or million gallons, is referred to as the "energy intensity" of a unit of water or wastewater. This simple framework provided a simple and transparent means for estimating the amount of energy that could be saved at different points in the "Water Use Cycle". (The California Public Utilities Commission (CPUC) adopted the term "Water Cycle".)

Since 2005, other parties have evaluated opportunities to save *energy embedded in water* (sometimes referred to as *embodied energy*). While the initial Water Use Cycle diagram has adapted by other state agencies to better fit the goals and objectives of their own programs, the fundamentals remained: the amount of energy used to perform water and wastewater functions are deemed "embedded" in water, enabling programs to target reductions of energy by reducing water production and use.

Recognizing that different state agencies use their own data and protocols to compute energy embedded in water, Figure N-1 illustrates the general approach.

249 Klein, Gary, et. al. *California's Water-Energy Relation*ship. California Energy Commission. CEC-700-2005-011-SF. November 2005.

Figure N-1: Framework for Computing the Energy Intensity of Water



Adapted from *California's Water Energy Relationship*, Figure 1-1 California's Water Use Cycle, California Energy Commission, CEC-700-2005-011-SF.

Understanding water sector electric data is important for several reasons:

1. Electric Reliability. Understanding how and when the water sector uses electricity can help to identify opportunities for electric reliability support. Specifically, the water sector tends to have significant opportunities to integrate energy efficiency, demand response, distributed clean/renewable generation, and energy storage into their systems and facilities. These four electric resources are essential building blocks for long-term electric reliability.
2. Energy Investments in Water Programs. California's regulated energy utilities (both electric and gas) have been authorized by the California Public Utilities Commission (CPUC) to invest energy ratepayer funds in "water-energy nexus" programs that achieve both water and energy benefits contemporaneously. Two key metrics determine the amount of energy benefit that accrues to energy ratepayers by saving (or "making") water:
   a. Direct Energy Savings—The amount of energy that is saved by any particular measure or strategy while creating a water benefit, and
   b. Indirect ("Embedded") Energy Savings, also referred to as "Energy Embedded in Water"—The amount of energy inputs to water resources and water and wastewater systems and facilities that can be "avoided" (saved) by saving water.

CPUC approved regulatory protocols are used to measure Direct Energy Savings. A CPUC approved methodology also governs the measurement of Indirect ("Embedded") Energy in Water. Under the embedded energy methodology, energy inputs to water resources and to wastewater treatment are summed along all segments of the water supply chain. The resultant metric, referred to as the "Energy Intensity of Water", is the amount of energy savings that can be claimed as "energy resources" when implementing a water saving strategy or measure. This metric determines the amount of energy utility incentives that can be invested in strategies and measures that achieve water benefits.

3. Recycled Water. Recycled water has a special place in the CPUC's water-energy nexus programs and methodology. Understanding Tulare County's water sector energy use helps to compute the energy value of recycled water which then determines the amount of energy sector investment that can be used to help water and wastewater agencies increase the quantity and quality of recycled water.

Energy Investments in Drought Resilience

The Energy Commission's landmark finding in 2005—that saving water in California could save substantial quantities of energy[250]—resulted in a recommendation to identify cost effective energy savings strategies through water efficiency and reductions of energy use by water and wastewater utilities.

> *The Energy Commission, the Department of Water Resources, the CPUC, local water agencies, and other stakeholders should explore and pursue cost-effective water efficiency opportunities that would save energy and decrease the energy intensity in the water sector.*[251]

The purpose of computing "energy embedded in water" is to enable determining the quantity of energy benefits that can be achieved for energy ratepayers by investing in water sector strategies.

Jurisdictional Constraints

Each state agency is charged with accomplishing a specific mission and vision, and each must accomplish its goals and objectives within the constraints of its jurisdictional and funding constraints. The CPUC, for example, is responsible for regulating the state's four large investor-owned energy utilities (IOUs): Pacific Gas and Electric Co. (PG&E), Southern California Edison (SCE), San Diego Gas and Electric Co. (SDG&E), and Southern California Gas Co. The three electric utilities provide about 75 percent of the electricity used in California; the remaining 25 percent is provided by more than 40 publicly owned utilities (POUs) that range in size from very

250 Klein, Gary, et. al. 2005. *California's Water-Energy Relationship*. California Energy Commission. November 2005. Publication Number: CEC-700-2005-011-SF.

251 California Energy Commission. *Integrated Energy Policy Report*. November 2015. CEC-100-2005-007CMF.

large (the Los Angeles Department of Water and Power serves 3.9 million customers) to very small (the smallest POUs serve less than 400 customers).[252]

The CPUC has no jurisdiction over the state's POUs. Consequently, its methodology for computing the amount of energy investment in water strategies and technologies is limited by the energy inputs to water and wastewater system and functions, and energy use by customers in using water, that are provided by energy IOUs.

Similarly, although water and energy are related, in California the two resources have historically been managed separately. For example, the CPUC regulates both energy and water investor-owned utilities; but different rules, regulations, policies, and protocols apply. Some POUs provide both water and electric service; but even within those POUs, it is rare to find a program that seeks to optimize investments across both resources—the infrastructure, operations, capital improvement programs, and user rates are typically managed separately.

Challenges to Optimizing Public Investments

Within a traditional policy and regulatory framework that has diligently strived to keep water and energy separate, "optimization" of public investments that recognize and reward multiple benefit streams is challenging. The Energy Commission acknowledged these challenges in its *2005 Integrated Energy Policy Report*.

> *Despite some efforts targeted at improving the energy efficiency of heating water, the state's largest energy utilities have no authority to invest in programs that save cold water, regardless of whether the programs yield energy benefits. Because of the potential for reduced energy demand from these programs, the Energy Commission, the CPUC, utilities, and other stakeholders should more carefully examine investment in cold water savings.*
>
> *Water utilities do, of course, invest in programs that save water. Water and wastewater utilities also participate in programs to increase the efficiency of their operations. Given the interconnectedness of water and energy resources in California, the fact that cost-effectiveness is determined from the perspective of a single utility and a single resource creates barriers to achieving greater energy savings from water efficiency programs. Water utilities only value the cost of treating and delivering water. Wastewater utilities only value the cost of collection, treatment, and disposal. Electric utilities only value saved electricity. Natural gas utilities only value saved natural gas. This single focus causes underinvestment in programs that would increase the energy efficiency of the water use cycle, agricultural and urban water use efficiency, and generation from renewable resources by water and wastewater utilities.*[253]

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252 *Differences Between Publicly and Investor-Owned Utilities.* California Energy Commission website: http://www.energy.ca.gov/pou_reporting/background/difference_pou_iou.html.

253 *2005 Integrated Energy Policy Report*. Energy Commission. Publication Number: CEC-100-2005-007CMF, p.150.

Although most California customers purchase electricity, gas, water, and wastewater services, there is no single program that seeks to optimize public investment in all four of these resources and utility services.

Electric Program Investment Charge (EPIC) Triennial Investment Plan 2015-2017

The Electric Program Investment Charge (EPIC) is funded by ratepayers of the state's largest investor-owned electric utilities, PG&E, SCE, and SDG&E. The purpose of EPIC is to invest in clean technologies that create benefits to the ratepayers that fund the program.

EPIC is the largest energy research and development program in California. The Energy Commission administers 80 percent of the fund ($162 million per year); the three electric IOUs administer 20 percent. The CPUC provides program oversight that includes approval of triennial investment plans.

Strategic Objective S1 sought to "Improve Energy Efficiency Technologies and Strategies in California's Building, Industrial, Agriculture, and Water Sectors"[254] through the following types of applied research and development activities:

- Improve energy efficiency technologies and strategies in California's building, industrial, agriculture, and water sectors.
- Develop and Test Advanced Industrial, Agricultural, Water and Demand Response Technologies and Strategies to Reduce Energy Use and Costs.
- Advance Strategies to Reduce California Buildings' Impact on the Water-Energy Nexus.

The EPIC 2015-2017 Triennial Investment Plan states:

> *The industrial, agriculture and water sectors are risk averse regarding new, unproven technologies and lack the resources to analyze and evaluate technologies at either bench or facility scale. However, these sectors are major energy consumers and producers of GHGs.*
>
> *Improvements are necessary to reduce energy waste associated with the treatment, delivery and conveyance of water throughout the state. Water related uses (by water agencies and end-users) comprise the largest electricity demand sector in California, consuming nearly 20 percent of California's electricity (or roughly 48 billion kWh/year). Peak electricity demand by water agencies and end-users is estimated to be about 9,000 megawatts (MW). Water deliveries to buildings and industrial facilities are often treated, pumped and used within the facility and then disposed. The state's dire water situation further highlights the need for new strategies, technologies, and tools to optimize water/wastewater processes and develop technologies and techniques to maximize water conservation in homes, businesses and industries.*

This project was funded through EPIC's 2015-2017 Triennial Investment Plan that included (a) reducing the energy intensity of water resources and water and wastewater systems as

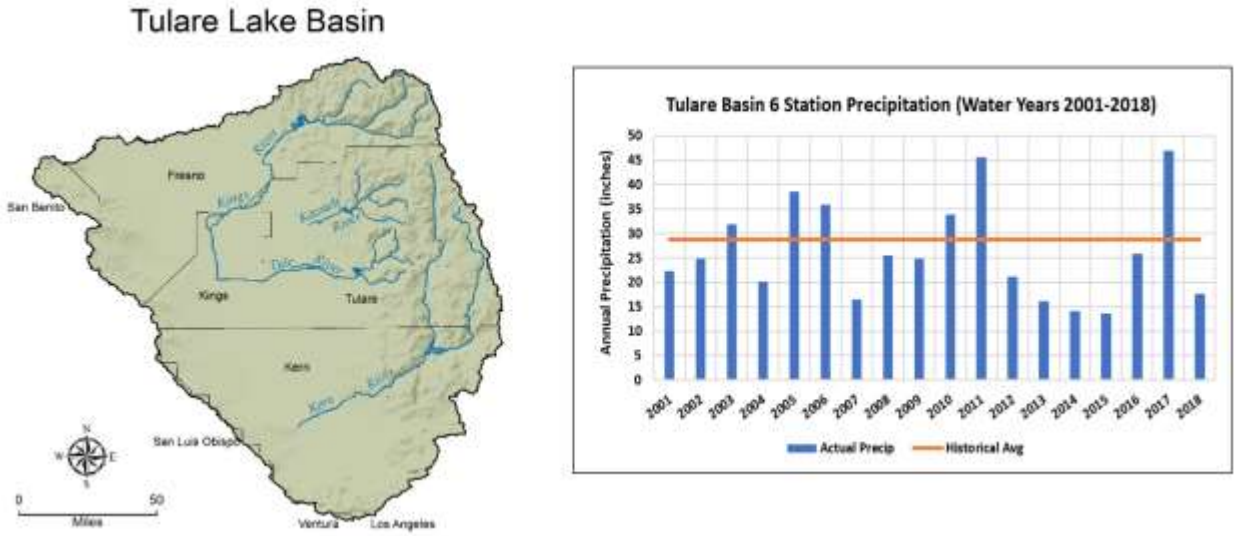
254 *2005 Integrated Energy Policy Report*. Energy Commission. Publication Number: CEC-100-2005-007CMF, p.37.

specific objectives, and (b) maximizing water conservation. It is the state's policy recognizing energy embedded in water that enables electric research and development funds to be invested in drought resilience—not for the water benefits, but for the electric and associated greenhouse gas emissions benefits.

Tulare County's Hydrology

Precipitation

Figure N-2: Historical Precipitation, Tulare Basin (Water Years 2001-2018)

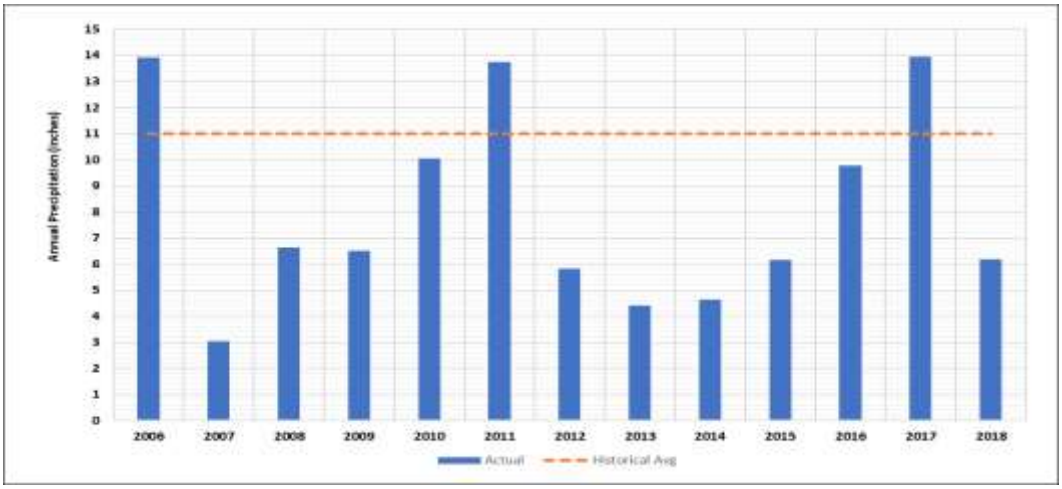


The six station index measuring precipitation for the Tulare Lake Basin exceeded the historical average of 28.8 inches during 6 of the past 18 water years.

Source: California Data Exchange Center.

The Tulare Basin Index is only one measurement of "drought" since it encompasses five counties: San Benito, Fresno, Kings, Tulare and Kern. Local precipitation is also an important indicator of both local water demand and supplies. Over the past 13 years, precipitation in Visalia exceeded historical average only three times.

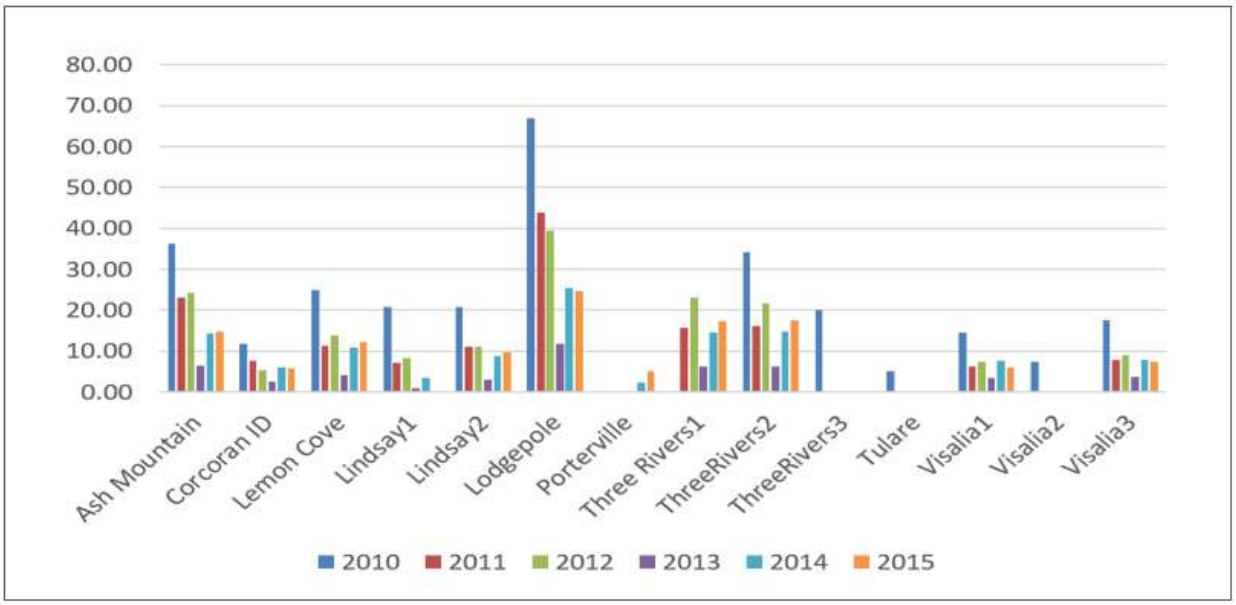
Figure N-3: Annual Precipitation in Visalia (Water Years 2006-2018)



Compiled from historical precipitation data recorded by the National Climate Data Center.

Figure N-4 shows the amount of precipitation received by precipitation station within Tulare County for water years 2010-2015.

Figure N-4: Tulare County Precipitation by Station



Tulare County's Water Sources and Uses[255]

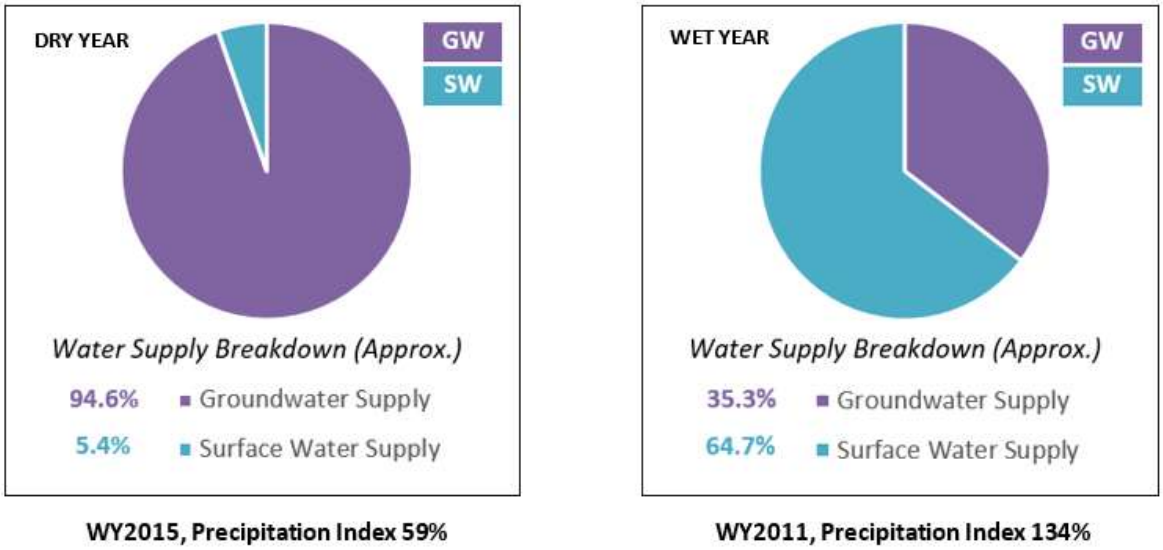
Water Sources

Tulare County has two primary water sources: surface water and groundwater.

255 Unless otherwise noted, all water supplies and demand estimates and graphs in this chapter were compiled from Department of Water Resources (DWR) Water Supply & Balance Data Interface Tool, LITE v.9.1 available on Department of Water Resources (DWR) website at https://www.water.ca.gov/Programs/California-Water-Plan/Water-Portfolios.

The specific mix of surface to groundwater used during any year depends on precipitation: much more surface water is used during wet years, and much more groundwater is used during dry years.

Figure N-5: Groundwater vs. Surface Water Supply Use in a Dry vs. Wet Year



WY2015, Precipitation Index 59% **WY2011, Precipitation Index 134%**

Source: California Department of Water Resources (CDWR) Water Supply & Balance Data Interface Tool, LITE v.9.1.

During wet years (precipitation index greater than 100 percent), more surface water is used, reducing groundwater pumping and withdrawals from deep percolation[256]. During dry years, the inverse occurs.

Tulare does not have easy access to seawater, so seawater desalination is not a viable option. Tulare County's primary untapped water resource opportunity is recycled water.

Recycled Water

In 2015, the State Water Resources Control Board (SWRCB) conducted a municipal wastewater recycling survey in conjunction with the California Department of Water Resources (CDWR). The purpose of this survey was to estimate the quantity of municipal recycled water produced and beneficially reused statewide.[257] Cities in Tulare County reported 18,537 AF of recycled water used for agricultural irrigation. The estimated potential for municipal recycled water is 33,500 AF per year.

Recycled water in Tulare County consists primarily of undisinfected secondary effluent from municipal wastewater treatment. Undisinfected secondary effluent used primarily for groundwater recharge or for agricultural irrigation.

256 "Deep percolation" refers to water that percolates the ground beyond the lower limit of the root zone of plants into groundwater.

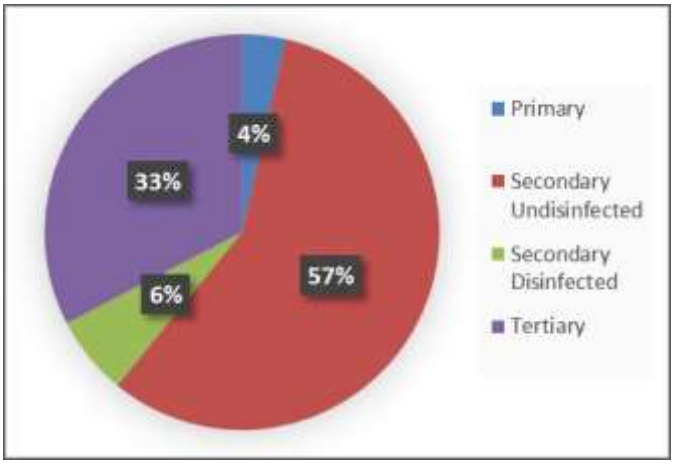
257 *Municipal Wastewater Recycling Survey*. State Water Resources Control Board's website: https://www.waterboards.ca.gov/water_issues/programs/grants_loans/water_recycling/munirec.shtml.

California's Water Code limits application of undisinfected secondary effluent to non-food crops or crops in which the water has no direct contact with the edible portion of the plant. Undisinfected secondary effluent must be applied in a manner that does not allow people to come into direct contact with the effluent. For this reason, undisinfected secondary effluent cannot be used to displace many types of uses of potable water for nonpotable uses, such as for irrigating parks and playgrounds, school yards, residential landscaping, and unrestricted access golf courses.[258]

The four largest urban wastewater treatment plants (Cities of Visalia, Porterville, Tulare, and Dinuba) treat 80 percent of the county's wastewater, a combined volume of 13.4 billion gallons annually. Until recently, 90 percent of the wastewater was treated to secondary undisinfected quality.

Increased awareness of the need to build local supplies for drought resilience have resulted in many urban areas now treating their wastewater to tertiary standards, at a minimum, so that recycled water can be used to displace use of valuable potable water supplies for non-potable purposes. Tertiary effluent can be used in urban areas with frequent human contact, such as to irrigate parks and golf courses. It can also be used for both food and non-food agricultural irrigation and groundwater injection.

Figure N-6: Wastewater Effluent Quality in Tulare County



In 2017, the City of Visalia completed the county's first tertiary wastewater treatment plant that now treats 33 percent of the county's wastewater effluent. Secondary undisinfected effluent still accounts for the largest volume (57 percent), but the cities of Porterville and Tulare plan to upgrade their systems to tertiary. When those upgrades are complete, nearly 90 percent of the county's urban wastewater will be tertiary quality.

Technological advances in water filtration and disinfection have led to a fourth "purification" stage with advanced filtration and ultraviolet disinfection of tertiary treated wastewater. The SWRCB is considering new regulations that would allow this new "purified" water resource to directly augment potable water supplies.

258 California Code of Regulations, Title 22, § 60304. *Use of Recycled Water for Irrigation.*

Water Reuse Definitions

Direct potable reuse (DPR) - There are two forms of DPR. In the first form, purified water from an advanced treatment facility is introduced into the raw water supply immediately upstream of a water treatment plant. In the second form, finished water is introduced directly into a potable water supply distribution system, downstream of a water treatment plant.

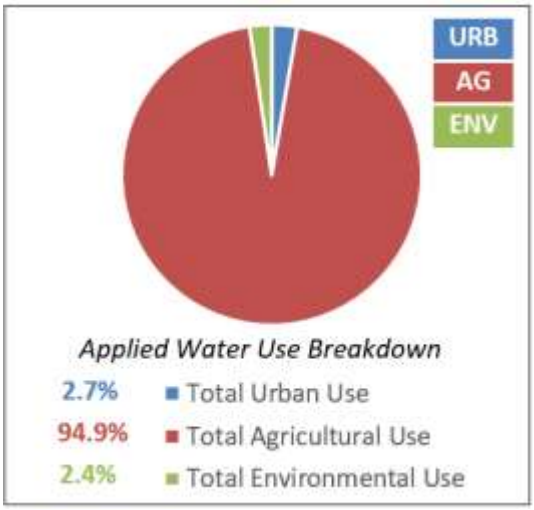
Indirect potable reuse (IPR) - In IPR, purified water from an advanced water treatment facility is introduced into an environmental buffer, such as a water body upstream from the intake to the drinking water facility, for a specified period of time before being withdrawn for potable purposes (see also de facto potable reuse).

De facto potable reuse - The downstream usage of surface waters as sources of drinking water that are subject to upstream wastewater discharges (e.g., unplanned potable reuse).

Source: State Water Resources Control Board (SWRCB)

Water Uses

Figure N-7: Tulare County Water Use by Sector, Water Year 2015



Total applied water during Water Year 2015 was 2,927.8 TAF.

Agriculture is the largest water user in Tulare County, accounting for 2778.5 TAF (94.9 percent of total applied water during Water Year 2015). Urban water uses accounted for 79.9 TAF (2.7 percent) during the same year. Environmental flows accounted for the remaining 69.4 TAF (2.4 percent).

Source: California Department of Water Resources Water Supply & Balance Data Interface Tool, LITE v.9.1 available at https://www.water.ca.gov/Programs/California-Water-Plan/Water-Portfolios.

Within the urban sector, landscape irrigation for both residential and commercial purposes continued to be the largest urban water use (35.2 TAF, 44 percent of total urban water demand). Indoor residential water use was a close second (31.3 TAF, 39 percent of total urban water demand). The commercial sector accounted for 5.5 TAF (6.9 percent) and the industrial sector accounted for 7.9 TAF (10 percent) during that same period.

Sources of Water Data

Urban Water Management Plans (CY2015)[259]

California Water Code, §10610-10656 and §10608, as amended, requires every urban water supplier that either provides over 3,000 acre-feet of water annually, or serves more than 3,000 urban connections, to submit an Urban Water Management Plan (UWMP).

Within UWMPs, urban water suppliers must:

- Assess the reliability of water sources over a 20-year planning time frame.
- Describe demand management measures and water shortage contingency plans.
- Report progress toward meeting a targeted 20 percent reduction in per-capita (per-person) urban water consumption by the year 2020.
- Discuss the use and planned use of recycled water.

The below tables were compiled from UWMPs for the four largest cities in Tulare County.

Table N-1: Population by Water Planning Year

Water Supplier	Service Area Population-Current and Projected				
	2010	2015	2020	2025	2030
City of Tulare	59,535	62,363	71,249	81,401	93,000
City of Dinuba	21,453	23,966	27,561	31,695	36,449
City of Visalia	134,410	138,404	157,741	179,779	204,896
City of Porterville	58,232	65,702	74,336	84,104	95,156
Totals:	**273,630**	**290,435**	**330,887**	**376,979**	**429,501**

Table N-2: Water Supplies and Demand by Water Planning Year (TAF)

Water Supplies	2010	2015	2020	2025	2030
Groundwater	66,435	54,444	74,190	84,256	99,225
Recycled Water	0	13,302	15,903	19,017	24,985
Total Supplies:	**66,435**	**67,746**	**90,093**	**103,272**	**124,211**
Water Demand					
Residential	41,876	34,803	50,579	57,964	67,962
Commercial	10,964	8,643	10,880	12,122	13,832
Industrial	3,367	4,804	5,582	5,683	7,257
Institutional/Governmental	2,805	2,105	2,901	3,919	3,584
Landscape	1,322	1,251	1,370	1,554	1,896
Agriculture (Recycled)	0	13,302	15,903	19,017	22,745
Other	466	851	1,201	1,380	1,679
Additional Uses/Losses	5,635	1,972	2,101	2,460	3,015
Total Demand:	**66,435**	**67,731**	**90,516**	**104,099**	**121,970**

259 "Urban Water Management Plans", Department of Water Resources (DWR) website: https://water.ca.gov/Programs/Water-Use-And-Efficiency/Urban-Water-Use-Efficiency/Urban-Water-Management-Plans.

Water Balance, Tulare County[260]

Table N-3: Tulare County Water Balance, TAF (CY2002-2006)

TULARE COUNTY WATER BALANCE	2002	2003	2004	2005	2006
Precipitation (% of "Normal")	**71%**	**86%**	**85%**	**120%**	**123%**
WATER USES					
URBAN					
Large Landscape	3.9	4.2	4.4	3.7	3.9
Commercial	9.2	10	10.4	8.9	9.3
Industrial	13.1	14.4	15	12.7	13.4
Energy Production	0.0	0	0	0	0
Residential - Interior	52.3	56.9	58.8	51	53.1
Residential - Exterior	54.1	59.5	60.7	52.6	54.9
Conveyance Applied Water	0.0	2.9	3	0	0
Subtotal	**132.6**	**147.9**	**152.3**	**128.9**	**134.6**
AGRICULTURAL					
Applied Water - Crop Production	2,641.6	2452.1	2703.8	2268.2	2218.2
Conveyance Applied Water	79.5	99.1	77	147.9	133.9
Groundwater Recharge Applied Water	0.0	0	0	1.7	1.2
Subtotal	**2,721.1**	**2,551.2**	**2,780.8**	**2,417.8**	**2,353.3**
ENVIRONMENTAL					
Wild & Scenic Applied Water	314.4	467.9	370	871.4	884.5
Managed Wetlands Applied Water	3.3	3.1	3.1	2.8	3.3
Subtotal	**317.7**	**471.0**	**373.1**	**874.2**	**887.8**
TOTAL WATER USES	**3,171.4**	**3,170.1**	**3,306.2**	**3,420.9**	**3,375.7**
WATER SUPPLIES					
Local Deliveries	369.2	496.8	385.4	762.6	746.8
CVP Base and Project Deliveries	516.1	560.1	433.9	828.3	695.9
SWP Deliveries	0.8	0.7	0.8	0.5	0.3
Groundwater Net Extraction	1,107.9	814.8	1218.2	155.5	263.5
Deep Percolation of Surface and GW	851.6	818.4	886.5	791.2	773.3
Return Flow from Carryover Storage	0.0	0	0	0	0
Recycled Water	325.8	479.3	381.4	882.8	895.9
TOTAL WATER SUPPLIES	**3,171.4**	**3,170.1**	**3,306.2**	**3,420.9**	**3,375.7**

260 Using Department of Water Resources (DWR) Water Supply & Balance Data Interface Tool, LITE v.9.1.

Table N-4: Tulare County Water Balance, TAF (CY2007-2011)

TULARE COUNTY WATER BALANCE	2007	2008	2009	2010	2011
Precipitation (% of "Normal")	**50%**	**77%**	**71%**	**116%**	**134%**
WATER USES					
URBAN					
Large Landscape	4.3	4	4.1	3.7	3
Commercial	9.8	9.5	9.6	8.8	7
Industrial	14	13.5	13.7	12.7	10
Energy Production	0	0	0	0	0
Residential - Interior	54.9	54.3	53.8	50.7	39.7
Residential - Exterior	58	56	56.2	52.5	41
Conveyance Applied Water	0	0	0	0	0
Subtotal	**141.0**	**137.3**	**137.4**	**128.4**	**100.7**
AGRICULTURAL					
Applied Water - Crop Production	2613.4	2907.2	2949.3	2614.2	2353.3
Conveyance Applied Water	48.6	73.5	80.4	127.9	156
Groundwater Recharge Applied Water	0	0	0	0	0
Subtotal	**2,662.0**	**2,980.7**	**3,029.7**	**2,742.1**	**2,509.3**
ENVIRONMENTAL					
Wild & Scenic Applied Water	242.1	445.3	413.1	700	894.8
Managed Wetlands Applied Water	3.3	3.3	3.3	3.3	3.3
Subtotal	**245.4**	**448.6**	**416.4**	**703.3**	**898.1**
TOTAL WATER USES	**3,048.4**	**3,566.6**	**3,583.5**	**3,573.8**	**3,508.1**
WATER SUPPLIES					
Local Deliveries	206.4	399.5	379.4	648.1	963.4
CVP Base and Project Deliveries	321.1	394.7	488.3	732.1	716.3
SWP Deliveries	0.2	0	0	0	0
Groundwater Net Extraction	1424.4	1372.3	1323.3	600.9	386.6
Deep Percolation of Surface and GW	842.8	943.4	968	870.8	528.5
Return Flow from Carryover Storage	0	0	0	0	0
Recycled Water	253.5	456.7	424.5	721.9	913.3
TOTAL WATER SUPPLIES	**3,048.4**	**3,566.6**	**3,583.5**	**3,573.8**	**3,508.1**

Table N-5: Tulare County Water Balance, TAF (CY2012-2015)

TULARE COUNTY WATER BALANCE	2012	2013	2014	2015
Precipitation (% of "Normal")	**71%**	**59%**	**45%**	**59%**
WATER USES				
URBAN				
Large Landscape	2.8	3	2.8	2.3
Commercial	6.9	7.2	6.7	5.5
Industrial	9.8	10.3	9.6	7.9
Energy Production	0	0	0	0
Residential - Interior	39.3	41	37.7	31.3
Residential - Exterior	40.2	42.4	39.2	32.9
Conveyance Applied Water	0	0	0	0
Subtotal	**99.0**	**103.9**	**96.0**	**79.9**
AGRICULTURAL				
Applied Water - Crop Production	2801	2812.5	2644.6	2764.3
Conveyance Applied Water	82.2	45.1	31	14.2
Groundwater Recharge Applied Water	0	0	0	0
Subtotal	**2,883.2**	**2,857.6**	**2,675.6**	**2,778.5**
ENVIRONMENTAL				
Wild & Scenic Applied Water	121.8	97.3	172.9	65.8
Managed Wetlands Applied Water	3.4	3.5	3.3	3.6
Subtotal	**125.2**	**100.8**	**176.2**	**69.4**
TOTAL WATER USES	**3,107.4**	**3,062.3**	**2,947.8**	**2,927.8**
WATER SUPPLIES				
Local Deliveries	357.7	185.1	177.1	91.7
CVP Base and Project Deliveries	524.3	303.6	156.1	62.7
SWP Deliveries	6.7	0	0	0
Groundwater Net Extraction	1504	1902.7	2063	2215.2
Deep Percolation of Surface and GW	574.3	555.1	360.2	473.9
Return Flow from Carryover Storage	0	0	0	0
Recycled Water	140.4	115.8	191.4	84.3
TOTAL WATER SUPPLIES	**3,107.4**	**3,062.3**	**2,947.8**	**2,927.8**

Tulare County's Electric Uses[261]

Electric Demand

Tulare County's primary electric utility is Southern California Edison. Data used to identify large energy uses by NAICS codes were obtained from SCE and compiled for this analysis.

Figure N-8: Portion of Tulare County Served by Southern California Edison (SCE)

Source: Southern California Edison (SCE)

SCE provided the following electric data for calendar year 2015:

Table N-6: Electric Use in Tulare County, CY2015

Sector	Electricity (GWh)
Residential	1,022.3
Non-Residential	2,646.7
Total Annual Electricity	**3,669.0**

Source: Southern California Edison

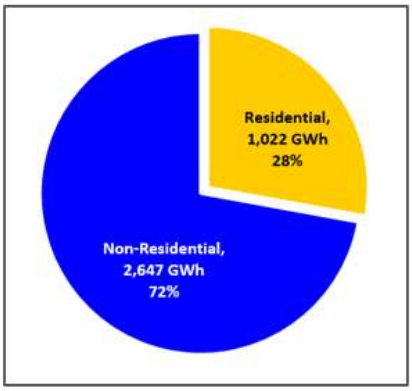


Table N-7 on the next page shows the breakdown of non-residential electricity provided by SCE to Tulare County customers during CY2015 by NAICS code.

261 Unless otherwise stated, all non-residential electric data and graphs in this chapter were compiled from electric data provided by Southern California Edison (SCE) for Tulare County.

Table N-7: Tulare County Non-Residential Electric Requirements (CY2015)[262]

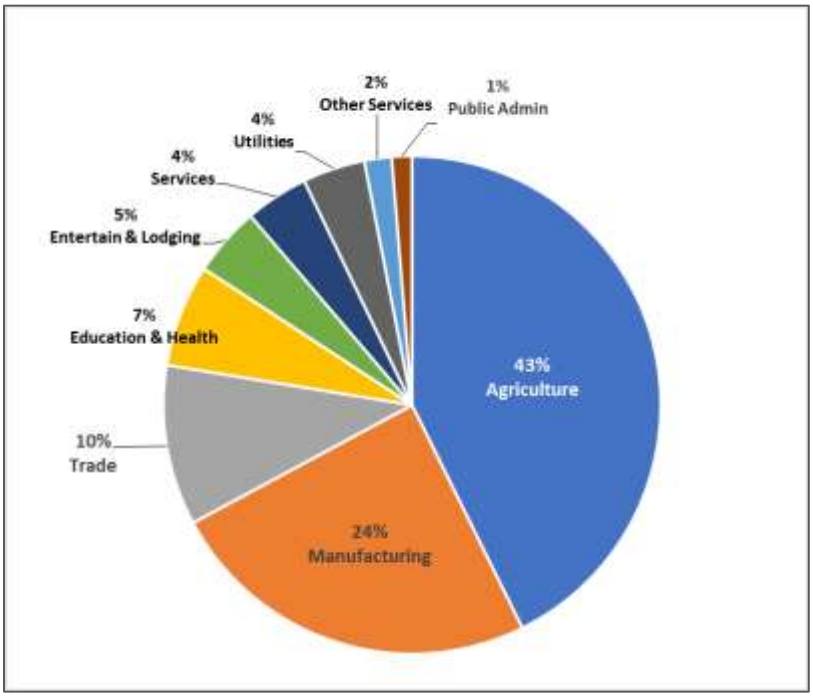
NAICS Code	NAICS Description	Total kWh	% of Total	Max kW	% of Total
11	Agriculture, Forestry, Fishing and Hunting	1,128,138,062	42.6%	250,064	49.3%
21-23	Mining, Utilities & Construction	107,327,881	4.1%	20,743	3.8%
31-33	Manufacturing	646,667,789	24.4%	91,811	16.6%
42-49	Trade (Wholesale & Retail), Transportation & Warehousing	275,336,643	10.4%	55,571	9.1%
51-56	Information; Finance & Insurance; Real Estate Rental & Leasing; Professional, Scientific & Technical Services; Administrative and Support, and Waste Management and Remediation Services	108,762,395	4.1%	24,074	4.0%
61-62	Educational Services; Health Care and Social Assistance	175,872,531	6.6%	60,028	9.0%
71-72	Arts, Entertainment and Recreation; Accommodation and Food Services	119,299,647	4.5%	25,443	4.0%
81	Other Services (except Public Administration)	46,878,666	1.8%	14,608	2.8%
92	Public Administration	34,643,150	1.3%	7,689	1.3%
99	Unknown	3,768,453	0.1%	205	0.1%
	TOTALS	**2,646,695,217**	**100.0%**	**550,236**	**100.0%**

The largest non-residential electric use is agriculture (43 percent). Manufacturing is the next largest (24 percent), followed by trade (10 percent). "Trade" includes wholesale, retail, warehousing, transportation.

These three electric uses that collectively comprise 77 percent of the county's annual non-residential electric requirements are primarily attributable to Tulare's agricultural economy. A portion of the remaining electric uses—for example, those related to utilities, professional and technical services, equipment installation and maintenance, etc.—are also related to agriculture and agricultural related businesses and activities.

262 CY2015 electric data were not converted to water year because SCE was changing out some meters during CY2014 and a complete set of 15 minute electric demands by NAICS code was not available for the beginning part of water year 2015 (Oct. 1 through Dec. 31, 2014). Electric consumption during CY2016 was very close to CY2015, indicating that the quantity of electric demand (kW) and use (kWh) was likely comparable during CY2014 as well. Consequently, CY2015 electric data are used throughout this report.

Figure N-9: Tulare County Non-Residential Electric Use by NAICS Code (CY2015)



Large Electric Uses

Largest Electric Uses

During calendar year 2015, several NAICS codes, 11 (Agriculture) and 31-33 (Manufacturing) accounted for 67.0 percent of total electric consumption and 65.9 percent of total electric demand:

- Agriculture (NAICS 11) accounts for 42.6 percent of the electric energy (kWh) and 49.3 percent of the electric demand (kW).
- Manufacturing (NAICS 31-33), much of which is related to agriculture and food and beverage processing, accounts for an additional 24.4 percent of the electric energy (kWh) and 16.6 percent of the electric demand (kW).

Dairy-related foods (cheese, dry and evaporated milk, ice cream, fluid milk) accounted for 87 percent of all food and beverage processing (excluding pet food).

Table N-8: Largest Electric Consumers by NAICS Code (Calendar Year 2015)

NAICS Code	Electricity (kWh)	% of Total	Electric Demand (kW)	% of Total
11 Agriculture, Forestry, Fishing and Hunting	1,128,138,062	42.6%	356,241	49.3%
31-33 Manufacturing	646,667,789	24.4%	120,199	16.6%
Total Annual Electric Use	**1,774,805,851**	**67.0%**	**476,440**	**65.9%**

Compiled from 15 minute electric data provided by Southern California Edison (SCE) for non-residential customers in Tulare County during calendar year 2015.

The next largest electric use by NAICS code was Trade (Wholesale & Retail), Transportation & Warehousing that accounted for 10.4 percent of total kWh and 9.1 percent of total kW.

NAICS code 11 includes 35,634,591 kWh and 11,764 kW for Agricultural Support Services.

Dairy and Dairy-Related Electric Uses

Of agricultural use, Dairies (NAICS 112120) accounted for 38.2 percent of the kWh and 25.4 percent of the kW.[263] Dairy-related manufacturing (milk products, cheese, ice cream) accounted for 56.0 percent of the kWh and 38.0 percent of the kW (361,920,639 kWh and 45,656 kW respectively) for NAICS codes 31-33 Manufacturing.

Allocating a percentage of electric use by support services for livestock and crop production increases dairy and dairy-related electric use to 39.5 percent of Tulare County's agricultural electric use, and 26.3 percent of agricultural demand.

Together, dairy farming and dairy-related manufacturing (milk products, cheese, ice cream) accounted for 793,129,127 kWh and 136,224 kW (44.7 percent and 28.6 percent of CY2015 kWh and kW, respectively) of total Agricultural and Manufacturing electric use (NAICS codes 11 and 31-33, see Table N-9 below). This estimate is conservative, in that it does not include electric use by other related services such as machinery manufacturing, equipment assembly, laboratory testing, and professional and technical services.

Table N-9: Dairy Farming and Dairy Related Manufacturing (Calendar Year 2015)

NAICS Code	Electricity (kWh)	Electric Demand (kW)
NAICS 11 Agriculture: 112120 Dairy Cattle and Milk Production	431,208,488	90,568
Allocated Agricultural Support Services	14,064,887	3,093
Subtotal Dairy Electric Use	**445,273,375**	**93,661**
NAICS 31 Manufacturing: 311511 Fluid Milk Manufacturing; 311512 Creamery Butter Manufacturing 311513 Cheese Manufacturing 311514 Dry, Condensed, and Evaporated Dairy Product Manufacturing	361,920,639	45,656
Allocated Warehousing, includes Refrigerated (NAICS 49)	44,422,490	12,960
Subtotal Dairy-Related Food Processing Electric Use	**406,343,129**	**58,616**
Total Dairies and Dairy-Related Electric Use	**851,616,505**	**152,276**

Water Sector Electric Use

Water and Wastewater electric use (collectively referred to herein as the "water sector") is found in NAICS codes 221310 (water) and 221320 (wastewater). Water sector electric use is small as a percentage of total non-residential electric use.

263 Three other agricultural sector NAICS codes - 111310 Orange Groves, 111332 Grape Vineyards, and 111335 Tree Nut Farming - accounted for an additional 382.4 million kWh (21.5%) and 179,688 kW (37.7%).

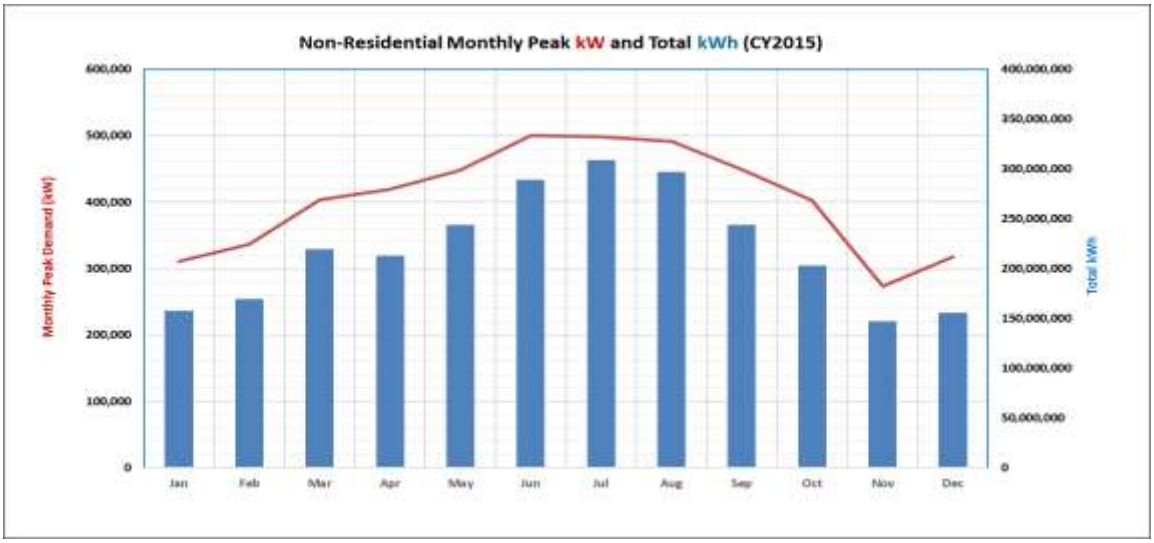
Table N-10: Water Sector Electric Use (CY2015)

NAICS Code	Electricity (kWh)	% of Total Non-Residential kWh	Electric Demand (kW)	% of Total Non-Residential kW
221310 Water	56,274,031	2.1%	13,585	1.9%
221320 Wastewater	32,456,505	1.2%	5,436	0.8%
Total Annual Electric Use	**88,730,536**	**3.3%**	**19,021**	**2.7%**

Seasonality of Electric Use

Like most regions in the Central Valley, more electricity is used during May through October when temperatures are highest. During CY2015, 60 percent of non-residential electricity was used during May through October. Figure N-10 shows the amount of energy (kWh) used each month in relation to the monthly peak electric demand.

Figure N-10: Tulare County Non-Residential Electric Requirements (CY2015)



The Energy Intensity of Tulare County's Water

The concept of "energy intensity"—the average amount of energy needed to perform a unit of work—is very simple. The energy intensity of one unit of a water resource, for example, is computed as the average amount of electricity and/or natural gas needed to pump, treat, or otherwise produce, one unit of water.

The challenge is that the data needed to perform the computation are often not readily available. Further, even when data are available, there may be gaps, overlaps, differences as to timing and technologies used to measure the water and/or energy, and other data inconsistencies that prevent "perfect" matching of the amount of energy used to the amount of water produced.

Average Energy Intensities (EIs) of Tulare County's water and wastewater systems were computed using the following data:

1. Water-Related Electric Use.
    a. Southern California Edison provided data about the quantity of electricity it sold during CY2015 in Tulare County by NAICS code. This enabled distinguishing among the quantity of electricity used by agriculture, food processing and other industries, and commercial and residential customers.
    b. Electric use (kWh) by tariff was used to estimate electricity used for water pumping vs. other purposes.

   This resulted in the following estimates of water-related electric uses.

Table N-11: Water-Related Electric Use (CY2015)[264]

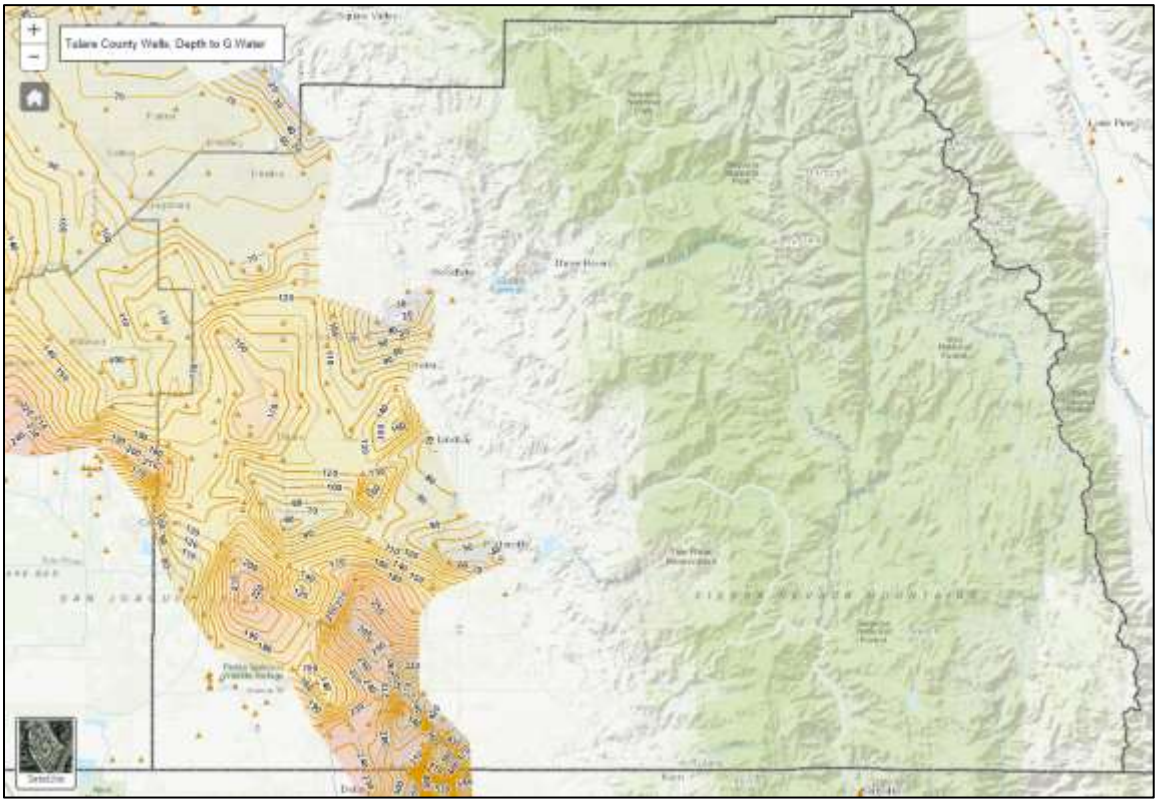
NAICS Code	Water (TAF)	Electricity (kWh)	Avg. Electric Intensity
Agricultural Pumping	2,779	765,080,718 kWh[265]	275 kWh/AF
Water Utilities	79.9	56,274,031	704 kWh/AF
Wastewater Utilities	41.6	32,456,505	780 kWh/AF

2. **Electric Intensity of Water Resources**. There are two primary water resources in Tulare County: surface water and groundwater. The electric intensity of surface water is low, since the topography in the populated areas of the county is fairly flat. The electric intensity of groundwater pumping, however, is considerably higher and highly variable: the depth to groundwater ranges from near zero to 470' (see *Figure N-11. Tulare Wells Depth to Groundwater, Fall 2017*).

264 Unless otherwise specified, all water data were obtained from Department of Water Resources (DWR) Water Supply & Balance Data Interface Tool, LITE v.9.1 for WY2015electric data were obtained from Southern California Edison for CY2015.

265 Electricity used for water pumping only (determined by reviewing electric sales by SCE tariff).

Figure N-11: Tulare Wells Depth to Groundwater, Fall 2017[266]



The energy intensity per groundwater well varies significantly, based on the depth to groundwater, as shown above.

Summary of Findings

1. Water Sources and Uses
   a. Tulare County has two primary water sources: surface water and groundwater.
      - There is little surface water storage capacity in Tulare County.[267]
      - The specific mix of surface to groundwater used during any year depends on precipitation: much more surface water is used during wet years, and much more groundwater is used during dry years.[268]
   b. The county's three largest municipal wastewater treatment facilities (the cities of Visalia, Porterville and Tulare) produce recycled water, primarily for agricultural irrigation and groundwater recharge.
      - In 2017, the City of Visalia became the first city to produce tertiary recycled water at its wastewater treatment facility.

266 "Groundwater Information Center Interactive Map Application." *Department of Water Resources.* https://gis.water.ca.gov/app/gicima/#bookmark_DepthBelowGroundSurface.

267 Tully & Young. *General Plan Update: Appendix G Phase 1 Water Supply Evaluation*. Tulare County. 2009.

268 See *Figure N-5. Groundwater vs. Surface Water in a Dry vs. Wet Year.*

- The cities of Porterville and Tulare currently discharge secondary undisinfected wastewater effluent to spreading basins for groundwater recharge and some agricultural irrigation. Both plan to produce tertiary treated recycled water in the future.[269]
- The primary constraint on beneficial use of tertiary treated recycled water is lack of recycled water distribution systems ("purple pipe") in Tulare County. Purple pipe infrastructure is a long-lead item that typically requires multiple years to design, finance, and construct. It is expensive to dig up existing streets and sidewalks to connect nonpotable water uses to recycled water.

c. Some water users already recycle and reuse water multiple times. Since there is no requirement for customers to report this information, the quantity of water recycled and reused by water users is not known.

2. Electric Sources and Uses

a. Two investor owned utilities provide electric service to Tulare County. SCE is the largest provider of electric service, covering about 90 percent of the electric demand; PG&E serves the remaining 10 percent.

b. As of 2017, utility scale solar PV installed by independent power developers in Tulare County totaled 310.6 MW and produced 746,285 MWh (load factor of 27.4 percent).270 The output from these solar facilities are sold to PGE& or SCE under long-term Power Purchase Agreements (PPAs). More utility scale solar PV projects are planned.

c. Several facilities are either in operation or planned to convert manure biogas to pipeline quality renewable gas or ethanol (transportation fuel).

d. Electric Uses.

- Residential electric use during CY2015 accounted for 33 percent of the county's total electric requirements.
- Of the remaining 67 percent for non-residential uses, 77 percent was either directly or indirectly related to agriculture.
- Electric use by dairies accounted for 38 percent of agricultural electric use.
- Commercial and industrial sectors accounted for 31 percent of all non-residential electric use.

3. Greenhouse Gas (GHG) Emissions[271]

a. The county estimated 2007 total GHG emissions at 5.2 million metric tons of CO2 equivalents (MMTCO2e).

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269 The drought resilience value of replacing secondary undisinfected wastewater effluent with tertiary recycled water depends on the extent to which the higher quality recycled water could be used to displace use of potable water supplies for nonpotable purposes.

270 California Energy Commission Website: *Solar PV and Solar Thermal Electricity Production by County*. Accessible at http://www.energy.ca.gov/almanac/renewables_data/solar/.

271 Tulare County. *Climate Action Plan, Appendix A: Calculations and Assumptions*. August 2012 as modified.

b. Dairies and feedlots accounted for 63 percent of total annual emissions.

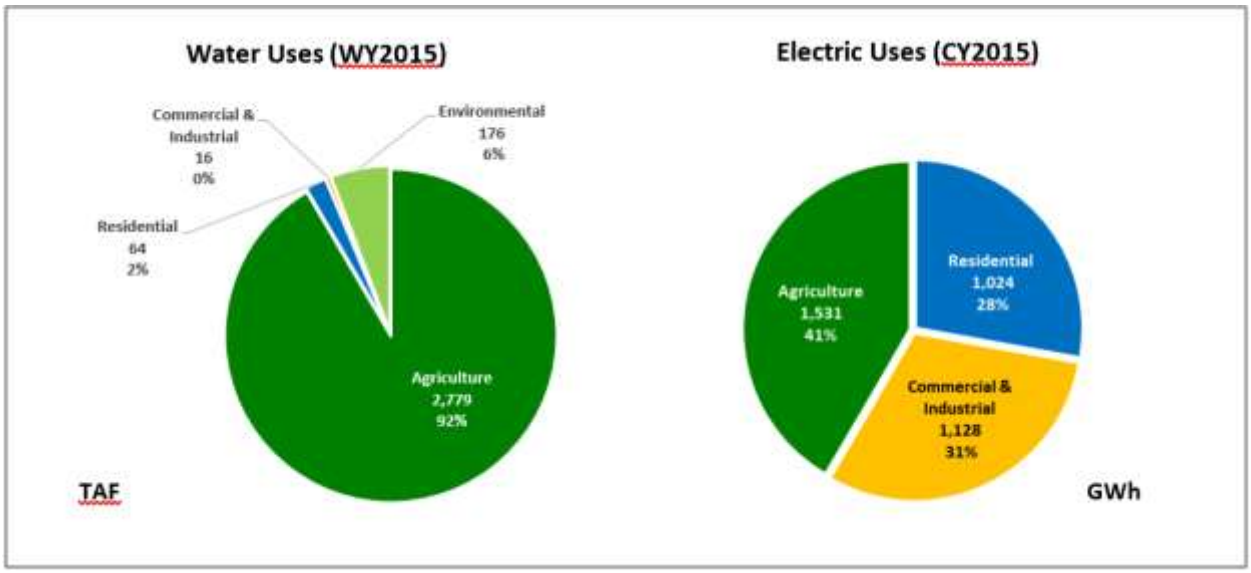
c. Mobile sources (on- and off-road) accounted for 16 percent of total annual emissions.

d. When normalized by population, total annual emissions equated to 36 tonnes of CO2e per resident.

4. Water-Energy Nexus

a. Large water uses were matched to electric uses to understand where drought resilient technologies could have the most significant impact on both resources.

Figure N-12: Water and Electric Uses in Tulare County



Sources: Water use data was obtained from California Department of Water Resources Water Supply & Balance Data Interface Tool, LITE v.9.1; electric use data was compiled from data provided by Southern California Edison.

- Clearly, agriculture is the largest user of water, and also a large user of electricity.
- Residential water use is very small compared to agriculture, but accounts for 77 percent of urban water demand. The residential sector also accounts for 28 percent of all electricity used in Tulare County. As a percentage of urban electric demand, residential uses account for 48 percent.
- Commercial and industrial water uses account for 17 percent of total urban water demand, but less than 1 percent of total water demand. Commercial and industrial customers are significant energy users, accounting for 52 percent of urban electric demand (31 percent of all electricity used in the county).

b. The energy intensity of Tulare County's groundwater varies with the depth to groundwater of each well, and the efficiencies of the individual well pumps and motors. Data were not available to compute detailed energy intensities of the county's water and

wastewater systems; however, countywide annual data provided a basis for computing a reasonable proxy for the electric value of saving water in Tulare County.

Table N-12: Interim Proxies for Energy Intensity of Tulare County's Water

Type of Water Resource or Water Use	Type of Energy Use	Average Electric Intensity (kWh/AF)
Agricultural Irrigation	Agricultural	275
Urban Water (mostly groundwater)	Groundwater Pumping, Water Treatment, Water Distribution	704
Wastewater Collection and Treatment	Wastewater	780

The above proxies were developed from the data show in Table N11. Water-Related Electric Use (CY2015).

In accordance with the methodology proposed by the Energy Commission in its 2005 white paper, *California's Water-Energy Relationship*, and adopted by the CPUC via its Water-Energy Nexus rulemaking,[272] the energy value of water saved indoors is deemed equivalent to the sum of energy inputs to urban water resources collected or produced, transported to urban water utilities, treated, distributed to energy users, and discharged to sewers for wastewater collection and treatment. The energy value of water saved outdoors has all of the same components <u>except</u> wastewater collection and treatment.

Data were insufficient to compute the electric intensity of Tulare County's urban water supplies by segment of the "Water Cycle".[273] The average electric intensity of the county's urban water supplies, from collection/production to distribution to water end users was therefore used to represent all of these energy inputs to urban water supplies

Table N-13: Estimated Energy Value of Urban Water Savings

	Water	Wastewater	Energy Intensity of Water Savings (kWh/AF)
Indoor	704	780	1,484
Outdoor	704	n/a	704

The above proxies for the energy value of indoor and outdoor water savings are deemed conservative because they only consider SCE electric data. (PG&E serves about 10 percent of the county's electric requirements; PG&E data were not obtained for this study. In addition, some agricultural pumping is served by public power that is not included in these computations.)

272 *Decision Regarding Tools for Calculating the Embedded Energy in Water and an Avoided Capacity Cost Associated with Water Savings.* CPUC Rulemaking 13-12-011. Decision 15-09-023, September 17, 2015.

273 See *Figure N-1. Framework for Computing the Energy Intensity of Water.*

APPENDIX O:
Data Challenges and Opportunities

As for most studies of this kind, the project team expended considerable time collecting and compiling data, and attempting to reconcile differences.

1. Most data were not readily available in forms that could facilitate ready analysis of candidate drought resilient technologies.
2. Many end use studies were conducted in the 1970s and 1980s with the assistance of federal funding from the U.S. Department of Energy. Since that time, end use studies are primarily conducted during utility program audits that evaluate the potential and/or achieved resource benefits and associated costs attributable to system retrofits. Whole facility and comprehensive industry end use studies are limited and sporadic. As a result, many estimates of water and energy use by industry, type of business, system, function, etc. developed within the past 10-15 years are based on end use studies that were conducted many years prior, some as many as 3-4 decades ago, that are no longer representative of current industry practices. Many of the studies that estimated water, energy (electricity and natural gas), and/or greenhouse gas emissions by industry sector, business segment, region, and water and/or energy technology solution or end use are stale and no longer representative of current industry processes, practices, and technologies.

Lack of Water and Energy Use Data: Food Processing

"The literature review showed a progression from an abundance of publically available data in the 1960s to much less available data in the twenty-first century.

- *Water Use Efficiency Report for California League of Food Processors*, Kennedy/Jenks Consultants and Brown & Caldwell, February 11, 2015.

"The lack of data with regards to water use within industrial subsectors, much less water use at the system or process level, when combined with the diversity of the industrial sector limits the ability to develop quantitative metrics regarding the relationship between water and energy within an industrial facility (for example, developing metrics or rules of thumb such as kWh of electricity per gallons of water used for a given condition and system)."

- Rao, Prakash and Aimee McKane (Lawrence Berkeley National Laboratory), and Andre de Fontaine (Advanced Manufacturing Office, United States Department of Energy), *Energy Savings from Industrial Water Reductions*, Lawrence Berkeley National Laboratory (Berkeley, CA), August 2015. Publication No. LBNL-190943.

3. There were no "perfect" data sets, and data collected and compiled by various parties for seemingly comparable purposes were often not consistent. Observed variances ranged from 10-100+ percent. Some variances appeared explainable by differences in timing, data

collection units, collection and compilation methods, and adjustments made for various purposes. Others may be attributable to data collection and compilation errors.

4. Even today, data are presently not collected and compiled with sufficient granularity to quickly identify opportunities for water and energy efficiency.
   a. Water and energy utilities typically provide metered services at the perimeter of a customer's facility. Meter data can be obtained for a customer site, end use data by system or function requires submetering or special studies and audits.
   b. The state's rules protect confidentiality of customer data, including water and energy use. Strict data security rules prohibit sharing customer data except on an aggregated basis (that is, in a manner that assures that individual customer's rights to data privacy are not inadvertently violated).
5. Electric utilities collect and store electric data at very granular levels enabled by advanced meters. These "interval" data enable detailed time-of-use analyses at the meter level. For this project, we were able to obtain aggregated electric data by NAICS code from SCE. NAICS data enable creating snapshots of time-of-use electric requirements by business segments which is helpful, if not perfect, for identifying potential opportunities for reducing water and electric demand through new technologies. The water sector, comprised of thousands of water and wastewater agencies, some of which are very small, does not have uniform requirements for collecting water consumption by business segment or end use.
6. Wherever data appeared to vary significantly, the project team noted the variances and used the data source that appeared most "authoritative" for purposes of state policies and programs. (For example, in most cases, where relevant data were available from state agencies charged with implementing applicable policies, programs, rules, and regulations, state data were used.)

   However, even "authoritative" data sources provided challenges.

   <u>For example</u>:

   California Department of Water Resources (CDWR) Water Supply & Balance Data Interface Tool, LITE v.9.1, used to support statewide Water Plan Updates, was used for estimated water supplies and demands. The tool is well structured and easy to use. Importantly, it enabled obtaining estimated water supplies and demands from Water Year 2002 (WY2002) through 2015 by county.

   Estimated urban water demand reported by Tulare County water agencies subject to the state's Urban Water Management Act[274] were close to CDWR's estimates during WY2015, but much lower for WY2010:

[274] California Water Code Division 6. Part 2.6. Urban Water Management Planning. § 10610-10656.

Table O-1: Water Demand Reported by UWMPs vs. CDWR Water Portfolio Tool

	Population	CY2010	CY2015
UWMPs for 4 Large Cities	290,435	66,435	67,731
County Overall	459,863	128,400	79,900
UWMP %	**63.2%**	**51.7%**	**84.8%**

Sources:

[1] UWMPs for 4 Large Cities (Visalia, Porterville, Tulare, Dinuba) compiled from UWMPs submitted to CDWR.

[2] County Overall extracted from California Department of Water Resources Water Supply & Balance Data Interface Tool, LITE v.9.1, for the County of Tulare.

APPENDIX P:
Estimated Technology Benefits

Table P-1: Estimated Annual Benefits to Tulare County from Three Drought Resilient Strategies

Technology	Estimated Annual Savings		
	Water (AF)	Electricity, Embedded (GWh)	GHG Emissions (MTCO2e)
Flood to Drip (Fodder Crops)	87,472	24	10,272
Recycle Food Processing Water	1,975	3	1,252
Residential Water Fixtures (Indoors)	4,134	32	381,288
Estimated Annual Benefits	**93,581 AF (30.5 Billion Gallons)**	**59 GWh (59 Million kWh)**	**392,812 MTCO2e (866 Million lbs)**

The above estimates are based on the following drought resilient technology strategies:

- Convert flood irrigation with manure effluent for alfalfa and other fodder crops to drip.
- Implement customer-side recycle/reuse of processing water used by Food & Beverage manufacturers.
- Accelerate Title 20 code changeouts for water efficient fixtures and appliances.

The following assumptions were used to compute these estimated benefits.

Water Savings by Type of Technology/Strategy

1. **Changing flood irrigation of alfalfa and other fodder crops to drip tape** will increase agricultural applied water efficiency for such crops by 40 percent.

   Assumptions:

   a. Tulare County harvested 56,800 acres of alfalfa during CY2016.[275]

   b. Manure water effluent currently being applied in Tulare County via flood irrigation was estimated in the following manner:

   1. A study conducted by the Congressional Research Service (CRS) estimated average California applied water use of 5 AFY per acre of alfalfa planted.[276]
   2. Blaine Hanson, a U.C. Davis researcher, computed water consumption of alfalfa based solely on seasonal evapotranspiration of 1.5 million gallons per acre per year (4.6 AFY/acre). This estimate did not consider inefficiencies attributable to irrigation

275 "Tulare County Crop and Livestock Report 2016." *Tulare County Economic Development Office*. (Tulare, CA.) September 2017.

276 Johnson, Renee and Betsy A. Cody. *California Agricultural Production and Irrigated Water Use*. Congressional Research Service. Washington D.C. June 30, 2015. Publication No. R44093.

method. Since converting manure effluent to drip tape has been demonstrated to increase applied water use efficiency by 40 percent, this indicates that applied water for alfalfa may be as high as 7.7 AFY per acre (4.6 AFY ÷ 0.6 percent).[277]

For conservatism, the CRS average of 5 AFY/acre of planted alfalfa was used to represent "Base Case."

c. A survey of irrigation methods conducted in 2010 by researchers from the University of California at Davis and the California Department of Water Resources reported that 77 percent of the alfalfa fields that participated in the survey use some type of surface flood irrigation. (Eighteen percent (18 percent) used sprinklers, 2 percent used drip irrigation, and 3 percent used some other type of subsurface irrigation.[278]

Computation:

The potential water savings achievable by using drip tape to deliver manure water effluent was therefore calculated as 87,472 AFY:

[56,800 acres x 77 percent using flood irrigation x 5 AFY x 40 percent water use efficiency]

2. **Food and Beverage Water Recycling/Reuse**. The California Department of Water Resources (CDWR) estimated annual industrial water use in Tulare County at 7.9 TAF (2015).[279] Most of the industrial water and energy use in Tulare County is for Food & Beverage (F&B) processing. A conservative 50 percent of total industrial water use was attributed to F&B. Potential water savings from on-site water recycling was estimated at 50 percent of that amount, yielding estimated water savings of 1.975 TAF. Most of the water used for food processing is groundwater.
3. **Accelerated Changeouts of Indoor Residential Water Fixtures**. Energy Commission staff's study of water, energy, and greenhouse gas emissions benefits attributable to 2015 Title 20 compliance[280] was used to estimate the amount of water savings allocable to Tulare County prorated by population (Tulare County accounts for about 1.17 percent of the state's total population.)

277 Hanson, Blaine. *Irrigation of Agricultural Crops in California*. Presentation to Air Resources Board Working Group on Low Carbon Fuel Standard (LCFS).

278 Tindula, Gwen N., Morteza N. Orang, and Richard L. Snyder. *Survey of Irrigation Methods in California in 2010*. Journal of Irrigation and Drainage Engineering. American Society of Civil Engineers (ASCE). March 2013.

279 DWR Water Supply & Balance Data Interface Tool, LITE v.9.1.

280 Compiled from [1] California Energy Commission. Staff Analysis of Water Efficiency Standards for Toilets, Urinals and Faucets. Publication Number CEC–400–2015–021; [2] California Energy Commission. Staff Analysis of Water Efficiency Standards for Showerheads. Publication Number CEC-400-2015-027.

Table P-2: Value of Early Title 20 Water Fixtures Changeouts for Tulare County[281]

California Title 20 Changes to Water Efficiency Standards	Estimated Annual Savings at Inception vs. "Full Turnover"				
	Projected Year	Water (MG)	Electricity (GWh)	Gas (Mtherm)	GHGs (tons eCO_2)
First Full Year	2018	12,250	303	45	3,511,151
At "Full Turnover"	2038	127,392	2,999	425	36,099,844
Incremental Annual Value of Early Changeouts		**115,142**	**2,696**	**380**	**32,588,693**
Tulare Potential @ 1.17% of State population[282]		**1,347**	**32**	**4**	**381,288**
Total Estimated Benefits if Changeouts could be completed within 5 years[283]		**9,766**	**232**	**29**	**2,764,338**

Electric Savings

Electric use was not available by end use. For conservatism, electric savings are estimated solely on the basis of avoided electricity embedded in saved water, using the energy intensity values shown in *Appendix N: Tulare County's Water-Energy Nexus, Table N-12. Interim Proxies for Energy Intensity of Tulare County's Water*.

Greenhouse Gas Emissions Reductions

Air Resources Board's factor of 0.941374 lbs/kWh was used to compute greenhouse gas emissions reductions attributable to savings of electricity embedded in saved water.[284] This is also a conservative estimate, since it does not include other types of electric savings and greenhouse gas emissions reductions that may be achieved by implementing the drought resilient strategies and technologies described herein.

281 Ibid.

282 Tulare County's population of 464,500 is 1.17% of the State's population (39.81 million). (See *New Demographic Report Shows California Population Nearing 40 Million Mark with Growth of 309,000 in 2017*, California Department of Finance press release retrieved from http://www.dof.ca.gov/Forecasting/Demographics/Estimates/E-1/.)

283 The incremental value of achieving 100% compliance with 2015 Title 20 Appliance Efficiency standards by the year 2022 (5 year period) is approximately 7.25 times the incremental annual benefit. See *Appendix K: Accelerated Compliance with New Codes and Standards*, Figures 5, 9 and L-1. Incremental Annual Statewide Benefits by Accelerating Title 20 Changeouts.

284 "Documentation of California's Greenhouse Gas Inventory (10th Edition - Last updated on 04-04-2017)." *Air Resources Board*. Retrieved from https://www.arb.ca.gov/cc/inventory/doc/docs1/1a1ai_importedelectricityunspecified_pacificsouthwest_electricitygeneration_unspecifiedsources_co2_2015.htm.

APPENDIX Q:
Case Study: "Best-in-Class" Municipal Recycled Water Program

A CASE STUDY

City and County of San Francisco's Non-Potable Water Program

and Blueprint for Onsite Water Systems

May 24, 2018

This case study was prepared with the assistance of the San Francisco Public Utilities Commission (SFPUC)

The purpose of this report is to identify ways that Tulare County and its stakeholders can increase opportunities for accelerating water and electricity efficiencies. Limited water supplies and increased climate variability are putting pressure on San Joaquin Valley cities, counties, and utilities. Addressing these challenges include, but are not limited to, increasing the use of non-potable water sources through the development of alternate water supplies, promoting new technologies, and streamlining permits and approvals.

This report looks at the San Francisco Public Utilities Commission's (SFPUC) experience in establishing the City and County of San Francisco's (CCSF) Non-Potable Water Program (NPWP) which is helping SFPUC meet its goal of developing an additional 10 million gallons per day of local water resources. SFPUC, in collaboration with other entities, has developed a step-by-step guide for implementing on-site water systems. The Blueprint guide can be modified and used by other water utilities and local governments to help address the on-going drought and increased water demand.[285]

Non-Potable Water Program (NPWP)

In 2012, the City and County of San Francisco (CCSF) adopted its Water System Improvement Program and an aggressive goal to reduce water demand by 10 million gallons per day (MGD) by 2018. The SFPUC implements numerous water programs to achieve this goal. One of these programs, the Non-Potable Water Program (NPWP) was approved in 2012 with the objective to save on-site potable water by using alternate water sources. The CCSF adopted the Onsite Water

285 "Blueprint for Onsite Water Systems: A Step-by-Step Guide for Developing a Local Program to Manage Onsite Water Systems." Outcome of an "Innovation in Urban Water Systems" conference held May 29-30, 2014 in San Francisco; funded by the Water Environmental Research Foundation and the Water Research Foundation and led by the San Francisco Public Utilities Commission (SFPUC). Published September 2014.

Reuse for Commercial, Multi-Family, and Mixed Use Development Ordinance (known as the Non-Potable Water Ordinance, Article 12C). The program took two years to develop and began as a voluntary program for specific building types.

In 2013, the program expanded to include district scale systems; and in 2015, it became a city-wide, mandatory program for commercial, multi-family and mixed use developments that met specific criteria. The program originally allowed for the collection and treatment of rainwater, storm water, gray water, black water and foundation drainage for on-site non-potable applications.

When the program began, a pilot project was initiated by the SFPUC using its new office building (277,500 square feet). The building was designed and built to collect, treat and use alternative water sources and included 1) a *Living Machine* water treatment system and 2) a rainwater harvesting system. The *Living Machine* technology treats all of the building's wastewater, up to 5,000 gallons per day (gpd) and then distributes the treated water for toilet flushing. Through a series of ecologically engineered wetlands located in the sidewalks surrounding the building and in the lobby, the wetlands treat and reclaim the building's wastewater (gray water and backwater) to provide all daily water needed to flush the building's high-efficiency toilets and urinals. The *Living Machine* reduced per person water consumption from 12 gpd (normal office building) to 5 gpd. In addition, a rainwater cistern (25,000 gallon capacity) was installed to capture rainwater from the building's roof and play area. Treated rainwater is used for landscape irrigation around the building and offsets approximately 8,000 gallons annually. The total project cost for these alternate water uses was less than 1 percent of the building's total construction costs ($1 million). The SFPUC building's potable water consumption was reduced by approximately 65 percent (800,000 gallons annually).[286]

Since 2012, many governmental and privately owned buildings have incorporated onsite water systems. During Fiscal Year (FY) 2015-16 (July 2015 to June 2016), 17 water budget applications to install onsite water systems were received by the Non-Potable Water Program. These 17 new projects proposed to offset approximately 38.3 million gallons per year of potable water. Combined with the 13 projects from FY 2014-15, 12 projects from FY 2013-14, and 18 projects from FY 2012-13, the estimated potable offset of the 60 projects is 62.2 million gallons of potable water each year.[287]

Currently, alternate water sources in the NPWP include:

1. ***Rainwater*** - precipitation collected from roofs or other manmade above grade surfaces.
2. ***Storm water*** - precipitation collected from at or below grade surfaces.
3. ***Gray water*** - wastewater from bathroom sinks, showers, and washing machines and laundry tubs.

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286 "Non Potable Water System Projects Report." San Francisco Public Utilities Commission. January 2017.

287 "Water Resources Division's Annual Report, Fiscal Year 2015-2016." San Francisco Public Utilities Commission.

4. ***Black water*** - wastewater containing bodily or other biological wastes from toilets, dishwashers, kitchen and utility sinks.
5. ***Foundation drainage*** - nuisance groundwater extracted to maintain structural integrity that would be discharged to City's sewer system.

The ordinance requires:

- All new development projects of 250,000 square feet or more of gross floor to install onsite water systems to treat and reuse available gray water, rainwater, and foundation drainage for toilet and urinal flushing and irrigation.
- All new development projects of 40,000 square feet or more of gross floor area to prepare and submit to the CCSF, water budget calculations assessing the amount of available rainwater, gray water, and foundation drainage, and the demands for toilet and urinal flushing and irrigation and Water Use Calculator.

Below is a table from the *Non-Potable Water Program Guidebook* published in January 2018.[288]

Table Q-1: Excerpt from the SFPUC's Non-Potable Water Program Guidebook

	Project Not Required to Install an Onsite System	Projects Required to Install an Onsite System
Requirements for alternative water sources and non-potable end uses	Projects may use any approved alternative water source for any approved non-potable end use in accordance with the required water quality and monitoring criteria	Projects must use available graywater, rainwater, and foundation drainage to meet toilet and urinal flushing and irrigation demands in accordance with the required water quality and monitoring criteria to the extent that: • 100 percent of these demands are met or 100 percent of available graywater, rainwater and foundation drainage sources are captured and treated Projects may also collect, treat and use blackwater and stormwater.
Eligibility for SFPUC grant funding	Projects are eligible for available grant funding through SFPUC's Non-potable Grant Program	Projects are not eligible for grant funding as the project is required to comply with Article 12C
Subject to SFPUC water use allocation program and excess use charges	Projects are not assigned a potable water use allocation and are not subject to excess use charges	Projects are assigned a potable water use allocation and are subject to excess use charges
Eligibility for water and wastewater capacity charge adjustments	Projects are eligible for adjusted water and wastewater capacity changes	Projects are eligible for adjusted water and wastewater capacity charges

The SFPUC partnered with local, state and federal agencies and research institutions to identify ways to successfully implement onsite water systems for non-potable applications.

288 *Non-Potable Water Program Guidebook*, San Francisco Public Utilities Commission, January 2018.

Development of this program from the ground up and provided several important "lessons learned":

1. Collaboration among all partnering agencies is key to program success.
2. Due to the lack of national standards for non-potable water uses, consistent water quality standards for treatment, monitoring and reporting is needed.
3. Any permitting process should address the Technical, Managerial, and Financial (TMF) capacity of the permittee. The SFPUC found that this was especially important for district scale systems where the number of end users is high and system operation is complex. Because of this, treatment operators must have the training, skills and capabilities to operate and maintain the onsite non-potable water system on an on-going basis.

Below are the ten key steps identified in the SFPUC Blueprint.[289] These steps and key elements are important for successfully implementation of onsite water systems for non-potable water applications. The Blueprint was created to assist communities that want to establish an onsite water systems program. In addition, the Blueprint can help address water, storm water, and wastewater management programs in a coordinated manner.

STEP 1. Establish Working Group: Establish a small working group to guide the development of the local program. Representatives from the departments of Public Health, Planning, Building Inspections, Public Works, and water utilities with authority over any aspect of the program must participate on, or be consulted by, the working group. This core group will be responsible for the development and implementation of the new program. Responsibilities include, but are not limited to, 1) identifying roles and responsibilities of individual agencies, 2) developing water quality criteria, monitoring and permitting requirements, 3) ensuring the new program reflects the needs of its core members, and 4) promoting the new program through incentives and other mechanisms. Private stakeholders, such as developers, non-profit organizations, or other non-governmental stakeholders that are engaged in green buildings, water conservation or reuse can be invited to participate or provide feedback.

STEP 2. Select the Types of Alternate Water Sources: Narrow the specific types of alternate water sources in the new program. It is important to identify the specific types of alternate water sources to be included in the program. The amount of resources and staff needed will increase with the number of alternate water sources that are included in the program. It may be easier to start with one alternate source to ensure success at the beginning of the new program. The most common types of alternate water sources include:

- Rainwater - precipitation collected from roofs.
- Storm water - precipitation collected from the ground.
- Gray water - wastewater from bathtubs, showers, bathroom sinks, and clothes washing machines.
- Black water - wastewater from toilets, dishwashers, kitchen sinks and utility users.

289 The complete Blueprint guide can be found at www.sfwater.org/np.

The same terminology and definitions should be used across the local building, plumbing and health codes to minimize confusion among city staff, developers and the public.

STEP 3. Identify End Uses: Classify specific non-potable end uses for your program. Alternate water sources can be used for a variety of non-potable uses within and outside a building. Identify the specific non-potable end uses, for example irrigation, that will be allowed and describe how and where the end use is allowed, for example spray or sub-surface irrigation. According to SFPUC, the most common indoor use is toilet/urinal flushing, which use 25 percent of the total water demand in a residential building and up to 75 percent of total water demand in a commercial building. Other potential non-potable water demands include irrigation, clothes washers, cooling/heating applications, and process water. These additional applications can increase non-potable water demand up to 50 percent for residential buildings and 95 percent for commercial buildings. Incorporating many end uses into a new program may result in a more complex program structure, but result in more widespread application throughout a jurisdiction.

STEP 4. Establish Water Quality Standards: Develop water quality standards for each alternate water source and/or end use. Water quality standards must be established once alternate water sources and end uses are identified for the program. Establishment of an on-site non-potable program requires researching statutes, regulations, and local codes and ordinances to ensure legal compliance and water quality for public safety. The International Plumbing Code (IPC) and the Uniform Plumbing Code (UPC) include alternate water sources and water quality standards for many alternate water sources. In addition, local ordinances and procedures commonly have to be updated or developed. Setting water quality standards can be the most time consuming components of a program. The Blueprint lists local, state and national guidelines and regulations that might be helpful when establishing a new program. Below is a summary of statutes and regulations identified by SFPUC when they developed San Francisco's Non-Potable Water Program.

Table Q-2: Statutes and Regulations Referred to in SFPUC's Non-Potable Water Program

ALTERNATE WATER SOURCE	REGULATION
Black water	California Title 22 (recycled water)
Gray water	California Plumbing Code - NSF - 350
Rain water	California Plumbing Code
Storm water	No state codes -- San Francisco Dept. of Public health established
Foundation Drainage	No state codes -- San Francisco Dept. of Public health established

STEP 5. Identify and Supplement Local Building Practices: Revise local construction requirements and building permit processes to reflect new program requirements. It is important to understand the steps of the building and plan review, permit process, and construction inspection in order to integrate onsite water systems requirements into these processes. For example, the plumbing code may need to be amended to allow for the installation of onsite water systems. Construction requirements may need to be amended for consistency between plumbing and building requirements. Typical requirements include system

bypass, backflow prevention devices, cross connection control, storage tanks, and non-potable system identification.

STEP 6. Establish Monitoring and Reporting Requirements: Establish water quality monitoring and reporting requirements for ongoing operations. Most jurisdictions do not have monitoring standards for the ongoing operation and maintenance of onsite water systems. Establishing standards and guidelines for onsite water systems is critical to ensuring public health and proper operation of public water systems. Monitoring and reporting frequency will vary depending upon the different contaminants and public exposure of the alternate water sources and end uses. For example, storm water and gray water must be monitored monthly and reported annually to the SF Department of Public Health; however, black water requires daily monitoring and monthly reporting.

STEP 7. Prepare an Operating Permit Process: Establish the permit process for initial and ongoing operations for onsite water systems. To be effective, procedures should be established for ensuring on-going compliance with monitoring and reporting requirements. This is typically done through an operating permit for a treatment system authorized by a local jurisdiction, which includes the ability to shut down the system if it fails to comply with permit requirements. Operating permits may include: 1) reviewing and approving an engineering or design report, 2) issuing a permit and 3) reviewing monitoring data. An engineering report should detail the collection of alternate water sources(s), treatment system and process and end use applications. Permits should be implemented in phases to ensure quality control. Phases could include: 1) a start-up permit for 1-3 months with ongoing inspections on a regular basis; 2) a temporary use permit for 3-9 months and frequent monitoring; and 3) a final permit once standards are consistently met and the operation is safe and reliable.

STEP 8. Implement Guidelines and the Program: Publicize the program to provide clear direction for project sponsors and developers. Clearly outlining the process for design, construction, and operation of onsite water systems and determining the responsible agency for each program elements is critical to program success. Developers need to have clear direction, especially with respect to building standards, permits, fees and operating requirements. Program elements could be implemented in phases to help developers successfully implement onsite water systems:

- ***Design Phase*** - application, engineering report, and construction permits.
- ***Construction Phase*** - treatment system review; construction certification, and cross connection control test.
- ***Operational Phase*** - permit review and final approval, monitoring, and reporting.

Providing fact sheets, guidebooks, "how to" papers, and checklists are also an important part of clearly communicating the objectives and requirements of a new non-potable water program. Identifying the responsibilities of each department involved in the program is critical for developers and property owners to understand how the program works.

The following chart shows the responsibilities for the City of San Francisco's permitting process, including the processing, inspecting, approving, and monitoring of on-site non-potable water uses.

Table Q-3: City and County of San Francisco's Streamlined Permitting Process

SFPUC – WATER DEPARTMENT	SAN FRANCISCO DEPT OF PUBLIC HEALTH	SAN FRANCISCO DEPT OF BUILDING INSPECTION	SAN FRANCISCO PUBLIC WORKS
Program Administration & Outreach	**Public Health**	**Construction**	**Right of Way and Mapping**
Review onsite non-potable water supplies and demands	Issue water quality and monitoring requirements	Conduct Plumbing Plan check and issue Plumbing Permit	Issue Encroachment Permits as needed for infrastructure in the right-of-way
Administer citywide project tracking and annual potable offset achieved	Review and approve non-potable engineering report	Inspect and approve system installations	Includes condition on a subdivision map or a parcel map requiring compliance with the Non-potable Water Ordinance prior to approval and issuance of said map
Provide technical support and outreach to developers	Issue permits to operate onsite systems		
Provide financial incentives to developers	Review water quality reporting		
Manages cross-connection control program			

STEP 9. Evaluate the Program: Promote the best practices for onsite water systems. It is important to determine the effectiveness, accomplishments, and lessons learned from the new program. On-going evaluation is necessary to determine whether water reduction is being accomplished. Evaluations also help adjust the program to ensure more water conservation and reduction in water demand. Monitor the regulatory compliance of all projects and collect data on the types of alternate water sources and end uses to document the amount of potable water offsets. The reports will help educate decision-makers, property owners and the public and continually help improve the program.

STEP 10. Grow the Program: Expand and encourage onsite water systems. Once a program has been established, it can be expanded through a variety of actions. A new program could start with a single building type and a small geographic area and then add more building types or expand to more geographic areas.

Additional examples to encourage expansion include:

- ***Increasing the types of alternate water sources*** - rainwater, storm water, gray water, black water, foundation drainage, cooling tower blow down, and condensate water.
- ***Increasing the non-potable applications*** - toilet and urinal flushing, irrigation, cooling tower make-up, clothes washers, process water, and decorative fountains.
- ***Providing incentives*** - reduced or waived permit fees, property tax and/or storm water fee reductions, water and sewer bill reductions, loans or on-bill financing, and grants or rebates.

The City and County of San Francisco provides grant funding of up to $500,000 for a project that implements onsite water systems. Other cities waive building permit fees and provide wastewater allowances to qualified properties with onsite water systems. Additional incentives could include rebates, and grants.

Lessons Learned

The development and implementation of the Non-Potable Water Program resulted in several "lessons learned" for the San Francisco Public Utilities Commission (SFPUC). These lessons were key in the successful implementation of the program. For example, the SFPUC learned that collaboration among all partnering agencies is key to program success. Also, permitting requirements are key to effective implementation. Treatment system operators must have the training, skills, and capabilities to operate and maintain onsite non-potable water system on an ongoing basis. Operator capacity should be assessed as part of the permitting process. The Technical, Managerial, and Financial (TMF) capacity of the permittee should also be evaluated under the permitting process. This is particularly important for district-scale systems where there is a large number of end users and system operation is complex. Finally, due to the lack of national standards, there is a need for consistent water quality standards for treatment, monitoring and reporting.

All jurisdictions face significant challenges to improving water-energy efficiencies and conserving limited potable water. However, they have different usage patterns, water demands and geographic conditions than the City and County of San Francisco. SFPUC's Non-Potable Water Program offers a step-by-step guide for improving water-energy efficiencies and conserving limited potable water. This suggested guide can be used as is, or modified, to address the specific needs of various jurisdictions.

Attachment 1

SUMMARY OF CITY AND COUNTY OF SAN FANCISCO (CCSF) WATER PROGRAMS

(www.sfwater.org/np)

Water Conservation Programs

1. ***Water Wise Evolutions***. Indoor and outdoor evaluations for residential and commercial buildings, including water efficient recommendations and irrigation system assessment, and leak identification. On site assessments included identifying old plumping fixtures that qualified for financial replacement incentives and free water-efficient plumbing devices, including showerheads, aerators and toilet leak repair parts.

2. ***High-Efficiency Toilet (HET) Direct Install program***. Evaluates and provides free replacement of inefficient toilets to non-profit, multi-family affordable housing provides and low-incomes rate discount program. The HET Direct Install Program helps reduce water usage and utility costs for customers who cannot participate in traditional rebate programs. It was funded by $1.2 million in state and federal grants.

3. ***Commercial Equipment Retrofit Grant Program***. Provides monies to businesses for onsite equipment upgrades, such as cold room, steam sterilizer, and laundry process water efficiency programs.

4. ***Toilet and Urinal Rebates***. Rebates are used to eliminate older, inefficient 3.5 gallons per flush (gpf) or more with new high energy toilets (HETs) with maximum flush of 1.28 gpf. Rebates of $125 for tank toilets, up to $500 for flushometer toilet models (high-efficiency urinals that use 0.5 gpf or less).

5. ***Clothes Washer Rebates***. The City and County of San Francisco (CCSF) partners with Bay area water agencies and Pacific Gas and Electric Company (PG&E) to provide water and energy rebates of $150 for Energy Star high-efficiency clothes washers, including residential, coin-operated, and commercial-style clothes washers.

6. ***Free High-Efficiency Plumbing Devices***. Provides free showerheads, faucet aerators, garden spray hose nozzles and toilet leak repair parts to residential and commercial properties. Single family and multi-family (10 units or less) customers are able to pick up selected devices from SF PUC.

7. ***Laundry to Landscape Program***. Provides discounted gray water kits, workshops and onsite technical assistance to residents who will design, install and maintain gray water systems that direct clothes washing machines water into gardens.

8. ***Landscape Audits***. Provides surveys and identifies irrigation improvements to San Francisco's largest retail customers and customers with more than one-half acre of landscape.

9. ***Customer Water Use Tools***. CCSF established a web portal for customers to view daily water use and other water use information. CCSF implements a leak detection program to notify single-family residential customers with three days of continuous water use. When automated

meter data shows this, customers are notified they may have a leak and should inspect indoor plumbing fixtures and irrigation systems.

10. ***Community Garden Grants***. Awards grants to community gardens to install dedicated water meters to monitor and manage water use.

11. ***Demonstration Gardens and Gardening Classes***. Offers classes in partnership with non-profits to show small-scale organic food products and water-efficient irrigations systems. These free workshops help create more water efficient landscapes and increases consumer knowledge about non-potable water supply alternates, such as gray water and rainwater harvesting.

New Water Supplies

1. ***Recycled Water Program***. Significant work has been completed, or is underway, to provide municipal recycled water to San Francisco's largest irrigation users. Providing recycled water to these large irrigation users is not only a logical first step in implementing any major recycled water program, but also is a critical step toward meeting the City's goal to diversify its water supply portfolio.

2. ***Recycled Water Truck-Fill Station***. SFPUC operates a truck fill station for SFPUC-permitted organizations to use disinfected Secondary-23 recycled water for irrigation of roadway and freeway landscaping, soil compaction, dust control, street cleaning, and sewer flushing.

3. ***San Francisco Groundwater Supply Project***. The San Francisco Groundwater Supply Project is a forward-looking, proactive project that allows us to diversify our water sources by blending a small amount of local, high quality groundwater with our regional water supplies. By diversifying in this way, our water supplies are less vulnerable to risks such as earthquakes, drought and maintenance activities, and we are helping to meet the long-term water supply needs of the City.

4. ***Regional Groundwater Storage and Recovery Project***. This project includes the construction of up to 16 new recovery wells and facilities. This is a partnership with SFPUC, City of Daly City, City of San Bruno, and California Water Service Company, allowing these agencies to operate the basin and provide a new 20 billion gallon regional dry year groundwater supply.

Non-Potable Water Program

1. ***Non-Potable Program***. Promotes the capture and reuse of water generated on site for non-potable purposes, such as toilet flushing and irrigation. On-site water reuse can help reduce potable water consumption by up to 50 percent in new multi0family residential developments and up to 95 percent in new commercial developments. Primary sources of water include gray water, rain water, storm water, black water and foundation drainage. This program applies to new commercial, multi-family and mixed-use developments.

2. ***Non-Potable Water Grant Program***. This program offers grants of up to $500,000 for projects meeting specific requirements.

3. ***Public Health Standards Initiative***. The SFPUC partnered with the National Water Research Institute (NWRI), Water Research Foundation (WRF), and Water Environment and Reuse Foundation (WE&RF) to develop public health standards for treated alternate water sources for non-potable applications, including water quality criteria, monitoring and permitting standards for onsite water systems. This research collaboration culminated in the publication Risk-Based Framework for the Development of Public Health Guidance for Decentralized Non-Potable Water Systems, which was released in March 2017. The SFPUC has also partnered with the US Water Alliance to convene the National Blue Ribbon Commission for Onsite Non-Potable Water Systems to advance best management practices that support the use of onsite non-potable water systems for individual buildings or at the local scale. The Blue Ribbon Commission released *A Guidebook for Developing and Implementing Regulations for Onsite Non-Potable Water Systems*, in 2017, which presents a concrete and actionable framework that states and localities can use for regulating and managing onsite non-potable water systems based on best in class science and research.

APPENDIX R: Tulare County Wastewater Treatment Facilities

The following descriptions of Tulare County's three largest municipal wastewater treatment facilities were developed through interviews with wastewater treatment operations staff during field visits. Except where otherwise noted, interviews during field visits were supplemented with publicly available information on the cities' respective websites.

The three largest wastewater treatment facilities that are described herein are:

- City of Visalia Water Conservation Plant (WCP)
- City of Tulare Wastewater Pollution Control Facility (WPCF)
- City of Porterville Wastewater Treatment Facility (WWTF)

City of Visalia Water Conservation Plant (WCP)

Visalia is both the largest wastewater treatment facility in Tulare County and has the highest quality treatment. The WCP serves the City of Visalia and the nearby community of Goshen. The WCP's treatment process uses aeration basins, membrane bioreactors (MBR), and ultraviolet (UV) disinfection to treat water to tertiary quality, resulting in high quality effluent that can be used for the highest recycled water purposes approved by Title 22. The WCP has a total capacity of 22 million gallons per day (MGD); the current treatment volume is about 12 MGD.

At the time of the project team's tour of this facility (Spring 2018), the WCP was nearing completion of a multi-year expansion project that included installing a Membrane Bioreactor (MBR) system[290] (the largest in California and the 12th largest in the world), ultraviolet (UV) disinfection, a biogas engine, and a unique "disintegrative" biosolids digester (the first of its kind in the United States).

Carollo Engineers developed a *Wastewater Treatment Master Plan Update* in 1993 that projected an average flow of 18.3 MGD in 2015 and 21 mgd in 2020[291]. These growth projections have not come to pass and the plant is operating at 55 percent capacity. The influent comes from about 85 percent residential and 15 percent industrial sources.

Visalia has established a water exchange agreement with the Tulare Irrigation District (TID) to deliver 11-13 thousand acre-feet (TAF) for irrigation in exchange for 5.5-6.5 TAF of surface water for groundwater recharge. This agreement represents up to 97 percent of the City's current effluent. There are a few local recycling projects, including watering Plaza Park and the

290 MBR is an advanced wastewater treatment technology that uses a combination of biological treatment and microfiltration.

291 "City of Visalia Municipal Service Review." *Tulare County Local Agency Formation Commission*. February 2013.

new Valley Oaks Golf Course. The water rights to the effluent is owned by California Water Service (CalWater), the water utility that serves the City.

Visalia contracted with Parsons Corporation to engineer the City of Visalia Water Conservation Plant Upgrades Project, which is nearing its completion after four years of construction. The upgrade includes the largest MBR system in California, the first disintegrative digester in the United States, and a canvas methane storage bubble that drastically increases the plant's capacity for energy generation from biogas. They also built a new generator facility, though it's not currently considered constructed until it is hooked up, which won't occur until the Air Resources Board issues them an Authority to Construct (ATC). The generator will help power the blowers and waste heat will be used to manage optimal temperature in the facility's digesters.

The upgrades project recently received an award from Southern California Edison (SCE) for utilizing technologies that would save 7,050,854 kWh each year. While the facility took advantage of energy-efficient technologies that reduce its emissions by 29 percent compared with the "business as usual" scenario, the update still increased the plant's overall CO_2e emissions by 7,980 tons per year compared with the previous condition of the plant. This was considered a significant and unavoidable impact of updating the city's water treatment.

The following technology opportunities were identified by operations staff of the City's Water Conservation Plant.

Technology Opportunities

Filter screen influent design

The filter screen influent pumps were designed to be gravity-fed up to 13 MGD. However, they're being required to pump for flows as low as 5.5 MGD.

Sludge concentration influent design

The facility's gravity belt thickener is located in the back of the Plant. Moving sludge this distance from the primary settling tanks requires more energy, as sludge experiences friction loss in pipes over long distances. Moving the gravity belt thickeners closer to both primary sedimentation and the mesophilic digesters would save energy. Alternatively, finding ways to reduce friction loss in the pipes through larger pipes, fewer curves, or hydrophilic pipe coatings would also reduce energy.

Pump galley design

If the pump galley had been designed 5 feet deeper, it would have created a natural gravity-fed siphon and reduced its energy use by half. If it had been built at the surface, it would still have to pump water to the MBR station, but wouldn't have to then pump it straight up to the filter trains. Either solution would save energy, but would require a large retrofit of the pump galley.

Renewable energy

One of the City's future priorities is to discover new ways to increase biogas production in the plant to generate more renewable energy.

Knowledge sharing

The City of Visalia's wastewater treatment management and operations teams have been engaged in this major update for the last four years. The team stated that they had learned through trial and error, and by working with different contractors and technology providers. More knowledge sharing is needed among industry professionals. The City is willing to share their lessons learned with other wastewater treatment utilities.

Recycled Water

CalWater owns the rights to the City's effluent; consequently, future reuse projects will require coordination with CalWater.

Visalia Water Conservation Plant Design and Operations

Influent

The City of Visalia's Water Conservation Plant is the largest wastewater treatment facility in Tulare County. Flows average 11.5-12 MGD. The plant has capacity for 22 MGD. Influent comes primarily from domestic users in the City of Visalia and the nearby community of Goshen. Influent is rich in Hydrogen Sulfide, a result of anaerobic processes in the sewer system leading to the plant.

Headworks

Headworks consist of a bar screen, followed by a muffin monster grinder. Solids are dewatered by a variable flow screw. Six influent pumps are used to transport this flow.

Grit facility

Grit from the headworks flows through four channels, where the water is divided up equally. A paddle creates a vortex and inorganics fall to the bottom. Pumps send the grit to a clarifier, and the grit is sent to landfill. Channel three is non-operational due to the need for replacement on the motor.

Biofilter

Influent is sprayed over an iron-impregnated wood chip media to remove Hydrogen Sulfide (H_2S). H_2S would destroy most metal components in the downstream processes if not removed. After 2-3 years, the wood chips will need to be replaced.

Primary settling tanks

There are five primary sedimentation tanks. Solids settle to the bottom and are skimmed from the bottom using a plastic chain that runs along the length of the tanks. Surfactants and soaps rise to the surface where they are skimmed off. Both are sent to the digesters. The skimmers are manually adjusted daily to account for changes in influent volume and quality. Water goes over a weir to the next stage.

Screen filter

Prior to the recent update, Visalia used a trickling filter to treat primary effluent. This bred an enormous number of snails. The new membrane reactors are sensitive to abrasives so to remove the snails, the facility introduced a screen filter. There are three drums that use an augur to force water through a screen, where solids are collected and dropped into dumpsters. After many months of operation, the snails have mostly been removed, and the rate of solid collection by these filters has dropped dramatically.

The pumps into the screen filters were designed to utilize gravity up to 13 MGD and begin pumping after that limit. However, there is an undiagnosed design flaw in which the pumps need to be run with flows as low as 5.5 MGD, essentially adding an unintended pump station to the treatment process.

Aeration basins

The aeration basins were redesigned during the update to include anoxic zones for removal of nitrogen. The facility was not required by their waste discharge requirements to add a Nitrogen removal stage but recognized the local problem of nitrate filtration into groundwater so implemented it anyway.

Three tanks are anoxic, the rest are aerated. In the aerated basins, primary effluent is mixed with sludge from the MBR system. After nitrification, water is pumped to the anoxic basins for denitrification, converting the nitrogen to nitrogen gas (N2) which is released to the atmosphere.

A blower facility runs 1-3 blowers at a time.

Membrane Bioreactor (MBR)

Visalia's membrane bioreactor is the largest in California, and the 12th largest in the world. It is made up of ten trains, each with eight cassettes of membranes that treat 3,500 gpm. The membranes are small, flexible pipes with billions of pores that use a vacuum to pull water through the pores and removing contaminants.

A different brand (Neuros) of blowers is used to bubble air through the membranes, preventing scum from clogging the pores. A third set of Kaiser blowers are used for agitation of the influent and effluent channels to prevent settling in the channels.

A pump galley was built below the MBR system. The MBR requires very little energy to move water through the membranes, so most of the energy is used to bring water to the pump galley, and then pumping the water up to the trains.

Sludge concentration

Sludge from the primary settlers is pumped to a gravity belt thickener facility at the back of the plant.

Anaerobic digestion

The facility runs two types of digester. The original mesophilic digesters run 24 hours a day. The new disintegrative digester, the first of its kind in the United States, uses extreme pressure to force thickened sludge through a tiny nozzle, giving it a thinner consistency before heating it in a boiler and producing methane.

Digesters have fixed domes to collect gas, which is transported to a new storage bubble. The storage bubble fills up an internal bladder as methane is produced, controlling pressure and the amount of gas moving to their digesters. Additionally, one of the digesters is solely used as a storage tank for methane.

Disinfection

A UV system disinfects MBR effluent. It runs four banks on high flows. The UV lights in the bank closest to the influent stream run at full power, and subsequent banks run between 40 percent-100 percent depending on need.

Energy generation

The facility has a 1 MW solar field where they are producing energy, but they are not yet producing energy from biogas. A cogeneration facility has been built but at the time of the project team's field visit, had not yet been connected to the generator. When complete, the biogas cogeneration facility will produce 1 MW of renewable energy.

Effluent

The facility produces high quality tertiary treated effluent that is used on a nearby golf course and Plaza Park. The facility also provides tertiary treated effluent to Tulare Irrigation District under an exchange agreement.

Biosolids

A dewatering facility takes decanted sludge from the digesters and uses an augur to pass it through a series of screens for water removal. Sludge increases from 1 percent solids to 23 percent solids. Five acres of concrete-lined sludge drying beds solar dry the sludge, after which the sludge is moved to a paved hauling dock. A contractor hauls away the solids and applies it to soil. Some of it is removed for landfill cover, but the landfill is limited with respect to much it can take.

City of Tulare Water Pollution Control Facility (WPCF)

The City of Tulare operates two conjoined facilities: one treats primarily domestic effluent and the other treats industrial effluent from the City of Tulare and the surrounding area. The two plants operate separate treatment processes, but both plants combine effluent after completing treatment for a total average of 11.36 million gallons per day (MGD). Sludge from both facilities are managed by the industrial plant.

Sludge from a Sequencing Batch Reactor (SBR) system[292] goes to a storage tank, where it mixes with domestic sludge and goes through two sludge Dissolved Air Flotation systems (DAFs).[293] It then enters anaerobic digesters to produce methane before going to the sludge drying beds. The sludge beds are currently one of the City's greatest challenges. During winter rains, the sludge beds fill up, exceeding storage capacity and forcing the plant to send sludge back to the Bulk Volume Fermenter (BVF)[294] for storage. The City received a permit in 2017 to send the sludge to landfill but the City is still producing more sludge than it has disposal capacity.

The WPCF has fuel cells capable of generating 1.2 MW of energy from methane. However, the digesters are not producing enough methane to operate the fuel cells economically. Consequently, biogas is currently being flared.

Tulare's effluent is qualified as secondary undisinfected effluent. Adding a disinfection stage would qualify it as tertiary effluent, meeting Title 22 standards and substantially expanding eligible reuses. After domestic and industrial discharges mix, the combined effluent is discharged across the street to 320 acres of storage/percolation ponds. Effluent is recycled on 2,200 acres of farmland. Eight hundred acres are owned by the City; the rest is owned by private farmers. (Since the effluent is secondary undisinfected, it can only be used on non-consumption crops.) The rest of the effluent remains in the percolation ponds.

The most recent facility update occurred in 2009, which expanded capacity of the industrial WPCF from 8 MGD to 12 MGD.

Technology Opportunities

The City of Tulare's General Plan anticipates continued use of reclaimed water for agricultural use; however, the Plan also includes other initiatives such as dual water systems for potable and non-potable water, reuse of gray water in homes or businesses for irrigation, and reuse of sewage effluent for irrigation on crops, golf courses, or City irrigation. The City plans to require use of recycled or non-potable water for landscape irrigation for new developments.

Achieving the Plan goals will require implementing tertiary treatment, since Title 22 prohibits use of secondary undisinfected effluent for urban uses in which the effluent could come in contact with humans.

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292 A Sequencing Batch Reactor (SBR) is a fill-and-draw activated sludge system for wastewater treatment.

293 Dissolved Air Flotation (DAF) clarifies wastewater by removing suspended solids.

294 "Industrial Wastewater Treatment Expansion Project." Parsons for City of Tulare. Retrieved from http://www.tulare.ca.gov/home/showdocument?id=488.

Upcoming expansions

The City plans to add 6 primary clarifiers and 6-8 secondary clarifiers to its domestic wastewater treatment facility when wastewater treatment volumes approach 80 percent of the combined facilities' capacity.

Table R-1: Incremental Beneficial Uses that Can be Met with Disinfected Tertiary Treated Wastewater (Partial List)[295]

Urban	Agricultural	Commercial/Industrial	Environmental & Other	Groundwater Recharge
▪ Fire Protection ▪ Toilet & Urinal Flushing ▪ Irrigation of parks and playgrounds, school grounds, residential landscaping	▪ Food crops where recycled water contacts the edible portion of the crop, including all root crops	▪ Structural fire fighting ▪ Commercial car washes ▪ Commercial laundries ▪ Industrial or commercial cooling or air conditioning involving cooling towers, evaporative condensers, or spraying that creates a mist ▪ Unrestricted access golf courses ▪ Industrial process water that may contact workers	▪ Wildlife habitat/ wetlands	▪ Seawater intrusion barrier ▪ Replenishment of potable aquifers

Disinfection

Unlike other plants that would need to implement advanced treatment systems to achieve tertiary quality effluent, Tulare only needs to add a disinfection stage. Disinfecting the City's effluent would significantly expand the types of beneficial uses for which the effluent could be used. The current plan anticipates adding two denitrification filters and sending both domestic and industrial flows through ultraviolet (UV) treatment before combining the effluent for delivery to holding ponds.

Land availability

The City of Tulare's WPCF has substantial land. After the 2009 update, the City discontinued use of many of its aeration lagoons, leaving over 25 percent of land unused. This presents opportunities for expansion and integrating new technologies and processes that may require a larger footprint than the City's existing facility. The Tulare General Plan allows purchasing additional land to create a buffer around the WPCF.

Sludge Drying

The City of Tulare's sludge drying beds risk overflowing during winter, leading to the need to manually remove sludge from the sludge drying beds and transport wet sludge to the Bulk

295 Title 22 Chapter 3. Water Recycling Criteria, Article 3. Uses of Recycled Water (Sections 60304-60307).

Volume Fermenter for extra storage. The WPCF could benefit from energy efficient drying technologies that accelerate the drying process and reduce the volume of biosolids.

Motors and Blowers

Many of the motors and blowers used at the City of Tulare's WPCF are 5-10 years old. These are frequently repaired, rather than replaced; and when they are replaced, they are often replaced with the same make and model rather than with more efficient equipment. The City plans to eventually replace its 100 hp motors with more efficient 75 hp motors that can produce similar flow and pressure, but these types of equipment updates are generally tied to larger retrofits rather than routine repairs and maintenance.

Test Bed

City operations staff have expressed interest in serving as a pilot host for testing and demonstrating new technologies.

Tulare WPCF Design and Operations

Domestic Facility Process

Influent

The domestic plant receives residential and commercial effluent from the City of Tulare and four industrial dischargers. The facility is designed for 6 MGD. The influent is high in nitrogen, which caused excessive nitrogen in the discharge until the anoxic basins were introduced.

Headworks

A four-motor lift station pumps influent from 40 ft. below ground to the headworks which separates solids with a mechanical bar screen, then puts the solids through a screw compactor for concentration. Grit is sent to a separate grit classifier for settling where it is removed from the bottom into a hopper and sent to landfill.

Primary Sedimentation Basin

Wastewater influent is sent to the primary sedimentation basin. Although the Plant treats about 4 MGD, the capacity of the primary basin is 13 million gallons. This enables secondary effluent to be recycled back through the primary basin for additional settling and retreatment. Settleable solids fall to the bottom, and scum floats to the top, where they are each skimmed off and pumped to the industrial plant's digesters.

Biotowers

Primary effluent is sprayed over redwood chips, which aerates the water and provides a surface for microbes to remove some of the BOD.

Anoxic basins

The facility uses anoxic basins for Nitrogen removal.

Aeration basins

Four 125 hp motors run multistage centrifugal blowers to keep dissolved Oxygen at appropriate concentrations. Oxygen is introduced by fine bubble diffusers, which cause the facultative microbes to grow rapidly, absorbing biochemical oxygen demand.

Secondary sedimentation basins

From the aeration basins, water flows into secondary sedimentation basins where mixed liquor settles to the bottom and scum floats to the top. Sludge from the secondary clarifiers is scraped off and is recycled back into the anoxic basins as Return Activated Sludge (RAS), providing a base population for facultative microbes.

Anaerobic digesters

The domestic plant has two digesters that are currently being used as storage tanks. They are filled daily with sludge from the primary clarifiers, and are pumped to the industrial digesters to produce biogas.

Effluent

Effluent is sent to a mixing box where it combines with industrial effluent. An effluent pump station moves the treated effluent across the street to storage ponds where it is held for irrigation. Since the City's effluent is not disinfected, it can only be used to irrigate non-consumption crops and for groundwater recharge. However, the effluent is of sufficient quality that adding a disinfection stage would qualify the effluent as tertiary recycled water.

A portion of the effluent is recycled on 2,200 acres of farmland, 800 of which is owned by the City of Tulare. The rest is owned by a set of nine ranchers and property owners in the nearby area. The remaining effluent is discharged to 320 acres of storage ponds across the street from the WPCF for percolation and groundwater recharge.

Biosolids

Sludge from the primary clarifiers are sent to the industrial plant and activated sludge from the secondary clarifiers are returned to the anoxic basins. Neither the domestic digesters nor a gravity belt thickener are currently being used to produce methane or biosolids.

Industrial Facility Process

Influent

The industrial wastewater that enters the WPCF is mostly from local dairies but includes commercial discharge, stormwater, some domestic wastewater, septage, and sludge supernatant. The influent has low pH and is very high in BOD and nitrates.

The City has a pretreatment program for major industrial dischargers (Dreyers, Morningstar Foods, Kraft, Saputo Cheese, and others).

Headworks

Four 100 hp motors pump water up to a bar screen, which removes large solids.

Bulk volume fermenter (BVF)

The influent from headworks is split between a bulk volume fermenter (BVF) and a FOG (Fats, Oils, and Grease) dissolved air flotation (DAF) tank. Up to 4 MGD is sent to the BVF, an anaerobic system that uses covered lagoons to facilitate the growth of anaerobic microbes that break down organic material. This system produces relatively little biomass relative to aerobic systems.

The BVF also provides storage for sludge when the sludge drying beds fill up during winter. This typically only occurs during winter when seasonal rains turn the sludge drying beds into ponds, and it is only done when needed.

FOG (Fats, Oils, and Grease) Dissolved Air Flotation (DAF)

The remaining influent from headworks goes through a FOG DAF system. It is currently only being used to pass flow through and has a capacity of 8 MGD. It is not yet being used to treat FOG.

Modified aerated equalization basins

The plant previously used aeration basins for treatment. After the Sequencing Batch Reactors (SBR) were implemented, these five basins were converted into aerated equalization basins with 50 hp floating aerators that remove some COD and condition the pH of the water before going through SBR.

Sequencing batch reactors (SBR)

A lift station moves 6,300-6,500 gpm of water from the equalization basins to the SBR. The SBR has six reactors, each one completing a 4-stage timed treatment process: fill stage, react stage, settle stage, and decant stage. Each reactor is filled up, then churned and aerated to allow facultative microbes to take up biochemical oxygen demand (BOD). The mixed liquor is allowed to settle, and a decanter pumps water from a foot below the surface over a weir as secondary effluent. The sludge at the bottom is carefully managed for volume so it can facilitate microbial growth in the next batch. Excess sludge is pumped on. Grease curdles at the surface, creating grease balls and is eventually removed. Four centrifugal blowers provide the air for the SBR system.

Sludge concentration

Excess sludge from the SBR system is sent to a 55,000-gallon sludge storage tank, before mixing with primary sludge from the domestic plant in two sludge DAF units that separate the solid and liquid phases of the sludge.

Anaerobic digestion

Three anaerobic digesters take in concentrated sludge and heat it in a boiler to a constant temperature. This produces biogas which is captured. Currently all biogas is being flared.

The digesters have iron sponge scrubbers that are not currently operating at 100 percent. When they are replaced, they will be able to capture more biogas from the digesters for energy generation, making it feasible to run the FOG DAF once again.

Energy generation

The facility is not currently generating their own energy. There is a 1 MW solar field, and 1.2 MW of fuel cells. However, the fuel cells were discontinued because the digesters weren't producing enough methane to recover the cost, and the solar panels are on hold until more fuel cells can be added.

The City is working on doubling the number of fuel cells on-site. Once these fuel cells are ready, the solar panels will be brought back on potentially increased.

Effluent

Water from the SBRs passes through a methanol-fed denitrification filter which removes most of the remaining ammonia and nitrates before entering the mixing box. There, it is combined with domestic effluent and goes to the holding tanks to be used for irrigating non-consumption crops.

Biosolids

Sludge from the digesters is placed in soil concrete-lined sludge drying beds. There are 42 beds. WPCF operators try to keep each of them at 6 in. depth to facilitate faster drying. Dried sludge is mixed, and then decanted to remove as much water as possible. The sludge is then sent to landfill.

During the winter, rains tend to prevent the sludge from drying so it remains in the sludge bed, increasing the depth of sludge to 12 in. or higher. If needed, excess sludge can be moved to the Bulk Volume Fermenter for storage.

City of Porterville Wastewater Treatment Facility (WWTF)[296]

The City of Porterville operates an activated sludge treatment plant that serves the City of Porterville and the Porter Vista Public Utility District (PUD) serving the unincorporated community of East Porterville. The City's current wastewater treatment facility (WWTF) has a design capacity of 8 MGD. It is operated at about 56 percent of design capacity, treating an average 4.5 MGD of primarily domestic effluent.

Foster Farms is the only major industrial customer in Porterville. It has a flow rate of 250,000 gallons per day (gpd) [0.25 MGD]. Porterville established a pretreatment program with Foster Farms to limit issues with influent quality.

The City's WWTF uses physical, chemical, and biological processes to remove solids from wastewater and treat the effluent to levels needed for safe discharge or reuse. The WWTF has a conventional treatment train of headworks, primary clarifiers, aeration basins, and secondary clarifiers. Effluent quality is considered undisinfected secondary, the majority of which is used to irrigate 630 acres of non-consumption crops. The remainder is sent to percolation ponds.

On May 5, 2015, the City awarded a contract for installation of a sludge de-watering system and electric air blower engines to replace old and inefficient dual fuel (biogas and natural gas) air blower engines.[297] The old engines were still operational despite very low efficiencies solely because their air quality permits had been grandfathered by the San Joaquin Valley Unified Air Pollution Control District. When the new electric air blower engines were placed in-service, the

296 Information about the Porterville Wastewater Treatment Facility was obtained by touring the facility and interviewing management and staff in November 2017. Information gathered during the tour and interviews were supplemented by the City's brochure describing its wastewater treatment facility design and operations (available online at: http://www.ci.porterville.ca.us/depts/PublicWorks/documents/WWTFBooklet.pdf. The photos used in this appendix are from the City's WWTF Booklet.

297 City of Porterville Council Minutes, May 5, 2015.

old biogas and natural-gas fired engines were retired. Biogas produced in the digesters is therefore currently being flared.

The City is considering a Biogas-based Compressed Natural Gas (BioCNG) facility as part of a master wastewater facilities planning process that commenced in 2017. To reduce its costs for the additional electricity that will be needed for its expanded and upgraded facilities, the City entered into a lease agreement with a solar developer and agreed to purchase output from the solar project on a long-term basis at prices less than the retail price of electricity.

On April 4, 2017, the City authorized engaging a professional engineering firm to commence master planning for the following facilities: Sanitary Sewer, Water System and Storm Drain Master Plan Updates, Recycled Water Feasibility Study, and Storm Water Resource

Plan. The scope of work[298] includes:

- Planning Documents and Design Standards: Inventory and review.
- Land Use Inventory: Update for current and anticipated projects.
- Design Standards for Water, Sewer, and Storm Drain Master Planning (including the City's Stormwater NPDES Permit and Annual Work Plan): Review.
- Existing and Projected System Capacities and Demands: Determine for wastewater collection, stormwater collection, and water distribution.
- Hydraulic and Hydrologic Models: Develop/Update and calibrate for water, sewer, and storm facilities; and evaluate the current and future operation of these utility systems through simulations.
- Wastewater Treatment Plant: Evaluate:
    - Needed Repairs and Replacements (R&Rs).
    - Hydraulic capacity.
    - Process Performance and Capacity.
    - Identify and rank solids treatment/reuse/disposal alternatives (includes candidate solids treatment (thickening, stabilization, dewatering); reuse/disposal alternatives; energy options.
- Stormwater Resources Plan: Conduct a Gap Analysis of existing Stormwater Management Plans; identify water quality issues; develop evaluation criteria, metrics, and a process for prioritizing storm water projects; assist in identifying stormwater projects.
- Recycled Water Feasibility Study: Planned to be funded via a SWRCB Recycled Water Planning Study Grant (scope will need to comply with terms of the grant agreement).
- Capital Improvement Plan: Develop prioritized portfolio of projects with key milestones and estimated costs of needed improvements "to enhance redundancy/reliability, eliminate hydraulic deficiencies, provide the capacity necessary to accommodate development

298 DRAFT Scope of Services for Carollo Engineers Inc. dated March 24, 2017.

through general plan buildout (coordinated with the 2030 General Plan Update), and allow for long-term replacement needs …".

- OPTIONAL: Blue Plan-It® (Carollo Engineers' proprietary decision support system) is a detailed water system model. (Note: This system does not replace hydraulic models—it models individual pressure zones and other key parts of the water and wastewater systems to run scenarios that are evaluated using hydraulic models.)

Technology Opportunities

Tertiary treatment

The City's master planning process includes consideration of tertiary treatment. Tertiary treated recycled water would increase the types of non-potable beneficial uses that could be met with the City's effluent.

Advanced Disinfection, Filtration and Purification

Many urban wastewater agencies are preparing for the potential approval of Direct Potable Reuse (DPR) by the State Water Resources Control Board (SWRCB). DPR would allow advanced treated water (that is, beyond tertiary) to be introduced directly into a potable water supply distribution system or into the raw water supply immediately upstream of a water treatment plant. Given that the City of Porterville is in the early stages of master planning for its water, wastewater, stormwater and recycled water systems, this is the opportune time to consider these types of advanced technologies.

BioCNG

The City is interested in developed a Bio Compressed Natural Gas (BioCNG) system from digester gas. This would create bio-methane from wastewater biosolids, which can be used on-site or transported for use by the city for other applications. Consideration of BioCNG is included within the scope of the City's master facilities planning effort.

Pilot Demonstrations of New Technologies

A technology pilot could utilize a portion of the plant's effluent stream from various stages of treatment to test the efficacy of their technology without impacting the facility's core operations. City WWTF staff have expressed interest in serving as a site for testing and demonstrating new technologies.

Porterville WWTF Design and Operations

Influent

Porterville relies solely on groundwater to serve their customers. The collection system consists of 150 miles of 6"-36" diameter pipes, and 21 sewage lift stations and associated mains. The Wastewater Treatment Facility (WWTF) receives primarily residential sewage (of 14,000 metered connections, 13,000 (93 percent) are residential). During the drought, the residential growth

rate of the City stagnated or declined. Water-saving measures reduced the amount of flow from 4.7 MGD before the drought, to 4.4-4.5 MGD during the drought. The City remains today under a Phase IV Drought Response Order.[299]

Foster Farms is the only major industrial customer, contributing 250,000 gpd (0.25 mgd) to the influent flow. The Foster Farms chicken farm discharges high Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), and Electrical Conductivity (EC)[300] wastewater. Foster Farms pretreats their effluent with a Dissolved Air Flotation (DAF) unit,[301] and has open lines of communication with the City of Porterville's WWTF in case a high-contaminant discharge occurs.

Headworks

Two mechanical bar screens remove large objects from the raw wastewater. Waste from the bar screens is passed through a grinder, washer, and compactor. Water passes through a chlorine contact tank for odor removal.

Wastewater then flows through an aerated grit channel. The grit is pumped to the grit classifier where the solids are removed from the water. Grinded solids are compacted and deposited in a container for removal to landfill.

299 Phase IV prohibits water waste (for example, "excessive water runoff" and washing of sidewalks and driveways) and restricts days and times for vehicle washing (only allowed on designated watering days and with hoses equipped with a shut-off nozzle); outdoor watering (prohibited Monday through Friday, and only allowed during certain hours on weekends); and ornamental water features are prohibited unless the fountain uses a recycling system.

300 BOD, TSS and EC are metrics used to characterize wastewater quality and to determine wastewater treatment strategies.

301 A water treatment process that clarifies wastewater or other types of liquids by removing suspended matter such as oil or solids.

Primary clarifiers

Four parallel primary clarifiers are used to accommodate flow rates. The clarifiers allow dense solids to fall to the bottom, and scum to rise to the surface. Both are scraped off and sent to the digesters.

Aeration basins

Compressed air is diffused in the basin with fine bubbles, leading to the growth of aerobic microbes that take up organic pollutants.

Secondary Clarifiers

A second set of clarifiers allows solids from the aeration basins to settle to the bottom in the form of activated sludge. Some of these solids become the mixed liquor that feeds the aeration basins, keeping a high population of aerobic microbes. This mixed liquor is called return activated sludge (RAS). The remaining mixed liquor is concentrated and sent to the digesters as waste activated sludge (WAS).

Sludge Concentration

The WAS goes through a dissolved air flotation (DAF) tank for concentration of solids. Air bubbles are dissolved into the DAF tank along with flocculants. The positively-charged flocculants attach to the negative surface of the microbes, concentrating them, and the bubbles attach to the surface of the microbes to carry them to the surface where they are skimmed off and sent to the digesters.

Anaerobic Digestion

Both primary solids and concentrated WAS are sent to the plant's four digesters. The organic matter degrades inside the chambers, releasing primarily biogas. As noted previously, biogas is currently being flared but the City plans to eventually implement a BioCNG system.

Disinfected Effluent

Porterville's treated water is approved for groundwater recharge and non-consumption agricultural irrigation. Porterville's water is pumped 4.5 miles to the City's reclamation area, which encompasses 946 acres—630 of which are available for effluent irrigation.

The City of Porterville contracts with one farmer who operates the reclamation area and takes both their water and sludge. The farmer flood-irrigates alfalfa, corn grown for animal consumption, and a few other crops.[302] Monitoring wells test groundwater quarterly under the reclamation area for nitrates. (These tests show that there are high nitrates but are inconclusive as to whether the wastewater effluent is the primary or sole source of the nitrates.)

About 43 percent of the City's annual effluent goes to percolation ponds to recharge groundwater.

Biosolids

After digestion, biosolids are moved to concrete-lined sludge drying beds. They then go through a final screw press for dewatering before being used for land application. The same contract for effluent covers biosolids; 833 acres of the reclamation area is fertilized with biosolids.

Energy generation

The City retired its dual fuel (biogas and natural gas) engine blowers in favor of new, efficient electric blowers. Digester gas is currently being flared until the City can implement its planned new BioCNG facility. The City entered into a long-term Power Purchase Agreement (PPA) for solar PV to help offset its increased electric requirements and costs attributable to the new electric blowers.

302 Treating the City's effluent to a higher quality could enable using the effluent via drip tape. Discussions with some farmers and irrigation experts indicate a potential increase of 40% in agricultural water use efficiency when converting flood irrigation to drop for some crops.

APPENDIX S: Municipal Wastewater Treatment Technologies

Wastewater infrastructure changes are expensive, difficult, and tend to take multiple years to accomplish; consequently, master facilities planning is conducted periodically, as needs arise. Further, given that significant capital investments are made in infrastructure, it is not simple to completely redesign a facility, even when there appear to be substantial potential benefits. Consequently, integration of new technologies into long-lived capital infrastructure tends to be opportunistic.

Wastewater treatment technologies have evolved considerably over the past few decades. Many processes are now more efficient and consume less energy. In addition, some new treatment technologies and processes have emerged.

Table S-1 below lists and briefly describes "conventional" biological wastewater treatment technologies and processes that are currently used or planned to be used by wastewater treatment facilities within Tulare County.

Table S-1: Municipal Wastewater Treatment Technologies

Headworks	
Bar Screen	Permeable vertical conveyor that catches large solids on bars, lifting them out while allowing water to pass through a mesh screen.
Grinder	Machine that breaks large solids into smaller pieces, typically with rotating metal teeth.
Compressor	Mechanical press that compresses ground up solids into dense cakes for subsequent disposal.
Grit Chamber	Basin that prevents abrasive materials such as sand and eggshells from entering into primary treatment. Typically composed of a spiral flow aeration tank that allows for rapid settling of solids.
Parshall Flume	Open channel device that measures volumetric flow rate. The flume constricts flow, drops in elevation, and then expands. Flow can be extrapolated by measuring the height of water at the inlet of the flume.
Magnetic Flow Meter	An open channel device that measures volumetric flow rate. Creates a magnetic field that requires an induction fluid. Uses the potential difference in fluid flow to determine flow rate.

Primary Treatment	
Conventional Treatment Pond	Basic lagoon used to remove BOD[303] and settleable solids. They have been used to effectively treat domestic wastewater for over 3,000 years and are considered optimal for small community wastewater systems that lack construction funding for more advanced treatment. Conventional treatment ponds require minimal energy inputs and maintenance, but must deal with sludge deposits and algal growth over time.
Aerated Pond	Modified lagoon that uses blowers to diffuse air bubbles throughout the pond, facilitating aerobic microbial growth.
Oxidation Pond	Modified lagoon designed to facilitate algal growth at the surface. The algae produce oxygen for aerobic microbes lower in the water column that degrade contaminants.
Oxidation Ditch	Raceway-style lagoon designed to facilitate algal growth throughout the water column, using mixers to bring nutrients to the surface. The algae produce oxygen for aerobic microbes lower in the water column that degrade contaminants.
Clarigester	Type of anaerobic digester used as both primary treatment and digestion. Two-storied tank with differential retention times for solids and liquids.
Primary Clarifier	Settling tank that allows heavy solids to fall to the tank's floor while light contaminants like oils and grease rise to the surface. skimming each off and separating water with a weir.
Secondary Treatment	
Activated Sludge	Basin seeded with aerobic microbes that are effective at degrading organic components of wastewater. The basin is aerated by compressed air bubbles which encourage microbial growth and uptake of contaminants.
Anoxic Basin	Low-oxygen basin used to encourage denitrification by anaerobic microbes. Utilized in cases of high nitrogen loads in effluent.
Trickling Filter	Aerobic treatment system that utilizes microbes attached to some medium in order to degrade contaminants. A thin film on the surface of the media oxidizes the organic load in the water.

303 Biochemical oxygen demand (BOD) is a measurement of the amount of oxygen needed to degrade the organic contaminants in the wastewater. A higher oxygen demand signifies that there is a higher level of organic waste present. **Source**: Rimbach, Raquel. "Naturally Reducing BOD, COD, and FOG Discharge with Bioaugmentation." *Pollution Equipment News*. March 28, 2018.

Secondary Clarifier	Settling tank that allows heavy solids to fall to the tank's floor while light contaminants like oils and grease rise to the surface. skimming each off and separating water with a weir.
Tertiary Treatment	
Membrane Bioreactor	The combination of a membrane process such as microfiltration and a biological process like activated sludge.
Sand Filter	Tank filled with a dense medium in which percolation and biological degradation remove contaminants.
Disinfection	
Ultraviolet	Eliminates pathogenic microbes through UV radiation.
Chlorination	Eliminates pathogenic microbes through chlorine contact, in either liquid or gas form. Typically followed by dechlorination.
Solids Management	
Dissolved Air Flotation	Tank that uses microbubbles as well as polymers and chemical coagulators to attach to solids, concentrating them at the surface and separating them from fluid components.
Gravity Belt Thickener	Horizontal conveyor belt with micropores that allow water, but not solids, to drip through, thickening the solids.
Aerobic Digester	Container in which air flows are introduced and solids are heated to facilitate the breakdown of solids by aerobic bacteria. This process releases heat, water, and carbon dioxide.
Anaerobic Digester	Container in which solids are heated in the absence of air to facilitate the breakdown of solids by anaerobic bacteria. This process releases primarily methane gas
Disintegrative Digester	Digester with a compressed input mechanism that physically breaks down solids before digestion.
Screw Press	Dewatering press the slowly pushes solids against a screen or filter where water can pass through but solids remain.
Sludge Bed (lined or unlined)	Groundwork basin where sludge can dry by solar evaporation. Basin can be lined with soil concrete, concrete, plastic, or other liner or it can be unlined, allowing moisture to percolate into the ground.

Energy Generation	
Fuel Cell	Cell that converts biogas into electricity using an electrochemical reaction. The chemical reaction requires a continuous source of fuel and oxygen.
Biogas Generator	Generator that combusts biogas to turn a turbine and generate energy.
Solar PV	Photovoltaic panels that use solar energy to generate electricity.
Effluent Disposal	
Storage Pond	Lined pond used to store water for irrigation or other recycled water use.
Percolation Pond	Unlined pond that allows recycled water to percolate out of the basin for groundwater recharge.
Leach Field	Perforated pipes laid in underground trenches that allow water to filter through gravel or other medium.
Spray Field	Area designated for effluent discharge via a fine mist.
Purple Pipe	Recycled water distribution pipe system designated by its purple color or signage.
Miscellaneous Systems and Equipment	
Centrifugal Pump	Water pump that uses a rotational impeller that takes advantage of centrifugal force to move water through a pipe at a specified flow rate.
Cavitation Pump	Water pump that uses a rotating augur to create positive displacement, pushing water through cavities in the cylinder. Can accommodate variable flows.
Variable Frequency Drive	A motor controller that drives an electric motor by varying the frequency and voltage supplied. Can be utilized to match motor energy expenditures to the specific needs of a plant.
Supervisory Control and Data Acquisition (SCADA)	A software system that manages information input/output in order to provide central control over a network of systems or processes and potentially automation of systems.

Table S-2 lists some new/emerging wastewater treatment technologies that may be candidates for Tulare County wastewater treatment facilities. The technologies are mapped to types of water and energy benefits and are briefly described on the next and subsequent pages.

Table S-2: Drought Resilience and Energy System Benefits of Identified Technologies

Technology	On-site Water Benefits					On-site Energy Benefits		By-Product Water Benefits	
	Increases Recycled Water Production	Secondary Treatment	Tertiary Treatment	Disinfection	Nutrient Management	Reduces Energy Use	Increases Energy Generation	Increases Water Efficiency	Prevents Groundwater Degradation
Algae Photobioreactor	✔	✔	✔		✔				
Algae Raceway Pond	✔	✔	✔		✔	✔		✔	✔
Membrane Bioreactors	✔	✔	✔		✔				
Pyrolysis and Biochar						✔	✔	✔	✔
Reactive Filtration	✔	✔	✔	✔	✔	✔		✔	✔
Vermifiltration	✔	✔			✔	✔			✔

✔ Indicates the types of benefits offered by these technologies.

Interestingly, many new technologies don't just treat wastewater—they also provide valuable by-products and other benefits. Examples include the Algae Photobioreactor and Algae Raceway Ponds that produce algae for a wide range of products and applications. Some technologies, such as biochar and reactive filtration, create a soil amendment that increases water retention, reducing erosion and groundwater degradation. Biochar is being explored as a means of keeping forests healthy and reducing soil erosion, risks of landslides during periods of heavy precipitation, and the frequency and magnitude of wildfires.[304]

Algae Photobioreactor

New designs for algae production use artificial light to produce algae within small footprint. Algae photobioreactors use clear cylindrical tubes to maximize light exposure for algae. LED lights promote photosynthesis independent from solar radiation. Many models are self-cleaning, which has the added benefit of mixing the water within the reactors to encourage algae growth. The process then uses filters to separate clean tertiary standard water from the algae. Some algae is returned to seed the reactors and the remaining algae is collected for use as fertilizer, biofuel, animal feed, pharmaceuticals, and other applications.[305]

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304 "Biochar & Forest Ecosystems." U.S. Biochar Initiative. http://biochar-us.org/biochar-forest-ecosystems.

305 Singh, R.N. and Shaishav Sharma "Development of suitable photobioreactor for algae production—A review." *Elseveir—Renewable and Sustainable Energy Reviews*, Vol.16, Issue 4, Pages 2347-2353. May 2012.

High-Rate Algal Pond (HRAP)[306]

Algae ponds have been around since the mid-20th century. They have been primarily used as oxidation ditches that grow algae to produce oxygen for aerobic bacteria. The bacteria then reduce biochemical oxygen demand (BOD) and suspended solids (measured as "TSS", "Total Suspended Solids"). High-rate algal ponds are designed to optimize algae biomass growth, rather than bacterial growth. Algae in HRAP systems take advantage of the nutrient content of wastewater, treating water to tertiary quality while producing algal biomass for commercial purposes.

Raceway ponds are shallow circular or oval ponds with a baffle in the middle and a paddlewheel to move the water around the pond, like a racecar on a track. Algae production decreases rapidly with depth because it requires sunlight. For this reason, algae ponds that treat a large volume of water require a large footprint. The paddlewheel mixes the water so algae growing at the surface doesn't shade algae growing below the surface. Carbon dioxide (CO_2) is bubbled through the pond for the algae to absorb for photosynthesis. The CO_2 can be scrubbed from other processes at the wastewater treatment plant to decrease the facility's emissions.

Algal biomass can be used as fertilizer, biofuel, animal feed, pharmaceuticals, and other applications. (*See description of HRAP on p. S-8.*)

Membrane Bioreactors (MBRs)[307]

MBRs combine a biological process like activated sludge with microfiltration. Microfiltration tubes are placed in a biologically active tank, allowing bacteria on one side of the membrane to break down BOD and TSS. The membranes' outer surfaces are covered with billions of pores that allow water to enter the microtubes, where water is transported from within the tubes to the effluent pipe. Aeration is used to keep contaminants from clogging the pores. Sludge from the bioreactor is either recycled to a facility's secondary treatment process or managed for energy generation or disposal.

> *Visalia recently implemented the largest MBR process in California. It is made up of ten trains, each with eight cassettes. The success of Visalia's process has made the technology attractive to other facilities in Tulare. Porterville is considering following in Visalia's footsteps by implementing MBR for tertiary treatment. The number of MBR projects in the region will likely increase in the coming years. MBR is energy intensive, requiring blowers for both the biological treatment process and aeration of the membranes. A modular design can mitigate this to an extent, allowing the trains to be active only when needed.*

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306 "Oilgae Guide to Algae-based Wastewater Treatment." *Oilgae.* http://www.oilgae.com/ref/report/wastewater_treatment/wastewater_treatment.html

307 "GE Introduces New Membrane Technology to Generate Renewable Energy from Wastewater." *GE News Release.* September 29, 2014.

Pyrolysis and Biochar

"Biochar is a solid, charcoal-like material formed by heating biomass in the absence of oxygen in a process known as pyrolysis. Though not a fertilizer, biochar—when applied to soil—boosts fertility by helping to retain water in the soil when it is dry, and it helps to promote drainage when conditions are wet and retain soil nutrients. This kiln can transform over 100 pounds of waste an hour, and it is agile enough to allow rapid testing of different inputs and production conditions."[308] (*See description of Biochar on p. S-9.*)

Reactive Filtration[309]

The University of Idaho invented reactive filtration technology, a process that simulates how nature cleans water. Reactive filtration mixes wastewater with iron ions, and pumps it up through a moving bed sand filter. As the water travels up through the sand, the iron ions coat the substrate and enhance its ability to remove contaminants from the wastewater. Wastewater that rises through the surface of the substrate is then exposed to ozone to eliminate pathogens and other contaminants before passing it through a biochar filter, which pulls nutrients onto the surface of the biochar. The water comes out clean and the nutrient-saturated biochar can be used as a soil amendment.

When applied to soil, the biochar reduces the need for nitrate fertilizers, and allows the soil to hold more water, increasing the uptake of irrigated water into plants and preventing groundwater degradation. (*See description of Biodryers and Sludge Pyrolysis (Bioforce) on p. S-10 and UC Idaho's Clean Machine on p. S-11.*)

Vermifiltration[310]

Vermifiltration is the use of earthworms within a filter media to remove biological contaminants. Vermifiltration requires pretreatment to separate large solids. Water is then sprayed over the surface layer of the filter media, which is home to thousands of earthworms. The earthworms digest the water, removing contaminants and converting them into earthworm casings. Water continues to filter down through different substrates such as woodchips or gravel. Water that leaves the filtration process is treated to secondary standard and can be reused for agricultural irrigation. (*See description of Biofiltro technology on p. S-12.*)

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308 "Biochar Pyrolysis Kiln." May 17, 2018. *Cornell University*. http://www.cornell.edu/video/biochar-pyrolysis-kiln.

309 "Clean Water Machine." *University of Idaho*. https://www.uidaho.edu/cals/clean-water-machine.

310 Samal, K., Rajesh Roshan Dash, and Puspendu Bhunia. "Treatment of wastewater by vermifiltration integrated with macrophyte filter: A review." *Journal of Environmental Chemical Engineering*, Vol. 5, Issue 3, Pages 2274-2289. June 2017.

High-Rate Algal Ponds (MicroBio Engineering)

MicroBio Engineering's Recovery of Nutrients, Energy, & Water (RNEW) process uses mechanically mixed raceway ponds with paddle wheel and CO_2 diffusion to biologically treat wastewater and mass produce algae feedstock, producing biofuels, reclaimed water, and fertilizer. The process reduces capital and operating costs by approximately 23% when compared to conventional treatment systems like activated sludge. With disinfection, tertiary treated water is produced.

The process requires 67% less energy than activated sludge processes, which only produces secondary quality effluent. Raceway ponds require a large footprint; algal productivity rapidly decreases with depth, so the ponds must be shallow. About 12 acres of ponds are required for every 10,000 residents. While the footprint limits which facilities may be able to utilize raceway ponds, many facilities in Tulare County have large amounts of land available, either on-site or as part of their reclamation areas for recycled water, and therefore may be candidates for this technology.

When recycled water is used to grow algae, it produces higher quality recycled water for reuse on subsequent applications. This ensures that the recycled water is used multiple times, maximizing its value before exiting the system, and ensuring that nutrients are being utilized by plants rather than leaching into groundwater.

Rather than considering algae ponds as a stage of treatment, it may be useful to consider the opportunity as a means for earning revenues from a water-efficient crop. Different algae species are now being farmed for multiple purposes, from food products for humans, pets and livestock, to cosmetics, biofuels, and other purposes.

Source: MicroBioengineering website

Biochar (many companies)

Biochar is a type of charcoal formed by heating organic material at high temperatures in the absence of oxygen. This can be accomplished via slow pyrolysis, fast, pyrolysis, hydrothermal carbonization, or gasification. These processes produce biochar and syngas. The syngas can be burned for energy as a renewable fuel, and biochar can be used for a variety of applications. Biochar is most frequently used as a soil amendment with the ability to enhance the water-energy-ag nexus, due to its unique properties:

Biochar variations. Source: UC Davis Biochar Database

- It is highly porous, giving it a large amount of internal surface area. When applied to soils, this increases the soil's water storage capacity, though the extent is determined by the feedstock used to produce the biochar. Biochar produced from wastewater sludge has been shown to be more effective at increasing soil water storage capacity than other feedstocks .
- It is highly adsorptive, meaning its surface holds onto constituents like nitrogen and phosphorous, preventing loss of nutrients to percolation into groundwater or runoff.
- When organic material is converted into biochar, the carbon is rendered inorganic, so it doesn't biodegrade. For this reason, biochar is effective at long-term sequestration of carbon.
- It increases crop yield by up to 15% by creating space in the soil to support microbiological communities that enhance soil biodiversity and disease resistance in crops. It also increases the drought resistance of fungal and bacterial communities within soil by promoting faster recovery from disturbances.

Biochar can also enhance some wastewater treatment processes:

- It can be used directly to treat water, as its adsorptive capacity is effective at removing constituents in wastewater, similar to activated carbon filters. Treating water with biochar in this way enhances the biochar's properties as a soil amendment by saturating its surface with nutrients pulled from the wastewater.
- Adding biochar to anaerobic digesters creates a biogas stream that is 90% methane, compared to 55-75% for non-biochar amended digestion, reduces sulfate production, and improves the digestate's quality as a fertilizer due to its high nutrient content.

Biochar can be produced by nearly any organic feedstock. All Power Labs uses mobile skids to travel to farms and pyrolize their organic waste so they don't need to set up permanent installations.

They have also been clearing many of the dead trees in California following the historic drought, reducing fuels to prevent potential wildfires. BioForce Tech received the first ever permit in the US for a full-scale pyrolysis plant that transforms biosolids into energy and biochar at Silicon Valley Clean Water. Team BluexGreen at the University of Idaho have developed a treatment process that utilizes biochar to treat water to potable quality, while enriching the biochar with nutrients for soil application.

Source: International Biochar Initiative website

Biodryers and Sludge Pyrolysis (Bioforce Tech)

***BioForce Tech BioDryers, modular assembly (from** BioForceTech's website)*

BioForce Tech has developed an energy efficient dryer for biosolids that is designed to create optimal conditions for bacterial growth. The exponential growth of bacteria within the reactor releases heat, drying the biosolids. By using the heat from biological organisms, the biodryer uses 70% less heat energy and 50% less electrical energy than a gas dryer. In addition, the volume of biosolids is reduced by 65-80%. The reactors are designed to be modular, with each treating up to 9 tons of biosolids in 56-hour batches.

Drying biosolids is the most energy-intensive aspect of cogeneration at wastewater treatment plants. In order to be feasible, the energy produced from biosolids must be more than the energy required to prepare biosolids for generation. High moisture biosolids require a great deal of energy to heat to the required temperature, so reducing the moisture content prior to digestion or other mechanism is economically necessary.

In addition to drying, BioForce Tech has developed their own pyrolysis reactor to process dried biosolids, rather than digesters (though either can be used) to create syngas for clean energy generation. This has the added benefit of heating the biosolids to a high enough temperature to eliminate pesticides and other contaminants, and it creates biochar as a valuable by-product. (Biochar, a fine charcoal used as a soil amendment, is created by pyrolysis of organic matter.)

BioForce Tech is currently piloting a full-scale operation at Silicon Valley Clean Water in Redwood City. The system is comprised of six BioDryers and pyrolysis. For this project, BioForce Tech obtained the first permit ever issued in the U.S. for a full-scale pyrolysis plant that transforms biosolids into energy and biochar, paving the way for the technology to be used in facilities throughout the state.

Sources: BioForce Tech's website and Newman, Sam., *et al* (2014). Biological Wastewater Treatment for Food Processing Industry. *Pacific Gas and Electric Company.* ET Project Number: ET 14PGE1511

Reactive Filtration (UI Clean Water Machine)

Team BlueXGreen is part of the University of Idaho. Members of the College of Agricultural and Life Sciences Department have developed a technology that uses biochar combined with iron salts and ozone to treat water, eliminating toxic chemicals, infectious bacteria, and viruses, as well as pharmaceuticals, antibiotics, and hormones.

The N-E-W Tech process focuses on the Nutrient-Energy-Water nexus, and aims to recycle all the effluent and byproducts the process creates back into productive use. The effluent is claimed to meet or exceed drinking water standards, and the biochar used to treat the water is enriched with nutrients and is reused as an agricultural supplement. Blue Water Technologies have licensed the patents for distribution and N-E-W Tech Systems are being installed in the US, South Korea, and England[1], including in one facility that treats over 10 mgd. Team BlueXGreen claims N-E-W Tech is the world's first carbon-negative advanced water treatment process, as the biochar they use sequesters carbon[1] (see biochar below), and they won the first phase of the Everglades Foundation's $10 million competition to develop a solution for phosphorous pollution in public waterways.

Many of the claims of Team BlueXGreen will need to be verified and more widely publicized before this technology sees widespread market adoption. There is very little information available on the research completed thus far, though its successes regarding funding, adoption, partnerships, and competitions appear promising.

Sources:

Loftus, B. (2016). Reimagining Wastewater. UI College of Agricultural and Life Sciences
Cabeza, Garrett. (2016). 'Biochar' Could Help Fix Land, Air and Water. Moscow-Pullman Daily News

Biofilters (BioFiltro)

BioFiltro uses physical and biological filtration, aerobic and anaerobic medias, and nitrification and denitrification processes to produce clean water and fertilizer, removing up to 99% of contaminants with very little energy input. The system relies on earthworms and bacteria to break down contaminants on the surface. Water trickles down through sawdust and gravel layers. Water is treated to secondary undisinfected standard quality, making it suitable for agricultural reuse on non-consumption crops. Tertiary disinfection for higher quality effluent can be added to expand the beneficial uses of recycled water.

BilFiltro facilities are modular and have been scaled to treat as little as 100 gpd to up to 2 mgd. They have been successfully used for treatment of effluent from sanitary waste, food processing, slaughterhouses, dairies, wineries, and aquaculture. Each facility is custom designed with the proper biological mix for the components in the wastewater.

Average removal efficiencies at BioFiltro plants include:

- >90% Biological Oxygen Demand
- >90% Total Suspended Solids
- >70% Total Nitrogen
- >90% Oil and Grease
- >30% Phosphorous

Operations are monitored centrally by telemetry with real-time automated controls and dashboards, making this technology suitable for remote locations. BioFiltro does not require qualified operators. The National Park Service is currently in discussions with BioFiltro to replace their activated sludge package plants within the Sequoia and Kings Canyon National Forests with BioFiltro systems.

BioFiltro offers "wastewater as a service", eliminating the high upfront capital costs of adopting the technology and charging a small fee per gallon treated. The model is a good fit for small community wastewater systems that have been unable to repair, update, or expand their operations due to insufficient funding.

BioFiltro won first place in the CleanTech Open Accelerator Program in 2011 and has gone through PG&E's emerging technology program. A study on the energy benefits of this technology by CSU Fresno estimated that BioFiltro consumes 85% less energy than conventional wastewater treatment technologies for a comparable volume and quality of wastewater.

Sources: BioFiltro's website and interviews with BioFiltro management.