Potable Water Reuse Report

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Direct Potable Reuse at the Global Scale: Regulations or Bust?

Key Takeaways:

- Potable reuse regulations are not being prioritized at the international scale for several reasons:
  - The urgent need for water supplies can leave insufficient time for regulatory development.
  - The effort to develop regulations is not justified by the low number of anticipated projects.
  - Some countries do not have a culture that favors regulatory development and enforcement.
  - Use of an environmental buffer provides an avenue for pursuing reuse without additional regulatory development.
  - In many countries, existing drinking water frameworks do not explicitly prohibit potable reuse.
- Multiple strategies are used for protecting public health in the absence of potable reuse regulations: leveraging existing frameworks, building off precedents from existing projects, employing risk management approaches and demonstration facilities, and engaging experts.
- Three different regulatory approaches are discussed based on the urgency of water supply, the number of projects, and the availability of resources: (1) permitting projects on a case-by-case basis without uniform requirements, (2) developing non-enforceable guidelines, and (3) enacting regulations.

Introduction

This inaugural series of the Potable Water Reuse Report has focused on direct potable reuse (DPR) regulations. The first issue looked at the multi-year effort to develop California's new DPR regulations while the second explored the site-specific factors leading to regulatory diversity in states across the US. Despite the differences, one unifying element from the first two issues was the important role that regulations (or guidelines) play in advancing DPR implementation in the US. In this third issue of the series, we turn our focus to the international scale. The distribution of potable reuse projects internationally shows a high density of projects in the US and a relatively low density of projects elsewhere. Outside the US, potable reuse regulations—both indirect and direct—are nearly nonexistent. One obvious question arises: "Would the development of regulations spur additional potable reuse implementation worldwide?" If the lack of regulations is an impediment, would investments in regulatory development promote more widespread adoption? To answer this, we interviewed several members of the international potable reuse community and found significant departures from the US perspective (Figure 1). In this issue, we provide a roadmap for countries considering potable reuse by exploring why potable reuse regulations are generally *not* being developed outside the US and what approaches are being used to protect public health in the absence of reuse regulations.

Guidelines vs. Regulations

Several countries have developed guidelines for potable reuse. Guidelines are useful for providing a consistent roadmap for potable reuse projects, but they are not *enforceable*. In contrast, regulations grant the power of enforcement to regulatory bodies to implement the law. This key distinction between guidelines and regulations is noted throughout this issue.

Figure 1: Potable reuse specialists interviewed for this issue of the Potable Water Reuse Report.

1. Why aren't there more potable reuse regulations?

The interviewees described several shared reasons for the lack of potable reuse regulations in their countries: (1) the need for new water supplies was too urgent to wait for regulations, (2) the low number of anticipated potable reuse projects in the country did not justify the development of regulations, (3) the regulatory culture allowed for case-by-case permitting in the absence of regulations, and (4) existing regulatory frameworks already allowed certain reuse practices.

Urgent Need for Water

In certain historical cases, the urgent need for new water supplies justified the implementation of potable reuse projects *prior* to the development of regulations. A water crisis in 1957 was the key motivator for the development of the world's first DPR project in Windhoek, Namibia, which became operational soon thereafter in 1968. The project was "born out of need," according to Pierre van Rensburg, an executive for the City of Windhoek. A reuse regulation was not a prerequisite for Windhoek, particularly when most countries had not yet developed national regulations for *conventional* drinking water supplies. Fast-forwarding from the 1960s to today reveals similar dynamics still at play. Prolonged drought in the Spanish region of Catalonia necessitated the rapid implementation of a potable reuse project augmenting the Llobregat River in Barcelona. Rafael Mujeriego, Professor Emeritus at the Universidad Politécnica de Catalunya echoed the importance of urgency, saying the project was "approved basically out of strict necessity." Water scarcity issues also prompted the Indian Institute of Technology (IIT) in Madras to develop new treatment facilities to augment a nearby lake for potable reuse, according to

Professor Ligy Phillip, the lead engineer for the project. Alternatives to potable reuse were often considered (e.g., desalination, building new dams), but reuse tended to be the most economical and rapid solution according to the interviewees. When urgency is high and the focus is on *developing a project*, the lack of regulations is not an impediment to implementation and can actually allow for faster implementation.

Low Number of Anticipated Projects

Dozens of cities up and down California's coastline are actively considering DPR and IPR as are several cities in Colorado and Texas. A similar pattern of widescale interest exists in Australia with potable reuse as a key element of future supply strategies for several cities including Perth, Brisbane, and Sydney. This high number of anticipated projects may explain why both countries have prioritized the development of regulations and guidelines. Regulators may have found it more expedient to develop a single set of regulatory requirements (or guidelines) rather than developing multiple sets of requirements on a project-by-project basis.

In other countries, the *low* number of anticipated projects may push regulators in the opposite direction. Outside of Windhoek, other Namibian cities are unlikely to pursue potable reuse according to Pierre van Rensburg, who noted that Walvis Bay on the Namibian coast considered potable reuse but ultimately selected seawater desalination given reuse's high complexity. In Barcelona, Rafael Mujeriego noted that it was unclear if reuse via the Llobregat River would be a permanent solution or merely a temporary fix. For these locations, the effort to develop regulations may not be worth the time and investment if the interest within the country is low or if a project is only meant to be an emergency supply. The lack of national regulations may therefore *not* be an impediment if a small pool of projects can be approved on a case-by-case basis.

Regulatory Development and Enforcement

Regulatory *culture* also influences a country's decision whether to develop regulations or not. Countries with long histories of regulatory development may have greater capabilities for developing new regulations than those with relatively short histories. For example, Namibia gained its independence from South Africa in 1990 but continued to use the South African Water Act until 2004. In 2023, the Namibian Water Resources Management Regulations were adopted, but they required a ten-year process for approval. Drawn-out regulatory timelines may motivate regulators to stick with a case-by-case permitting approach to avoid the lengthy process of adopting new regulations.

The European Union (EU) has a unique regulatory culture given that countries must grant primacy to EU directives over national regulations. Due to the time-consuming process of consensus-building, the development of new directives in the EU can be slow. Countries with immediate interest in potable reuse (e.g., Spain and Belgium) may need to develop their *own* regulations if they want to implement potable reuse prior to an EU directive. Investing in regulatory development carries risk because a national regulation may be superseded by a future EU directive. The possibility that the EU develops its own potable reuse directive, however, may be low. According to Rafael Mujeriego:

> "I don't expect anything coming from the top down. You will have to go all the way around, from the bottom up,"

in other words, from member states up to the EU.

> "The urgency and extent of new conservation and reuse measures brought about by the intense droughts affecting Mediterranean areas pose real challenges for a collective approach by European Union authorities."

Another consideration is whether regulators have the resources and authority to *enforce* regulations. Interviews uncovered a wide degree of enforcement of existing drinking water or environmental discharge regulations between countries, with some interviewees describing only weak levels of enforcement. Countries that cannot enforce regulations may be less motivated to spend the

Water Recycling Guidelines: A Consistent Framework but not Enforceable

While the Australian Water Recycling Guidelines have been in place since 2008, Richard Theobald of the Western Australian Health Department, noted that Australia still doesn't "…have a written law at this time that says 'thou shalt' simply because our law is lagging behind the formation of guidelines." Despite this, Ian Law, Principal of IBL Solutions expressed that the presence of specific water recycling guidelines in Australia has been crucial to helping projects move along: "Being able to go into a meeting with the Australian Water Recycling Guidelines as a starting point initiates discussion." However, Stacey Hamilton, Team Leader of Treatment Performance and Review for Water Corporation in Western Australia expressed that even with the existence of the guidelines, there was still a lot to learn as they developed their project. Stuart Khan, Professor at the University of Sydney echoed that even though the guidelines are helpful, they have not kept up with the state of the science and there has been no funding or clear ownership to update and revise the guidelines—an issue that can impact regulations as well.

In California, a project with less than two months of retention time in the environment is defined as DPR. However, most of the world does not make this distinction and sees great value in "the kiss of nature" regardless of the amount of time water spends in the environment. Jacob Bossaer, CEO of BOSAQ acknowledged that the Torreele facility in Belgium has been practicing aquifer recharge for over 20 years with retention times less than 60 days, but this is not considered DPR in the region.

time developing them. Others noted that regulatory bodies were not the only entities that could provide oversight and enforcement of water quality and treatment performance. In Windhoek, a private management agreement between the City of Windhoek and the operator of the facility (the Windhoek Goreangab Operating Company) sets the terms for water quality, quantity, monitoring, and treatment performance. The City can leverage financial penalties for failure to meet the terms, according to Pierre van Rensburg. Such enforcement of contractual agreements may be an important mechanism to augment regulatory bodies particularly when potable reuse facilities are operated by private entities on behalf of a municipality.

Regulatory culture can sway a country's decision to pursue potable reuse regulations. Countries with extensive experience developing regulations and the authority to enforce regulations are more likely to benefit from the effort to develop regulations than countries lacking these factors.

Value of the Environmental Buffer

In many countries implementing IPR, the lakes, reservoirs, and aquifers that serve as environmental buffers are key to gaining public and political acceptance. These positive associations may be linked to the public's experience obtaining their water supplies from these same sources of surface and groundwater. In addition to public acceptance benefits, using environmental buffers can also provide permitting pathways that do *not* rely on the development of new potable reuse regulations. If an IPR project can be permitted under an existing surface or

Ask the experts: What are the biggest implementation challenges?

Public Acceptance

Ligy Phillip said the hardest part of implementing her project at IIT was "convincing the people…and overcoming the psychological inhibition that this is wastewater." Stacey Hamilton similarly said "there was no point in building a scheme if the community said no." Chee Meng Pang said "despite the technical rigor in developing the NEWater process, a major challenge was to convince Singaporeans that NEWater, with its multi-barrier treatment process, was safe." As with other successful reuse projects, Singapore implemented a comprehensive public communications and community engagement program (including a visitor center) to educate and build public acceptance for NEWater.

Political Acceptance

Stuart Khan believes Australians have overcome the "ick/yuck" factor, but the cost impact that potable reuse would have on consumers could have significant political ramifications. Ligy Phillip also indicated that convincing policy makers was key to securing funding for her project.

Technical Capacity

Pierre Van Rensburg cited "…the capacity to implement such a project or to put it together in the first place," as an important challenge. Stuart Khan similarly said that "some of our regulators would be very uncomfortable approving smaller water utilities to run a potable reuse scheme without the confidence that they could do it competently." He noted that the existing shortage of treatment plant operators could be exacerbated by the additional requirements for potable reuse operators.

Financial Capacity

Ligy Phillip expressed concerns that projects may "cut corners" to save money increasing the likelihood of process failures. Chee Meng Pang noted that membrane technology costs were a significant concern when the project was first proposed in the 1970s. By the 1990s, membranes costs had dropped due to greater competition and economies of scale allowing for a more cost-effective project. One workaround has been to engage international consortiums that finance, plan, design, build, and even operate potable reuse plants around the world. The City of Windhoek's plant is operated by WINGOC—a partnership between Veolia and WABAG. Jacob Bossaer's company, BOSAQ, is one of the private firms seeking to design, build, and operate potable reuse plants in Europe.

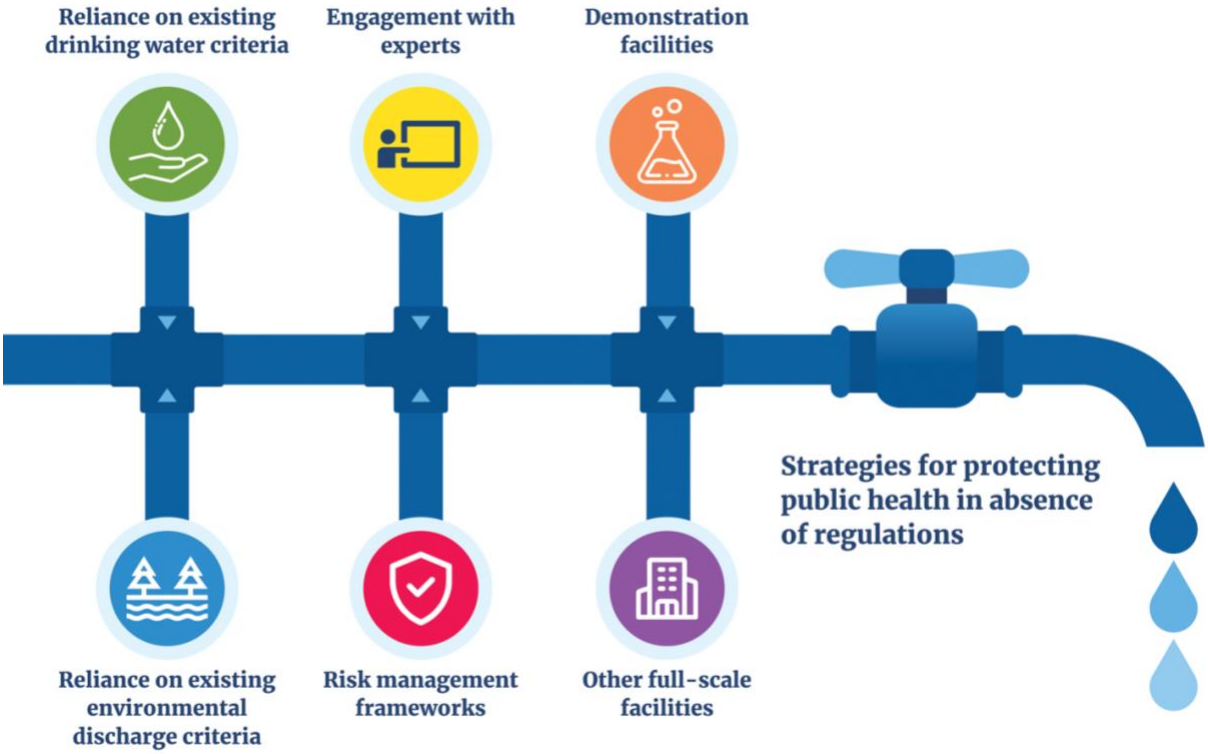

Figure 2: Strategies for protecting public health when there are no potable reuse regulations in place.

groundwater regulation, then an additional reuse regulation is unnecessary. In a country like Spain, where DPR is expressly *not* allowed, the use of the environmental buffer (like the Llobregat River) provides an avenue to reuse wastewater without developing a new regulation. Similar approaches are being taken in India and Belgium.

2. Public Health Protection in the Absence of Regulations

If potable reuse regulations are not being developed across the globe, what strategies are projects using to ensure public health protection? Interviews identified four key strategies to protect public health: (1) use existing regulatory criteria and projects, (2) develop project-specific risk management approaches, (3) utilize demonstration facilities, and (4) engage industry experts for scientific and technical review (Figure 2).

Existing Criteria and Projects

During the development of the Windhoek project, there were no potable reuse guidelines or projects to serve as precedents. As the project evolved, however, there was increasing access to guidelines for drinking water that could be leveraged to set water quality targets for reuse. Josef Lahnsteiner noted the availability of several key drinking water documents that were used in the 1990s including from the World Health Organization, the Namibian government, and consultants. Many other projects are using a similar strategy that relies on existing drinking water guidelines to inform water quality criteria. Pierre van Rensburg pointed out a potential gap, however, since many of the drinking water criteria don't fully "take into account the fact that your water source is treated wastewater." Today, there are potable reuse-specific guidelines such as the WHO's Potable Reuse Guidelines that can help bridge this gap.

In addition to using existing regulatory criteria, many looked to the pioneering projects to guide both their treatment and water quality goals. Chee Meng Pang, Director of Water Quality with PUB, Singapore's National Water Agency, explained that Orange County Water District's (OCWD's)

> "Groundwater Replenishment Scheme and Water Factory 21 projects were major inspirations for PUB's NEWater process and heavily influenced PUB's decision to adopt an RO-centric treatment process for water recycling."

Interviewees expressed similar use of Windhoek's and others' treatment and regulatory frameworks, which were used to inform their own criteria. According to Stacey Hamilton, the Water Corporation's potable reuse treatment train was influenced by OCWD and PUB with modifications to fit the Western Australian context.

Figure 3: Nesapakkam 10 Million Liters per Day Potable Reuse Pilot Facility, Chennai, India. Provided courtesy of the Chennai Metropolitan Water Supply and Sewerage Board.

Project-Specific Risk Management

Project-specific risk management strategies can also be leveraged when regulations are absent. In the EU, all water production facilities must develop a Water Safety Plan that focuses on treatment performance monitoring and controlling risks from the source to the tap, in lieu of relying on end-point monitoring. This type of risk-based approach is also referred to as the Hazard Analysis and Critical Control Point (HACCP) framework. In Belgium, a Water Safety Plan is required to begin a project, according to Jacob Bossaer, and the plan must assess risk from pathogens and chemicals while ensuring that water quality criteria are always met. The Australian Framework for Management of Drinking Water Quality uses the same risk-based approach per Stuart Khan:

> "The key focus of the guidelines is about critical control points. It is about understanding from catchment to tap where the vulnerabilities are in the system, making sure you have barriers in place to protect you from those vulnerabilities, and monitoring to focus on the performance of those barriers."

Demonstration Facilities

Demonstration facilities were noted by several interviewees as important for building confidence in potable reuse. Notably, Windhoek's original 1968 design and the updated plant design in 2002 were based on years of pilot-testing data. Projects in Spain, India (Figure 3), Singapore, and Australia have also developed demonstration facilities. Interviewees unanimously spoke of the value of demonstration facilities to inform treatment design and water quality criteria, but also for gaining both political and public acceptance.

Expert Engagement

The final approach described by interviewees is to engage experts to help set or review proposed standards, evaluate treatment design and performance, and provide independent review. Both Pierre Van Rensburg and Josef Lahnsteiner acknowledged the contribution from industry experts in developing the water quality criteria for the Windhoek project. Chee Meng Pang explained the role experts play in the NEWater projects:

> "PUB convenes a meeting of our Expert Panels twice a year to review the water quality results collected from our raw waters sources, treatment through waterworks and NEWater plants, and up to the customer tap."

As projects are developing, experts can provide feedback on multiples aspects from water quality criteria to treatment and operations.

3. Moving Forward

Issues 1 and 2 of the Potable Water Reuse Report illustrated that, in the United States (US), years may be needed to raise funding, conduct research, and engage experts to develop public health criteria for potable reuse regulations. This issue highlights that outside of the US, regulations may not be needed or appropriate in all situations. Multiple alternative pathways can be considered (Figure 4). In some cases, the urgent need to implement a project may be too pressing to wait for the development of a regulation. The Namibian drought in the late 1950s and Cape Town's Day Zero threat in the 2010s are both examples of periods of urgent water need. Under such circumstances, a case-by-case permitting approach will likely be most efficient. This may also be the best-suited approach when there are few anticipated projects or when regulatory bodies have limited experience or capacity to develop new regulations.

Regulations tend to be appropriate for countries with the opposite circumstances: time, funding, and capacity to develop new regulations, the potential for widespread implementation, regulatory bodies with the power of enforcement, and support from both the public and political spheres. A middle-ground option is the development of guidelines that can provide a consistent framework as a starting place for permitting even if they are not enforceable. Guidelines may be most appropriate in areas with intermediate scales of implementation where support from the political, regulatory, and public spheres may be moderate. Ultimately, each country or state should consider these factors when selecting a regulatory approach. The flowchart in Figure 4 synthesizes these lessons and provides a step-by-step process for a tailored regulatory approach.

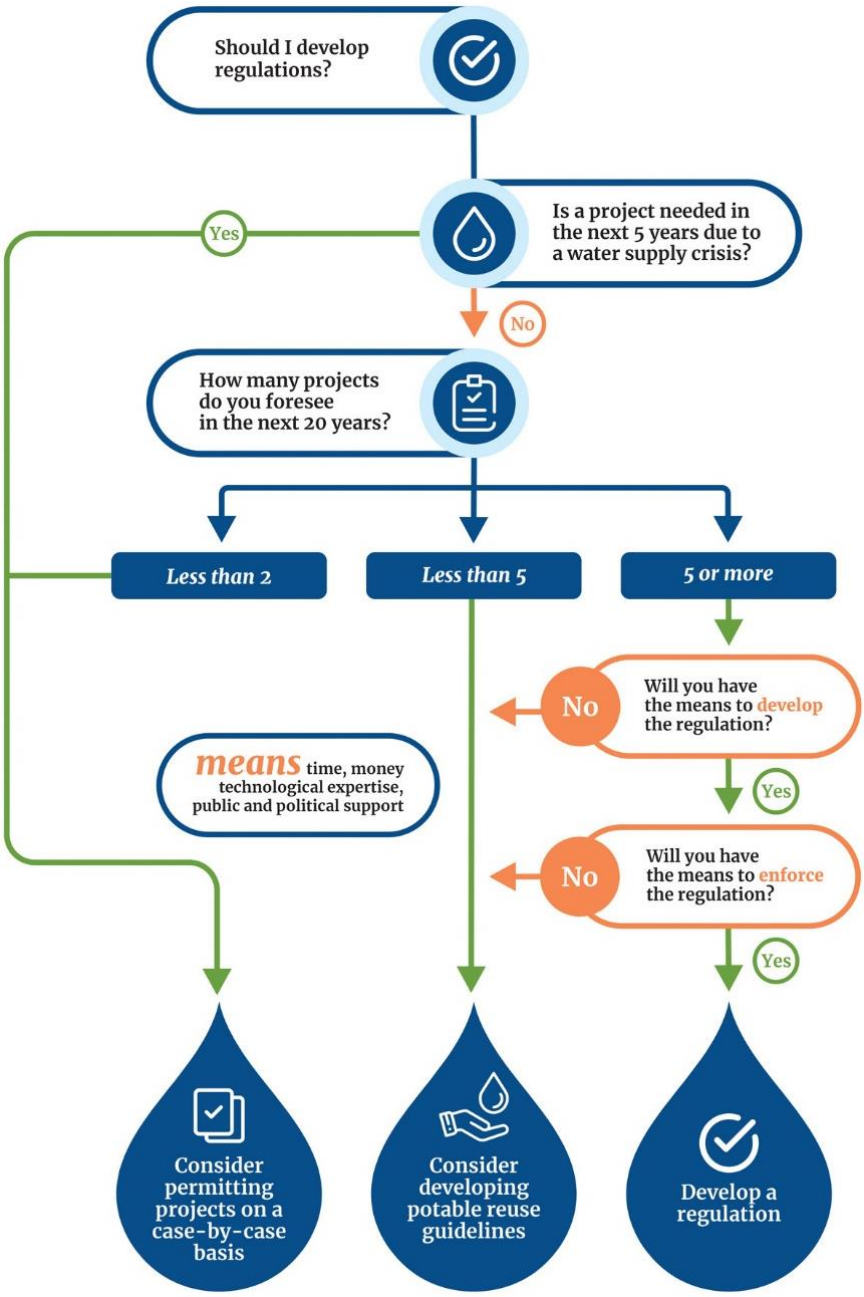

Figure 4: Decision tree for a tailored approach for potable reuse.