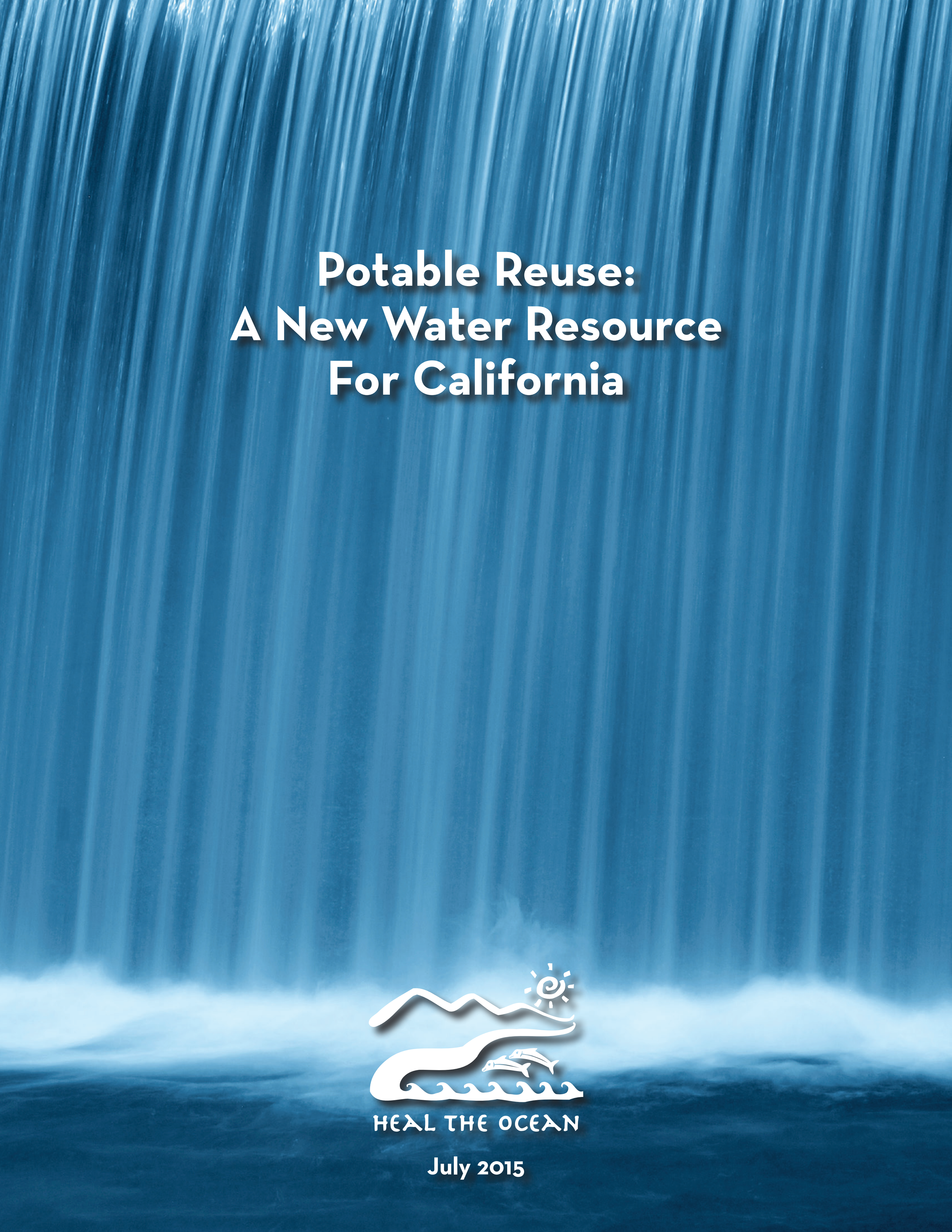

Potable Reuse: A New Water Resource For California

HEAL THE OCEAN

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About Heal the Ocean

Heal the Ocean is a citizens' action group, based in Santa Barbara, CA, focusing on upgrading of wastewater treatment methods (including septic and wastewater) to solve ocean pollution issues. We employ engineers, researchers and scientists, lawyers, GIS mappers, and other experts to locate sources of pollution, assess their significance, and develop solutions as well as find the means of financing to clean up sources of pollution. We hire engineering firms to perform cost feasibility studies for advanced wastewater management methods as well as line up state funding for septic-to-sewer projects and wastewater treatment plant upgrades to produce recycled water.

Acknowledgments

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Heal the Ocean also wishes to acknowledge the enthusiasm and help of our 3,000 supporters, who continue to help our fight for healing and protecting the ocean.

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Introduction

For decades, California has successfully navigated the limits of its water supply through targeted investments in efficiency and conservation programs. These investments have spurred reductions in per capita water use that have allowed the state to keep total water demand steady – even with a growing population. But today, amid the worst drought in generations, California has reached the limits of its existing water infrastructure. The state's antiquated water rights system has produced commitments to water deliveries that are five times greater than actual water available.[1] The drought prompted the Governor, for the first time in state history, to order significant reductions in urban water use as well as implement programs to achieve similar cuts across the state's agricultural sector.[2;3]

These conservation programs are critical, but water reductions cannot be the sole response to this drought or to the next one. The state must build resilience against water scarcity by investing in local water infrastructure – particularly recycled water projects.

Greater production of recycled water, especially in projects that utilize advanced treatment processes to purify wastewater into a reusable water resource – must be a central plank of the state's water supply planning efforts now and into the future. With hundreds of millions of gallons of treated wastewater disposed into the Pacific Ocean every day, recycled water offers significant opportunities to combat water scarcity in California's coastal cities while simultaneously reducing wastewater discharges to the marine environment.[4]

Investing in recycled water projects will strengthen the state's water system by transforming a wasted resource into a locally controlled and drought-resilient supply of water for coastal communities across the state.

Potable Reuse and a Sustainable Water Supply

When describing recycled water, "potable reuse" encompasses all water reuse systems in which wastewater undergoes advanced treatment to produce a source of highly treated, purified water for ultimate use as a source of drinking water. Potable reuse projects fall under two different categories: **indirect potable reuse** and **direct potable reuse**.

Indirect potable reuse (IPR) – the only type of potable recycled water project permitted in California under state regulations adopted in 2014 – is designed to retain purified water in an environmental buffer, such as a natural groundwater aquifer, for at least 2 months prior to use as a source for drinking water.[5] IPR has been the only option for potable reuse projects while the feasibility of direct potable reuse (DPR) undergoes review by an expert panel convened by the State Water Resources Control Board (State Water Board). These regulations are aimed at the more direct use of purified water in municipal drinking water systems – bypassing the need for an environmental buffer. Unlike non-potable reuse projects, wherein tertiary-treated recycled water is delivered through a separate "purple pipe" distribution system, IPR projects consistently meet all state and federal drinking water standards and can be used to supplement drinking water supplies following groundwater recharge and retention.

This paper illustrates the promise of potable reuse to significantly expand California's water supplies through IPR projects that have been successfully demonstrated across the state as safe, affordable, and environmentally sustainable.

KEY INDIRECT POTABLE REUSE FACTS

- **Safe:** IPR projects in California are required to meet all state and federal drinking water regulations through the implementation of advanced treatment processes, including: microfiltration, reverse osmosis, and ultraviolet light disinfection/advanced oxidation.

- **Affordable:** IPR projects are cost-effective and affordable compared to alternative water supplies such as imported water from the State Water Project or ocean desalination. Significant public funding opportunities are now available to indirect potable reuse projects in California thanks, in part, to the successful passage of the 2014 "Proposition 1" Water Bond.

- **Environmentally Sustainable:** IPR projects use less energy than imported water from the State Water Project and ocean desalination projects.

- **Proven:** IPR projects have been demonstrated as a drought-resilient supply of water with a proven track record in California and in cities across the world.

TERMINOLOGY AND TYPES OF RECYCLED WATER

Non-Potable Reuse
Tertiary-treated recycled water that can be used for irrigation at public parks and lawns, freeway medians, etc.

Potable Reuse
Describes all recycled water projects where wastewater undergoes advanced treatment for use as a source of water for municipal drinking water systems.

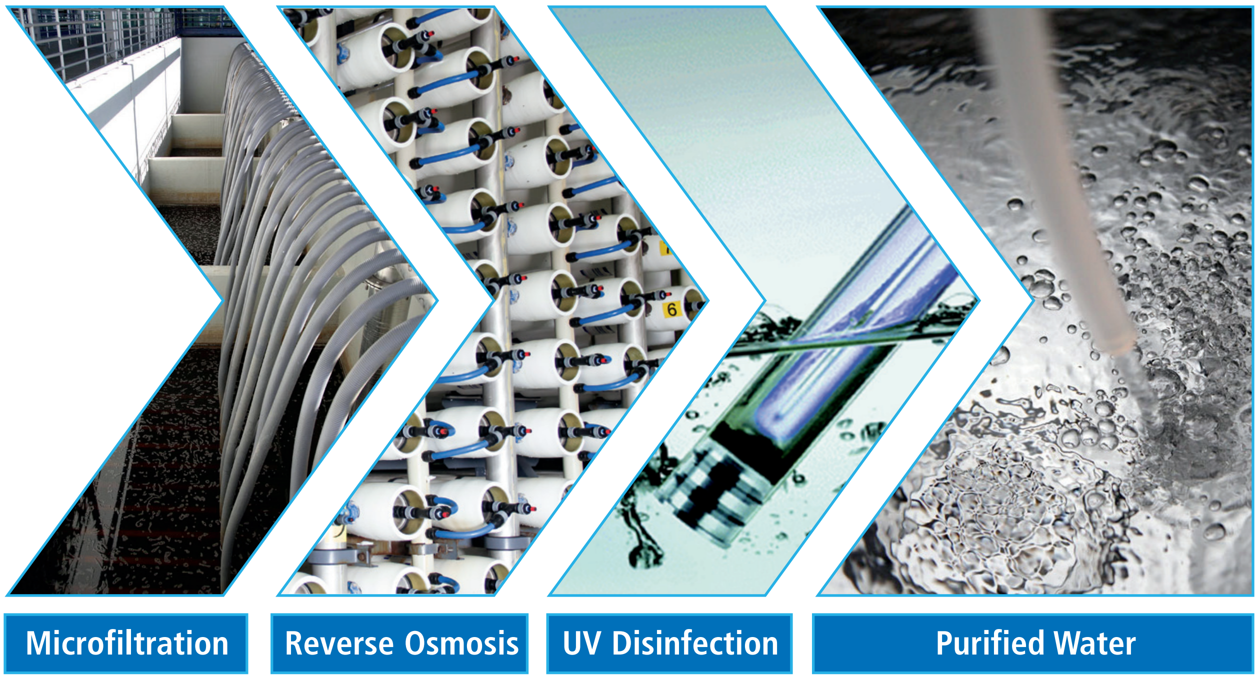
Indirect Potable Reuse (IPR)
The only type of potable reuse project permitted under existing state regulations. Purified water in an indirect potable reuse project is introduced into an environmental buffer – such as a natural groundwater aquifer – and retained in the buffer for at least 2 months prior to use as a source of drinking water.

Direct Potable Reuse (DPR)
A type of potable reuse project that is designed to achieve more direct use of purified water in a municipal drinking water system – bypassing the need for an environmental buffer.

Purified Water
Water produced via advanced treatment processes in potable reuse projects.

Producing Purified Water via Advanced Treatment

Indirect potable reuse projects employ a multi-barrier/step treatment process that includes microfiltration, reverse osmosis, and ultraviolet light disinfection/advanced oxidation, which produces purified water that is safe and suitable for use as a source of drinking water following groundwater recharge.



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The following three-step advanced treatment train in IPR projects is designed to effectively remove pathogens and contaminants of emerging concern (referred to as "CECs," which include compounds such as pharmaceuticals and personal care products), and produces purified, near-distilled water:

- **Microfiltration (MF)** removes bacteria and larger particles.[6]
- **Reverse osmosis (RO)** – the most critical stage in the multi-barrier treatment process – removes at least 99% of viruses and a significant percentage of CECs.[7;8]
- **Ultraviolet light (UV) disinfection** acts as a final barrier against pathogens that may still be present following MF/RO treatment. UV is combined with hydrogen peroxide to produce an advanced oxidation process that ensures the effective destruction of more resistant CECs – like N-Nitrosodimethylamine (NDMA).[9]

Following the three-step advanced treatment process, IPR projects must store and retain purified water in an environmental buffer – such as a natural groundwater aquifer – for at least 2 months prior to use as a source of drinking water.[10] Treatment processes in IPR projects are constantly monitored to ensure that systems are working properly; however, in the unlikely event of a failure in the treatment processes, retention of purified water in an environmental buffer provides water managers with ample time to implement appropriate response action plans before purified water is used in a municipal drinking water system. Following storage and sufficient retention in the environmental buffer, groundwater is extracted and treated at the groundwater wellhead or at a conventional drinking water treatment plant – along with water from other sources – for distribution to water customers.

Indirect potable reuse projects are tightly regulated and have been demonstrated to be safe by scientific assessment of projects around the world.

Years of successful experience and numerous studies of IPR projects from California to Singapore have demonstrated purified water as a safe source of drinking water.[12] Extensive testing at IPR projects has shown that advanced treatment technology can transform a wasted resource into a drought-resilient supply of high-quality, purified water.

While it is impossible to achieve zero risk in any context – including conventional drinking water treatment – a 2012 study by the National Research Council found that indirect potable reuse projects pose less of a risk to public health than traditional water supplies.[13] IPR projects are able to reduce the risk of contaminants entering drinking water supplies by employing significantly better treatment technology than in conventional drinking water treatment systems. The safety of IPR projects has also been corroborated by the U.S. EPA through its own recycled water guidelines.[14]

The combination of the multi-barrier treatment process produces near-distilled, purified water that is superior in quality to traditional tap water (see Table 1 for water quality goals and results from San Diego's IPR "Water Purification Demonstration Project"). Furthermore, State Water Board regulations for IPR projects require sufficient treatment processes to effectively remove pathogens and chemical contaminants before purified water is introduced into an environmental buffer.[15] IPR projects produce purified water that consistently meets federal and state drinking water standards.[16]

> "IPR projects produce purified water that consistently meets federal and state drinking water standards."

Table 1: San Diego Water Purification Demonstration Project Key Water Quality Results and Goals

CONSTITUENT	UNITS	AVERAGE CONCENTRATION	WATER QUALITY GOAL
Total Organic Carbon	mg/L	ND	0.5
Total Dissolved Solids	mg/L	14	300
Chloride	mg/L	3.1	50
Sulfate	mg/L	ND	65
Turbidity	NTU	0.05	0.2
Bromoform	ug/L	ND	0.5
Methylene Chloride	ug/L	ND	4.7
Trihalomethanes, Total	ug/L	ND	80
Bromodichloromethane	ug/L	ND	0.56
Dibromochloromethane	ug/L	ND	0.5
HAAS	ug/L	ND	60
NDEA	ng/L	ND	10
NDMA	ng/L	ND[1]	2
1,4-Dioxane	ug/L	ND	1
1,2-Dichlorethane	ug/L	ND	0.5
Boron	mg/L	0.23	1
Nitrate as N	mg/L	0.65	1
Nitrite as N	mg/L	ND	1
Ammonia as N (unionized)	mg/L	<0.007	0.025
Phosphorus, Total	mg/L	0.02	0.1
Nitrogen, Total	mg/L	0.8	1

Source: Adapted from City of San Diego, 2013[11]
ND = Not detectable; below laboratory reporting level
[1]NDMA was sampled 15 times in UV/AOP effluent with one sample exceeding the project's water quality goals with a concentration of 5.5 ng/L. It should be noted that this sample was below the State Water Board's Notification Level of 10 ng/L.

Indirect Potable Reuse as an Affordable Supply Alternative

With dwindling surface water supplies, indirect potable reuse projects offer a cost-effective method to meet water supply needs.

Conservation and water-efficiency projects are often the least expensive means to help boost water supplies; however, in instances where reductions in demand cannot keep up with shortfalls in supply, water purveyors are well advised to invest in IPR, which is an affordable supply alternative. Figure 1 illustrates how IPR projects are:

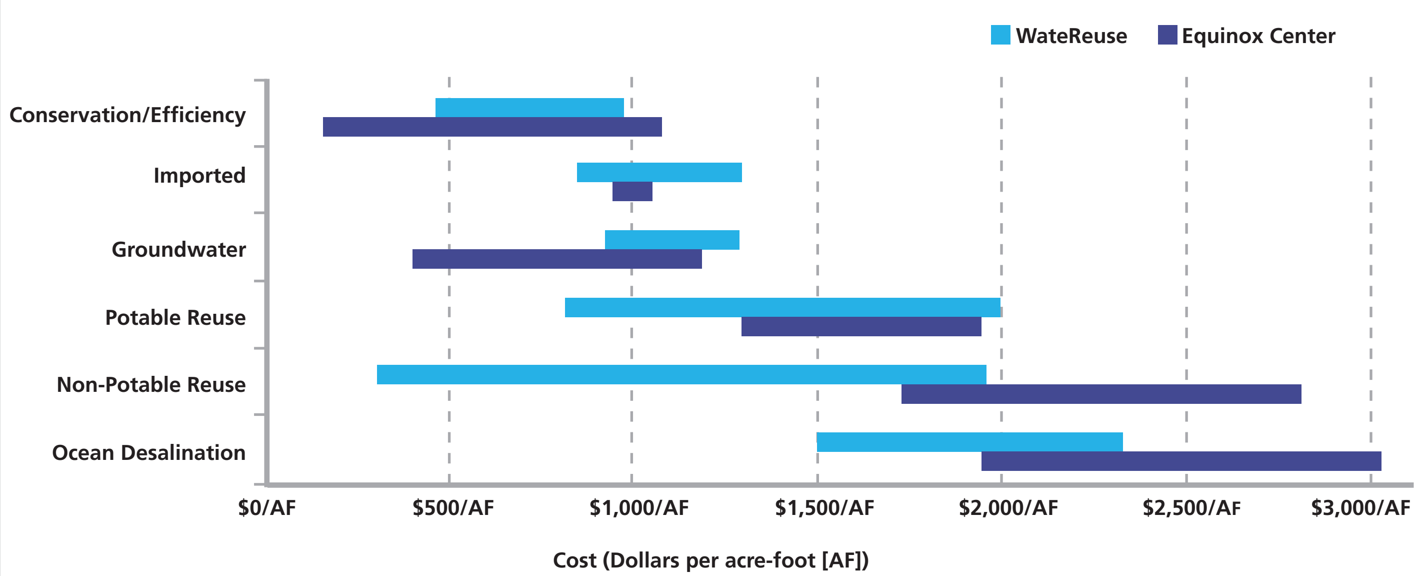
1) Cost competitive with imported water and groundwater projects;

2) Cheaper than ocean desalination and non-potable ("purple pipe") reuse projects.

IPR projects are less expensive than non-potable reuse purple pipe projects because of the significant expense of installing a separate distribution system for tertiary-treated recycled water. Historically, the cost of imported water has been inexpensive; however, these costs have risen rapidly in recent years and, today, IPR projects are more cost-effective by comparison. Finally, ocean desalination projects are more expensive than IPR projects because seawater has a higher salt content than wastewater and thus requires significantly more energy to treat (see the following section, *Energy Demand of Indirect Potable Reuse*).

While the ultimate cost of a particular water supply project will depend on variable site-specific factors, the data in Figure 1 (below) gives a general indication of the financial logic for moving forward with planning for IPR projects. It is important to note that these figures do not account for potential funding from generous grant sources, such as the 2014 Proposition 1 Water Bond, which can provide significant financial assistance. The Orange County Water District was able to defray a substantial amount of the expense of its groundbreaking IPR project through over $90 million in grants – ultimately reducing costs from $850/acre-foot (AF) to $478/AF.[17;18]

Figure 1: Financial Costs of Water Supply Alternatives



Sources: Adapted from Equinox Center[19]; WateReuse Research Foundation[20]; CA Department of Water Resources[21]
Note: Costs in 2014 Dollars; Equinox Center data is based on the localized costs of water supply alternatives in the County of San Diego.

Energy Demand of Indirect Potable Reuse

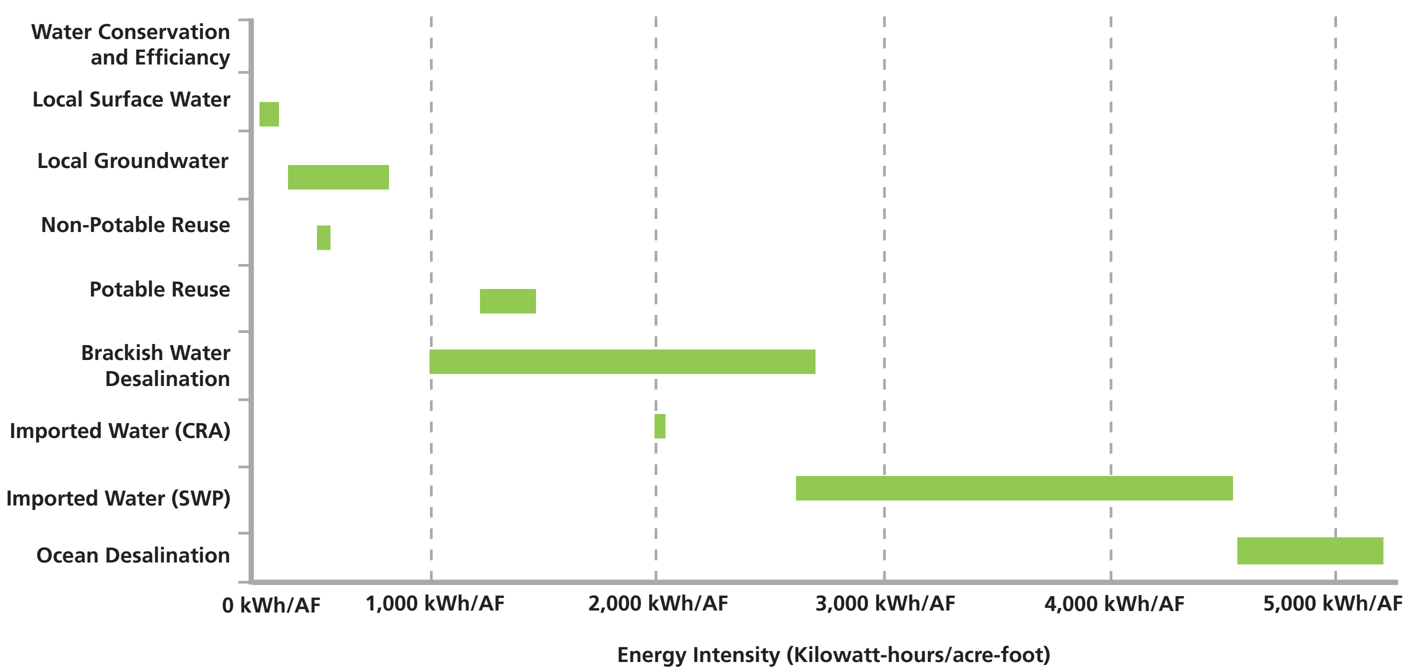
Indirect potable reuse projects are less energy intensive and more environmentally friendly than alternative water supplies such as imported water from the State Water Project or ocean desalination.

California's water system accounts for 19% of the state's total energy use – a substantial percentage.[22] Thus, as the state moves to increase energy efficiency and to achieve greater reductions of greenhouse gas emissions, serious consideration of the energy footprint of California's water infrastructure is crucial.

The energy intensity of water projects is primarily related to the power required to move and treat water. Compared to ocean desalination projects, IPR projects are less energy intensive because they utilize and treat wastewater supplies that are less salty than seawater. As a general comparison, treated wastewater has 500-700 mg/L of total dissolved solids (TDS) – a measure of salinity – while seawater contains roughly 35,000 mg/L.[23;24] In both IPR and ocean desalination projects, reverse osmosis is used to remove the vast majority of TDS by forcing source water at high pressures through semi-permeable membranes. With higher initial TDS levels, ocean desalination projects require up to four times more energy than IPR projects to achieve sufficient removal of TDS levels to meet drinking water standards (see Figure 2).

> "...serious consideration of the energy footprint of California's water infrastructure is crucial."

Figure 2: Energy Requirements for Water Supply Alternatives



Source: Adapted from Cooley and Heberger, 2014[25]
SWP = State Water Project; CRA = Colorado River Aqueduct
Note: Water Conservation and Efficiency projects are assumed to have negligible energy requirements.

Financing Indirect Potable Reuse Projects

With the State of California providing significant funding for the planning and implementation of recycled water, there has never been a better time to finance indirect potable reuse projects.

The successful approval by voters of the Proposition 1 Water Bond in November 2014 has opened up significant new funding sources for water recycling projects. Out of the total of $7.5 billion in funding within the Water Bond, the state is allocating $625 million to recycled water projects in the coming years.[26] The State Water Board, the agency responsible for disbursing recycled water funds from the Water Bond, is awarding funding for 35% of construction and implementation costs of individual recycled water projects – up to a total of $15 million per project.[27] All recycled water projects are also eligible for State Water Board 1% low interest loan financing to fill the required "match" (remaining expenses) not covered by grant funds. IPR and DPR projects (once regulations are approved for the latter) are the state's top priorities for recycled water funding.[28]

To further assist recycled water projects, the State Water Board has created a Facilities Planning Grant Program to fund planning studies to assess the feasibility and cost of converting wastewater treatment facilities into recycled water plants or build new recycled water plants from the ground up. The Facilities Planning Grant Program provides funding for 75% of planning costs, up to a total of $75,000 per project.[29]

Construction Grants
35% up to $15 million

Low Interest Loans
1% financing

Facilities Planning Grants
75% up to $75k

Successful Indirect Potable Reuse Projects

GROUNDWATER REPLENISHMENT SYSTEM – ORANGE COUNTY WATER DISTRICT

The Orange County Water District's "Groundwater Replenishment System" (GWRS) is the largest indirect potable reuse facility in the world – producing purified water both for groundwater recharge and as a barrier to seawater intrusion.[30] The GWRS utilizes the multiple-barrier process of microfiltration, reverse osmosis, and UV disinfection to achieve its purified water product. A trailblazer for this type of project, the Orange County Water District originally contracted with the National Water Research Institute to organize an Independent Advisory Panel to validate the safety and quality of its water before completing construction of the GWRS. The GWRS has provided substantial benefits to the region, including enhanced management and recharge of groundwater supplies.[31]

In 2015 the Orange County Water District completed a 31,000 AFY expansion of the GWRS, bringing the total production at the facility to 103,000 AFY, which is enough water to serve 850,000 people.[32]

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ADVANCED WATER PURIFICATION FACILITY – CITY OF SAN DIEGO

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San Diego's "Pure Water Program" is currently implementing an IPR project that would be the first in the state to augment a surface water reservoir with purified water. The City plans to have an initial 15 million gallon per day (MGD) project in place by 2023 and a long-term facility of 83 MGD by 2035. In anticipation of 2016 state regulations for surface water augmentation projects, the City of San Diego commissioned its Water Purification Demonstration Project to conduct extensive testing and assessment of the safety and feasibility of recharging a local surface water reservoir with purified water.

The Future: Direct Potable Reuse

Direct potable reuse projects are currently being evaluated in California and other parts of the world as the next stage in potable reuse and water sustainability.

Regulations for direct potable reuse are expected in the coming years and are aimed at eliminating the need to store purified water in an environmental buffer before being used as a source of drinking water. Like all water sources used in municipal drinking water systems, purified water from DPR projects will still be required to undergo conventional drinking water treatment before delivery to residential, agricultural, commercial or industrial water customers.

DPR projects are currently not permitted in California; however, the State Water Board convened an expert panel to study the feasibility of DPR, with results expected in 2016. Until regulations are adopted for DPR, potable reuse projects must employ indirect potable reuse standards that include the use of an environmental buffer. Regulations for DPR are expected to significantly expand the opportunities for potable reuse projects in California, in that DPR projects can be implemented in communities that lack an adequate environmental buffer – groundwater aquifer or surface reservoir – for interim storage.

Conclusion

California's water system was built for a predictable and consistent climate. From surface water reservoirs to the State Water Project, California's water infrastructure was designed from assumptions about precipitation patterns of a different era. 21st Century California faces a new water paradigm in which the increasing impacts of climate change are fueling greater water scarcity and more intense droughts than the state's infrastructure is built to withstand. In the face of this threat, complacency and the status quo are not tenable. California can, and should, seize the present opportunity to strengthen its water and wastewater infrastructure by implementing potable reuse projects in all parts of the state. These vital projects offer a locally controlled supply of water that is safe, affordable, and environmentally sustainable, and must be a critical part of a state water portfolio built to strengthen resiliency against the challenges of a changing climate that increasingly threatens the precious water we have left.

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Pg. 7: The World's Largest Wastewater Recycling System for Indirect Potable Reuse. Jim Kutzle, Courtesy Orange County Water District (OCWD).
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