Potable Water Reuse Report

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Direct Potable Reuse Regulations and the Importance of Adaptability in a Rapidly Evolving World: A California Case Study

Welcome to the Potable Water Reuse Report!

A collaboration between the University of Southern California ReWater Center and Trussell, this publication is intended to connect the potable water reuse community — including practitioners, regulators, and academics — to keep them up-to-date with the industry's rapidly evolving developments.

In this first of three issues focusing on the development of regulations for direct potable reuse (DPR), we examine the development of California's recently adopted DPR regulations and their implications for the industry at large.

Direct Potable Reuse (DPR): Welcome to Primetime

After an intensive 13-year effort, California recently adopted regulations for DPR, joining Colorado to become the second state with finalized requirements. With the proverbial dam now broken, several additional states are considering or actively moving forward with DPR regulatory development.

There is no debating that California has been a national leader in potable reuse, and while many states will likely choose to deviate from the specifics of California's DPR regulatory requirements, it is an opportune moment to look back at the DPR regulatory development process and reflect on what went well and what could be improved.

Now that California's DPR regulation is complete, learning the lessons from California's experience will position other states to more thoughtfully plot their own course to DPR requirements.

1) What Went Well

The California water industry used several legislative mandates (i.e., Senate Bills 918 and 322, Assembly Bill 574) to drive the fast pace of DPR regulatory development from its inception in 2010 to its close in 2023. Throughout this period, California invested in several strategies that played valuable roles in shaping the DPR requirements (Figure 1).

Research Investment

Given the industry's limited experience with DPR, California pursued an intensive research effort to identify and address knowledge gaps. This took the form of the California DPR Initiative, a research collaboration between WateReuse California and The Water Research Foundation, that provided over $24 million of funding for 34 research projects. These projects proved fundamental in answering the questions that arose as regulators and experts thought about this new paradigm. The research helped confirm the feasibility of developing DPR regulations in 2016 and pointed toward a final set of priority research

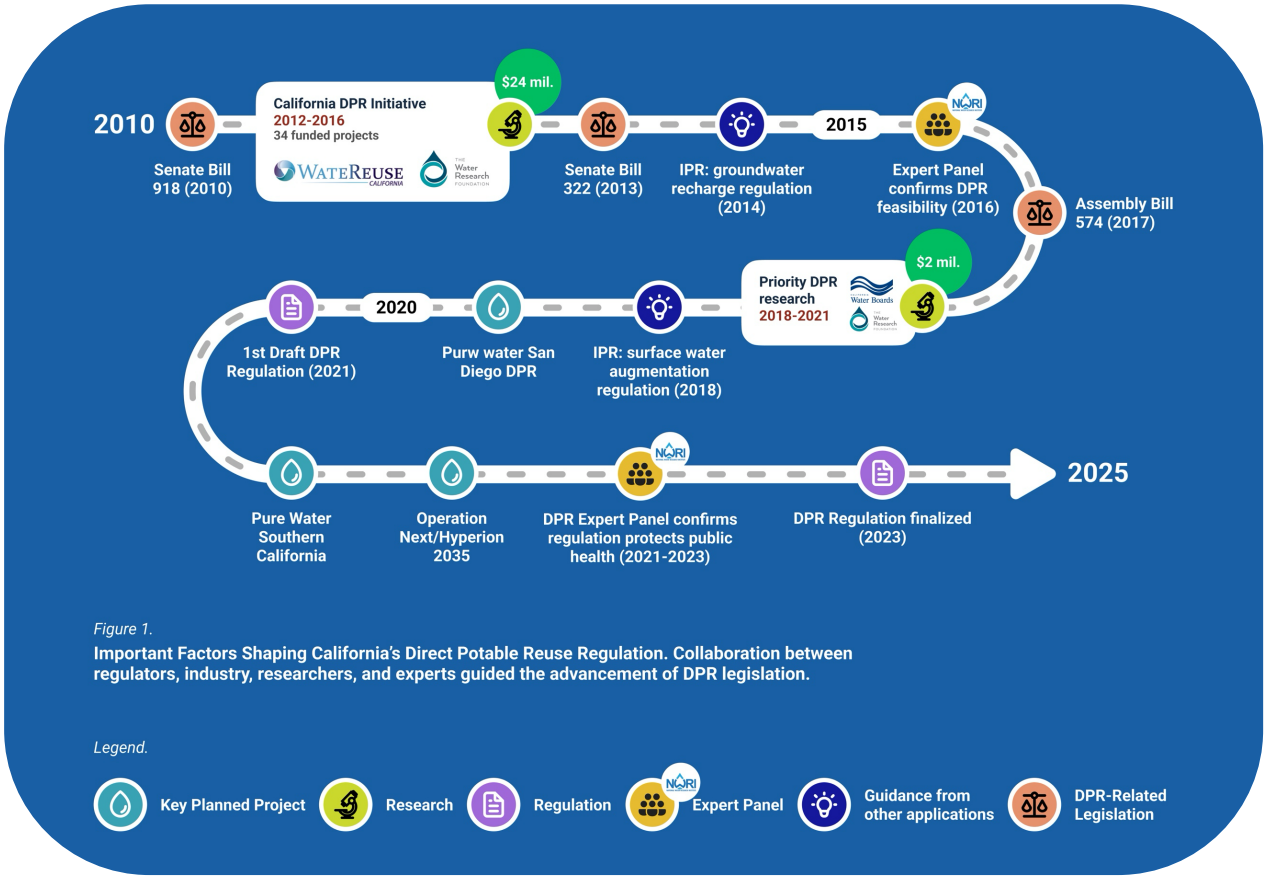

Figure 1.
Important Factors Shaping California's Direct Potable Reuse Regulation. Collaboration between regulators, industry, researchers, and experts guided the advancement of DPR legislation.

topics. An additional $2 million was invested for this final phase in support of DPR regulatory development. The massive research investment can be credited with rapidly bringing DPR out of its infancy and informing many of the requirements in the regulation.

Guidance from Other Applications

The impact of California's 60+ year experience with indirect potable reuse (IPR) cannot be understated. Many of the challenges associated with protecting public health in DPR are also considerations for IPR. The long history and evolution of IPR requirements for the control of pathogens and chemicals, the role of source control and monitoring, treatment, operations, staffing, and governance all informed the DPR requirements. Experiences outside of California were also evaluated, including existing DPR treatment trains in Namibia and Texas, advanced source control monitoring schemes in Singapore, and Australian frameworks for pathogen crediting. While the application of these approaches was tailored to fit California's needs, there is great value in learning from and leveraging these other potable reuse applications.

Independent Expert Panel Engagement

Regulatory requirements benefit from input and critical review by an independent panel of experts. *Independence* is a key feature of such panels, which should be beholden neither to the regulators nor the industry, but provide recommendations based on where the *science* says to go. An assembly of panelists with appropriate expertise can provide complementary skillsets to the regulatory staff developing the regulation, educate them on new topics, and help develop a scientific basis

for decision making—especially for topics that do not have clear right and wrong answers.

A strong scientific basis is fundamental for a mature and lasting regulation. The two California bills that required the regulators to assess the feasibility of developing DPR regulations (Senate Bill 918) and develop DPR regulations (Assembly Bill 574) included requirements to engage expert panels and specified their roles. This clarity ensured that the expert panels provided input and oversight on public health, scientific, and technical matters impacting the regulation. Ultimately, the regulation's adoption was contingent on the expert panel affirming the public health protection of the requirements. The California DPR Expert Panels (DPR Feasibility Expert Panel and DPR Criteria Expert Panel) also identified critical knowledge gaps and helped shape the priority DPR research portfolio supporting regulatory development.

Learning from Early adopters

Between the first draft of the DPR regulation in March 2021 and the final draft in October 2023, there were **major** changes across nearly every aspect of the regulation—from pathogen and chemical control to operator certification and permitting logistics. What could cause such changes if all the research was complete *before* the first draft? These new changes were shaped largely by agencies in the DPR planning phase attempting to apply the draft requirements to their projects. For example, Pure Water San Diego's proposed raw water augmentation (RWA) project includes the use of a small reservoir (i.e., an environmental buffer more commonly associated with IPR) prior to a drinking water treatment plant. Such a project—which blends DPR with elements from IPR—was an unanticipated configuration that had not been accounted for in the draft regulations. The Pure Water Southern California project also proposed a unique, hybrid IPR/DPR configuration that falls outside of the typical direct-to-distribution form of DPR.

The long history and evolution of IPR requirements for the control of pathogens and chemicals, and the role of source control and monitoring, treatment, operations, staffing, and governance all informed the DPR requirements.

Another unforeseen configuration for DPR was highlighted when the Pure Water Southern California's 150 million gallons per day (MGD) project and the City of Los Angeles' 200+ MGD Operation Next/Hyperion 2035 DPR project began discussing blending their purified waters together—which would result in an organizational complexity not envisioned in the regulations. These planning-level studies exposed the limitations of the first draft by highlighting the vastness of potential DPR configurations. Ultimately, the planning done by the early adopters of DPR resulted in changes to the regulations that added flexibility for a wider variety of projects. These changes impacted several areas of the regulation including both chemical and pathogen control requirements. The engagement of project-specific expert panels provided further confidence in the acceptability of diverse DPR configurations.

2) What Could be Improved

While California did many things well to develop the DPR regulation—leaning on research, expert panels, planning-level studies, and guidance from other locations— the one aspect that did not inform the regulations was knowledge gained from operating, full-scale DPR projects. Unfortunately, the urgent need for new water supplies is driving expedited regulatory development schedules (including California, Colorado, and Arizona) that may

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preclude the possibility of having operational experience before the regulations are complete. Why is this experience from operating projects so valuable? The California IPR regulations for groundwater recharge (GWR) are a perfect example of a regulation adapting and evolving due to the knowledge gained from operational experience.

Learning from the Past

California spent over 40 years refining its GWR regulation (Figure 2). The final 2014 GWR regulation contains so many updates that it may appear unrelated to the original 1974 draft. One of the key elements refining these requirements was the operational experience of two projects that were underway or under development in 1974. The Los Angeles County Sanitation Districts' (LACSD) GWR project, which began in 1962, was spreading

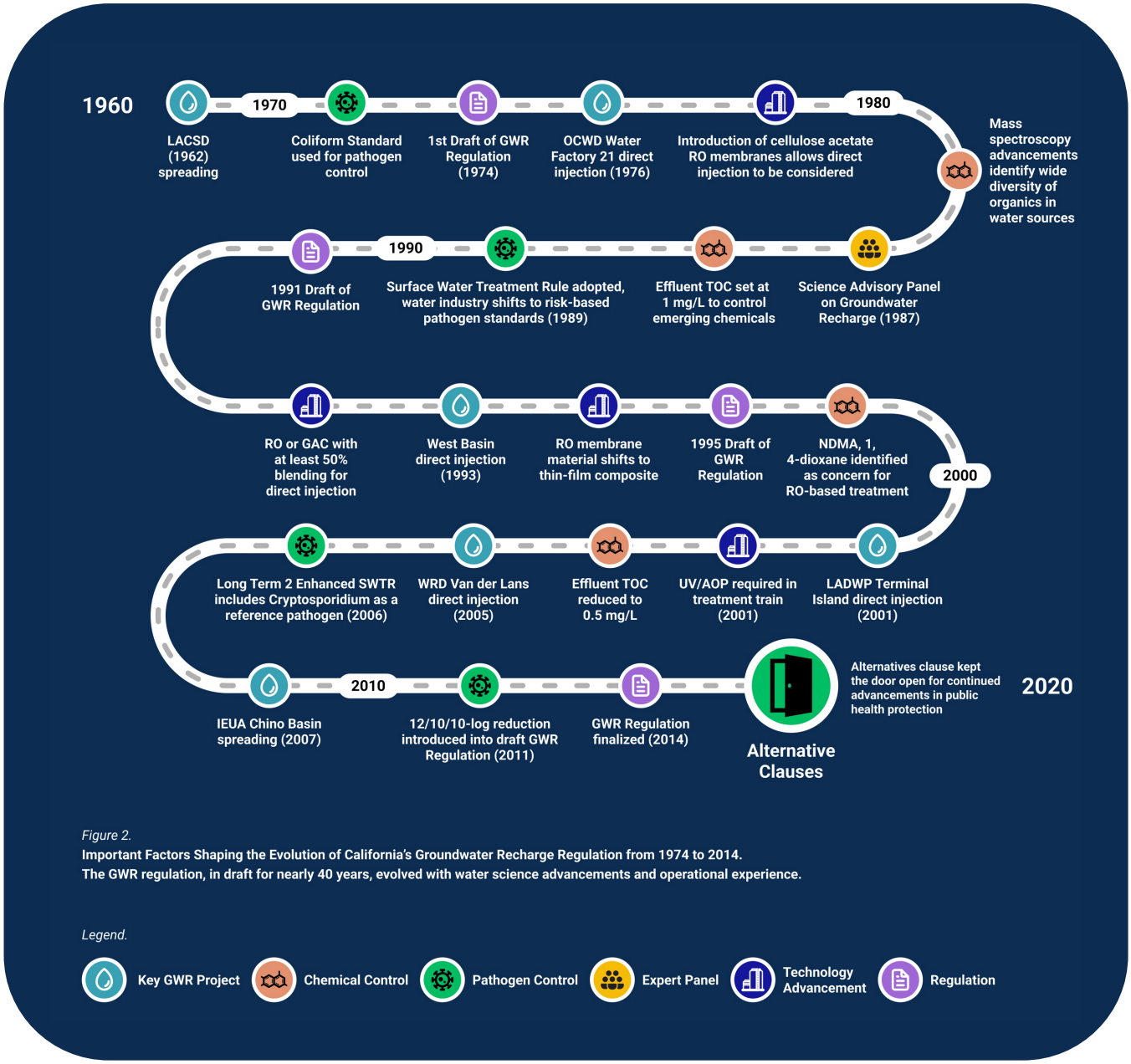

Figure 2.
Important Factors Shaping the Evolution of California's Groundwater Recharge Regulation from 1974 to 2014.
The GWR regulation, in draft for nearly 40 years, evolved with water science advancements and operational experience.

tertiary effluent and benefiting from the additional treatment provided as the water passed through the soil into the aquifer (i.e., soil aquifer treatment). For more than a decade, surface spreading was the only form of GWR considered. However, in the early 1970s, Orange County Water District (OCWD) began evaluating advanced treatment at their Water Factory 21, exploring both reverse osmosis (RO)-based and granular activated carbon (GAC)-based treatment. With higher quality, advanced-treated effluent, direct injection into the aquifer could also be considered. This project experience led to a bifurcation that still exists today—one set of criteria for spreading and a separate set for injection—and showed how quickly new experiences can fundamentally reshape a regulation. These pioneering projects also provided specific case studies to find gaps or pitfalls in the regulation. This was especially evident in the early 2000s when detections of N-Nitrosodimethylamine (NDMA) and 1,4-dioxane in recharged groundwater highlighted the possibility that certain contaminants present in wastewaters could pass through both tertiary and RO treatment. This experience resulted in a significant expansion of the advanced treatment requirements; in addition to RO, direct injection projects also require high-dose ultraviolet light (UV) and an advanced oxidation process (AOP) (for the photolysis and oxidation of recalcitrant compounds) to protect against emerging compounds. The acceptability of the potable reuse criteria in protecting public health was also confirmed with large health-effects studies in both the Los Angeles and San Diego regions.

Another major change that occurred between 1974 and 2014 was how the industry thought about controlling pathogens. It may be surprising, but the proverbial 12/10/10-log reduction of virus/*Giardia*/*Cryptosporidium* requirement that is synonymous with California potable reuse and widespread throughout the potable reuse world today did *not* make its first appearance until 2011. In 1974, water was determined to be microbially acceptable if minimum levels of treatment were provided and the concentration of coliform bacteria was maintained at low levels. At the same time, scientific research was demonstrating that water with non-detect levels of coliforms could still result in infection and disease associated with non-bacterial pathogens (i.e., virus and protozoa). The nascent field of quantitative microbial risk assessment was also providing new approaches for estimating the relationship between treatment and risk. The shift from the coliform standard to risk-based treatment occurred in the United States with the Environmental Protection Agency's (EPA's) adoption of the Surface Water Treatment Rule in 1989. Even though these scientific and regulatory advancements occurred outside of potable reuse proper, their imprint on the development of 12/10/10 is clear. The original GWR regulations were able to adapt to these fundamental shifts in public health protection and protect against the emerging pathogens of the time.

Balancing Experience and Flexibility

California's GWR experience teaches us that we should be prepared for a rush of new information once we gain operational and permitting experience at DPR facilities. How then, should DPR regulations be structured to account for our limited DPR experience? One mechanism that California used in its IPR regulations is to allow projects to propose alternatives to any of the provisions in the regulation assuming that the project could demonstrate that it provides equal or better protection of public health. This broad "alternatives clause" allows projects to adapt to innovations in treatment and monitoring technologies, but also allows flexibility in requirements for other topics such as governance, staffing, certification, and source control (topics that often don't get fleshed out completely until projects are starting up or operating). This broad flexibility can equally be used by the regulators to adapt the requirements to the "dynamic" nature of public health protection. To date, the alternatives clause has not been used frequently in IPR settings, though this is perhaps related to the fact that the regulatory requirements were refined for 40 years prior to finalization. From

this perspective, the alternatives clause—or another mechanism to allow updates to the requirements—feels particularly vital to the DPR regulations, where California has *no* operational experience (and the world has limited experience).

While the DPR regulations did include some flexibility for specific topics (i.e., chemical control), unfortunately, **the DPR regulations specifically do not include a *broad* alternatives clause**. For many people in the California water industry, this omission was the most important shortcoming of the regulation. Representatives from many of the largest agencies in the State spoke with general appreciation at the public hearing for the DPR regulations but urged the State Water Board to include greater flexibility in the form of an alternatives clause. This was the number one "ask" from the water industry throughout the public comment period given how difficult it is to amend or reopen a regulation once it is finalized. Without this flexibility, the fear is that the DPR regulation may limit innovation, restrain future projects, and close the door on an adaptive approach to public health protection.

Looking Forward

The urgency of water supply issues in the climate change era will demand rapid solutions. California's experience provides a template for other areas to consider as they move forward with DPR regulations.

Several strategies can and should be employed to inform DPR requirements including the use of research, expert panels, planning studies, and guidance from other applications. One element that will likely not be available to guide regulatory requirements in the near future is operational experience. With less operational experience, regulations should consider more flexibility to be able to adapt to the rapid influx of new knowledge regarding how to best protect public health while ensuring the operability, sustainability, and cost-effectiveness of DPR projects.

So how do we include flexibility or adaptability into regulatory development? It is likely that this will vary state by state (or country by country) based on the local regulatory process, but multiple models exist:

1. **The California GWR Example**: Include an "alternatives clause" that allows a regulation the flexibility to evolve. This mechanism allows projects to propose alternatives that improve the public health protection, economics, and operability of DPR projects.

2. **The Colorado DPR Example**: Develop a regulation that refers to a policy document that is more adaptable than the regulation itself.

3. **The EPA's Surface Water Treatment Rule Example**: The Surface Water Treatment Rules underwent several enhancements over the 17-year period from the initial 1989 rule to the "final" version (the Long Term 2 Enhanced Surface Water Treatment Rule) in 2006. While this approach is time-consuming and requires broad support from stakeholders, it allows for evolution by reopening, amending, or enhancing existing regulations to adapt to new knowledge.

The potable reuse industry is known for coupling innovation with public health protection to break into the next frontier. We need to ensure our regulations allow us to evolve with our future experience and do not hold us back.