NATIONAL WATER RESEARCH INSTITUTE

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Meeting 1 Panel Report

Review of Proposed City of Boise Recycled Water Program

Based on an Independent Advisory Panel Meeting
September 9, 2021

Prepared by

NWRI Independent Advisory Panel to review the
Proposed City of Boise Recycled Water Program

Prepared for

City of Boise
Public Works Department
PO Box 500
Boise, ID 83702

Submitted

December 17, 2021

Disclaimer

This report was prepared by an Independent Expert Advisory Panel (Panel), which is administered by National Water Research Institute. Any opinions, findings, conclusions, or recommendations expressed in this report were prepared by the Panel. This report was published for informational purposes.

About NWRI

A 501c3 nonprofit organization, National Water Research Institute (NWRI) was founded in 1991 by a group of California water agencies in partnership with the Joan Irvine Smith and Athalie R. Clarke Foundation to promote the protection, maintenance, and restoration of water supplies and to protect public health and improve the environment. NWRI's member agencies include Inland Empire Utilities Agency, Irvine Ranch Water District, Los Angeles Department of Water and Power, Orange County Sanitation District, Orange County Water District, and West Basin Municipal Water District.

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History of the Panel

In June 2021, the City of Boise (the City) contracted with National Water Research Institute (NWRI) to form an Independent Advisory Panel (Panel) to review documents and meet with city representatives to give feedback on the proposed Recycled Water Program (Program).

A four-hour meeting of the NWRI Independent Advisory Panel for the City was held September 9, 2021, in Boise. Kevin Hardy, Executive Director of NWRI, facilitated the meeting.

Panel Purpose and Activities

The NWRI Independent Advisory Panel review is intended to provide expert consensus opinions on scientific, technical, and policy advice on the most challenging issues that arise as the Recycled Water Program is developed and implemented. The City has identified the following targets for the Panel's initial evaluation:

- Fully vet the Program's potential scientific, technical, and policy concerns.
- Inform pilot project design.
- Recommend strategies to optimize Program implementation and operation.
- Assist the City in navigating relevant Idaho Department of Environmental Quality (IDEQ) processes.
- Support community education and outreach.

The Panel's review will include:

- Addressing public health issues including chemical and microbial contaminants.
- Characterizing the fate, mobilization, and transport of contaminants underground.
- Establishing monitoring and reporting standards for regulatory compliance.
- Evaluating fit-for-purpose technologies that accelerate implementation.
- Informing an effective community engagement and communication program.

The City's Project Team presented information about the project to the Panel and asked the Panel to respond to questions on topics ranging from community engagement to regulation and test planning. The questions are listed and responded to in the Panel Questions and Responses section of this report.

Panel Membership

The Panel consists of the following six experts:

- Panel Chair: Rick Warner, PE, Warner & Associates
- Shawn Benner, PhD, Boise State University
- Daniel Gerrity, PhD, Southern Nevada Water Authority
- David Reckhow, PhD, University of Massachusetts Amherst
- Channah Rock, PhD, University of Arizona
- Rupam Soni, PE, Metropolitan Water District of Southern California

More information about the NWRI Panel process can be found in **Appendix A**. Short biographies of the Panel members are in **Appendix B**.

Meeting Agenda and Attendees

Staff from the City and NWRI collaborated on the agenda for the meeting, which is included in **Appendix C**. The agenda was based on meeting the following specific objectives:

- Reflect on the framework, end water quality goals, and initial implementation approaches.
- Vet the Program's potential scientific, technical, and policy concerns.
- Inform pilot project design.
- Recommend strategies to optimize Program implementation and operation.
- Provide time for the Panel to begin writing the draft report.

Meeting attendees included NWRI staff, city staff, and various stakeholders. A list of attendees is in **Appendix D.**

Pre-Meeting Review Materials

Before the meeting, the City provided the following background materials for review:

1. Recycled Water Program NWRI Briefing Packet
2. Recycled Water Master Plan
3. Water Renewal Utility Plan
4. Treasure Valley Managed Recharge Feasibility Study
5. Treasure Valley Comprehensive Aquifer Management Plan
6. Boise Climate Adaptation Assessment
7. IDAPA Ground Water Quality Rules
8. IDAPA Recycled Water Rules

Summary of Recommendations

For this meeting, the City of Boise gave the Panel a series of questions for specific guidance that will help the Project Team. This section contains a brief summary of the questions and Panel responses. More detailed answers and supporting narrative are in the Panel Questions and Responses section.

Community Engagement Plan

CE-1: Does the community engagement plan support the goals and objectives of the Recycled Water Program?

- The Panel commends the City for its proactive approach to community engagement so early in the proposed project. The City has proposed a robust treatment approach that has a long history of success in other communities. Sharing this information in a transparent way will be valuable to garnering additional public support.

CE-2: Are there any recommendations for our outreach approach?

The Panel feels that the following key goals and steps could help the City's outreach be more effective:

- Better define the project purpose, goals, and objectives.
- Identify and expand the pool of stakeholders and bring them into the planning process early.
- Build messaging that clearly and precisely conveys the project purpose and goals to those stakeholders.
- Continue engagement and messaging through all phases of the project, including during ongoing operations in the future.
- Measure outreach results.
- Develop a rapid-response communications protocol.

CE-3: Are there any best practices that have helped communities effectively engage their community in the early stages of recycled water programs that we ought to consider?

- The City has already implemented a number of community engagement strategies that have been successful in other communities. The Panel supports the City's plan to use the pilot-scale system for public tours and outreach.

- Developing and leveraging local expertise is a best practice in successful water recycling projects. The Panel recommends the City develop a community engagement team that can explain the project to stakeholders. For example, WateReuse Arizona brought together experts including engineers, academics, students, economists, psychologists, and educators. These experts offered a base of knowledge to convey complex engineering concepts and could respond to a wide range of public questions and concerns.

Regulatory Summary

RS-1: Does the current regulatory and permitting approach consider appropriate environmental and public health compliance for the envisioned Recycled Water Program?

- The Panel recommends that the City engage local regulators throughout the project to facilitate future regulatory changes. Regulator participation is common at expert panel meetings in California and appears to have helped facilitate implementation of some projects.
- The Panel recommends the City meet with DEQ to validate that the proposed level of treatment is appropriate for aquifer recharge. Idaho regulators may be very cautious and require a robust treatment approach for pathogen removal/inactivation, especially considering that this would be the first permitted Class A recycled water aquifer recharge project in the state.

RS-2: Are there additional topics that should be considered as the Program begins?

- The Panel recommends that the City collaborate with stakeholders to identify their concerns. A successful plan will likely involve an expansive collaborative approach to this element of the project.
- The Panel also recommends that the City better identify what its treatment goals are and, ultimately, the objectives and methods for aquifer recharge, whether by infiltration basin, vadose zone injection, or direct injection into deeper aquifer zones.

Water Quality Summary

WQ-1: Based on our proposed source water and existing data, what additional testing/sampling would you recommend to ensure public/environmental safety?

- The Panel recommends fully characterizing the feed water quality in terms of expected contaminants, concentrations, and variability over time. In addition, the City needs to have a clear understanding of the water quality needs of the industrial users. Developing a collaborative relationship with the wastewater producers and the end users will facilitate that effort.

- A detailed water quality sampling plan is essential and it is anticipated that one will be established as the Program is implemented. The City has identified a wide range of potential industrial wastewater dischargers to the proposed third water renewal facility (Third WRF) in southeast Boise. A wastewater source water quality monitoring and testing program will complement environmental control and industrial waste inspection programs.
- Water quality sampling and testing for aquifer recharge must be aligned to protect public health. IDAPA 58.01.11 provides guidance for primary and secondary water standards, based upon regulated contaminants from the EPA's primary Drinking Water Regulations and Idaho's Secondary Maximum Contaminant Levels for drinking water. Additionally, the Panel recommends that source water quality testing include a representative list of unregulated chemical constituents, such as PFOA/PFAS and other contaminants of emerging concern (CECs). The Panel can help the City develop the most appropriate list of unregulated constituents. The Panel also recommends the City test and monitor for enteric virus, *Giardia*, and *Cryptosporidium* because the wastewater flows to the Third WRF may include municipal wastewater (Recycled Water NWRI Briefing Packet, page 23).

WQ-2: Are there any recommended modifications to the source water quality monitoring plan, such as frequency or other analytes?

- The Panel may have more feedback once more information is developed and available.
- The City should consider developing a source water quality plan that encompasses a wide range of sampling sites and contaminants. As additional data is collected, the City can modify the testing and inspection program. Source water control and effluent monitoring must be integral to an ongoing water quality program, particularly as new industries are established in Boise.
- Based upon the limited industrial wastewater quality data collected in 2020 and the wide range of potential future industrial dischargers, the Panel recommends the City evaluate source water quality control programs developed in other communities that have a wide variety of industrial users and dischargers.

Preliminary Pilot Test Plan

PP-1: Does our proposed approach to pilot testing accomplish the following goals:

a. Evaluate treatment train performance for demonstration of program objectives for water quality and regulatory compliance.

b. Provide opportunities to engage and educate the public about water safety.

Panel responses are under PP-2.

PP-2: Are there any recommendations for additional evaluation or objectives for pilot testing?

- The City should be prepared to extend the pilot test/demonstration phase beyond the proposed one-year timeline and expand testing to assess seasonal fluctuations. Also, running the pilot for multiple years will provide data for community engagement, training, and other purposes.
- From a design and implementation perspective, there may be value in the City identifying and selecting a single end use and specifically designing for that purpose. Although an RO-based treatment train may offer the most flexibility from a regulatory perspective, it may not be the most appropriate option for a fit-for-purpose recycled water program. The City may be able to achieve desired water quality objectives with alternative treatment approaches, although this will require further refinement of end use and sustainability goals over time. If there are future scenarios that do not require RO treatment, they may need to be incorporated into the pilot testing plan.

Panel Questions and Responses

The City asked the Panel to evaluate the proposed City of Boise Recycled Water Program and answer questions that will help the City advance the Program. The City's questions and Panel responses follow.

The Panel acknowledges and appreciates the pre-meeting review materials and the quality of the presentations that the City provided.

Community Engagement Plan

CE-1: Does the community engagement plan support the goals and objectives of the Recycled Water Program?

The Panel commends the City for its proactive approach to community engagement so early in the proposed project. There are many examples in the water reuse industry of how public perception has facilitated or hindered implementation of other projects, so this early effort is a promising sign for long-term success.

One theme that will emerge throughout this report is the importance of establishing legitimacy for a project. This is a concept introduced by Harris-Lovett et al. (2015), which is attached in **Appendix E**. An effective way to achieve pragmatic legitimacy, in particular, is strategic community engagement. Pragmatic legitimacy is established when stakeholders understand how the project will benefit them.

The City has identified a number of important stakeholders and has already used innovative approaches to engage those people and groups. In particular, the Watershed Education Center is a great resource for educating and interacting with the public. The Watershed Education Center, coupled with a future demonstration facility, will show how water reuse can help the City achieve its innovation, sustainability, and workforce development goals.

While there is local support for water recycling, Boise residents have also expressed concerns about water quality. However, the City's preliminary pilot and water quality monitoring program should help alleviate those concerns over time. The City has proposed a robust treatment approach that has a long history of success in other communities. Sharing this information in a transparent way will be valuable to garnering additional public support.

It is important that the City has a plan for how water quality data should be shared with and interpreted for stakeholders. Having a plan in place now will help the City to be successful in the future.

The Panel identified several opportunities for the City to potentially improve its already robust community engagement effort. These opportunities are described below.

CE-2: Are there any recommendations for our outreach approach?

Overall, the Panel is impressed with the City's commitment to outreach and engagement. The Panel feels that several key goals and steps could help the City be more effective. The following Panel recommendations are described in detail in this section:

- Better define the project purpose, goals, and objectives.
- Identify and expand the pool of stakeholders and bring them into the planning process early.
- Build messaging that clearly and precisely conveys the project purpose and goals to those stakeholders.
- Continue engagement and messaging through all phases of the project, including during ongoing operations in the future.
- Measure outreach results.
- Develop a rapid-response protocol.

Clearly define purpose, goals, and objectives

The Panel believes the messaging about project benefits could be more clearly defined. It is useful to frame the project in the context of climate change, resiliency, and sustainability, but the direct benefits of this project to the community should be clear. It was not clear to the Panel if sustainability alone will justify the project to stakeholders. To achieve buy-in, the Panel recommends that the City identify the top three to five benefits of the project to use in messaging and branding.

The Panel recommends that the City continue to emphasize how the project will protect the Boise River by reducing discharges and protecting river water quality as a benefit and core message. Other examples of specific benefits that the City might cite include how the project will store water for the future or how the project will ultimately save ratepayer funds. These might not be messages the City will use but are examples of the level of precision and clarity that will improve public understanding.

Expand the stakeholder pool

The Panel notes that substantive partnerships with key stakeholders are absent: Important stakeholder groups that should be engaged early are the industrial users and Suez, the water provider. Engaging regulators early is also critical. These are high-priority stakeholders and strategic partners whose involvement and support are critical to advancing the recycled water program. The Panel recommends engaging with them as soon as possible.

The Panel recommends that the City expand and include a broader range of stakeholders as it develops the Program. It is important that stakeholders with a wide range of interests and areas of expertise are involved in an advisory capacity. Examples of stakeholders that the City needs to engage include:

- Water purveyors.
- Industrial water users.
- Groundwater users.
- Regulators.
- Public health/county officials.
- Homeowners' associations.
- Other community, environmental, and nonprofit groups.

The Panel notes that the Treasure Valley Water Atlas, an online resource created by Boise State University, may be a beneficial resource in identifying potential stakeholders and partners.

The current community engagement strategy has done an admirable job of engaging at the constituency level. But this is only one level of what should be a multi-tiered strategy. The City seems focused on outreach and education to the community; however, the public's support alone may not drive project success.

Build messaging for specific stakeholders

The Panel recommends that the City prioritize and customize engagement strategies for each stakeholder group to garner support and encourage collaboration.

There are examples of water reuse projects that have been hindered by different stakeholders having different roles and commitments within a one-water framework. The Panel recommends the City coordinate stakeholder roles and commitments, as much as possible, to ensure that all parties are working toward the long-term success of the water reuse project. Furthermore, coordinated teams of stakeholders can serve as project ambassadors to the communities they serve.

Continue outreach and engagement

The Panel recommends that the outreach described in the timeline continue beyond Phase 1. It is critically important that outreach and engagement continue through all phases of the project and into the future—even after the facility is operational.

Measure outreach results

The Panel recommends that the City develop metrics to evaluate the effectiveness of its outreach and to understand community support. The City needs to measure more than the number of people it reaches; it should measure data on behavior changes or knowledge gained as the project progresses. For example, some organizations give pre- and post-surveys to people on demonstration facility tours to determine if the tour changes their perception of recycled water quality. Others conduct regular community surveys and focus groups. These metrics will help the City in develop messaging and evaluate when buy-in is sufficient to move the project forward politically. Community plans and needs change over time, and these metrics can provide important feedback on community understanding and support for the program.

Develop a rapid-response protocol

The Panel recommends that the City consider developing a rapid-response protocol for the Recycled Water Program. A rapid-response protocol will help the City address and respond to public concerns or misinformation that is expressed on social media or during public events.

Other Communication Considerations

A different approach and level of community engagement and outreach is needed for aquifer recharge; the City does not need to skirt around potable reuse as a future use. The more that the City can do now to prepare its water users for indirect potable reuse (IPR), the more likelihood of success in the future. The Panel specifically recommends:

- Terminology should be specific and consistent when discussing IPR. Consider speaking about aquifer recharge as a way of banking water for the future, which aligns with the vision of resiliency and sustainability and implies that IPR may be implemented later. This direct, clear communication will also build additional trust and transparency between the City and residents.
- The potential aquifer recharge element brings new risks and opportunities where strategic partnerships will be important. For example, the project will need support from a suite of groundwater users in the Treasure Valley, many of whom have both legal and political standing around aquifer recharge.

- The City should anticipate areas of potential resistance. For example, one potential concern facing many communities is rapid population growth, which is a driver for water reuse projects. However, population growth is not always perceived positively by the community, so growth can become a barrier to water reuse. The City should continue to assess the community's perception of growth—and its implications for the proposed project—and factor that into the community engagement plan. The City may consider including this topic in the rapid response plan.

One potential communication disconnect is a reliance on activities that have been successful in other municipalities—beer and bottled water, for example—but that might not be relevant for this project. If the project produces water for industrial reuse, then the Panel recommends the community engagement plan should give examples of how the public will benefit from an industrial reuse project. In other words, it does not make sense to bottle and distribute drinking water if the final project is not for potable reuse.

Panel requests for clarification

The Panel had a number of questions for the City that were addressed in a letter provided by the City. To see the City's responses, see the letter in **Appendix F**.

- The City may have already completed a comprehensive alternatives evaluation but this work was not apparent from the pre-meeting review documents. It would help the Panel to see exactly how the City selected industrial reuse as the preferred alternative. In other words, was there sufficient quantitative evidence to eliminate the potential for potable reuse at one of the existing water renewal facilities, or was the industrial reuse option selected because it was the most acceptable to the public?
- The Panel would like to better understand stakeholder concerns about the proposed 2014 project and how that influences decision making by the City. Perhaps agricultural reuse is still a viable pathway forward with a more comprehensive and inclusive outreach and communication plan.

CE-3: Are there any best practices that have helped communities effectively engage their community in the early stages of recycled water programs that we ought to consider?

The City has already implemented a number of community engagement strategies that have been successful in other communities. The Panel supports the City's plan to use the pilot-scale system for public tours and outreach. This has been a highly successful approach for other benchmark water reuse projects, including the City of San Diego's Pure Water Program and the Padre Dam Municipal Water District's Advanced Water Purification Program. The

Metropolitan Water District of Southern California also operates a demonstration facility that is available for public tours.

In addition to giving the public an opportunity to see advanced treatment in action, the demonstration facility will generate high quality water, which will foster moral legitimacy for the project. Moral legitimacy occurs when stakeholders understand that project planners can be counted on to protect their interests and that they are fully competent and committed to doing so.

Another way to establish moral legitimacy is by describing similar successful projects. The Panel recommends that the City explore reuse projects that are similar to the proposed industrial focus. The City has identified water reuse projects within Idaho and the Orange County Groundwater Replenishment System as important case studies that will support public acceptance. Examples of other projects include:

- West Basin Municipal Water District's Edward C. Little Water Recycling Facility.
- Singapore's NEWater project.
- Reno-area discussions to convey municipal recycled water to a nearby industrial area (Tahoe-Reno Industrial Center or TRIC).

The Panel recommends the City consider building partnerships to leverage local expertise. This best practice offers opportunities to engage with local consultants, academics, regulators, and stakeholders in ongoing research efforts that will increase confidence in water recycling technology, the project's capacity to operate under normal conditions, and its ability to stay ahead of emerging challenges. Many successful reuse projects have pursued research funding to achieve this goal.

The strongest projects have involved close collaboration between industry and academia. In fact, collaborations between local consultants, academics, and utility staff have been critical to the development of water reuse regulations in California and Nevada. The City may also consider partnerships with local agencies such as Idaho Department of Environmental Quality (IDEQ), Idaho Department of Water Resources (IDWR), and United States Geological Survey (USGS). Introducing trusted community and non-proponent partners into the technical analysis reassures the public and regulators.

The Panel recommends the City develop a community engagement team that includes experts from a wide range of disciplines who can explain the project. For example, WateReuse Arizona brought together a team of experts that included engineers, academics, students, economists, psychologists, and educators. These experts offered a base of knowledge to convey complex engineering concepts and could respond to public concerns from a wide range of perspectives.

Regulatory Summary

RS-1: Does the current regulatory and permitting approach consider appropriate environmental and public health compliance for the envisioned Recycled Water Program?

The current IDAPA 58.01.17 regulations capture some of the proposed directions for the project (industrial reuse and spreading of recycled water for groundwater replenishment, for example). IDAPA 58.01.17 regulations do not explicitly permit direct well injection of Class A recycled water for aquifer recharge. For clarity, the Panel defines direct injection as application of the finished water into an aquifer without percolation through a vadose zone. Nevada's recent experience with expanding its recycled water regulations, which was informed by pilot-scale research, may be valuable to the City if it decides to pursue an option that is not specified in current regulations.

The Panel recommends that the City engage local regulators throughout the project to facilitate future regulatory changes. Regulator participation is common at expert panel meetings in California and appears to have helped facilitate implementation of some projects.

In general, the regulations are consistent with California's Title 22 framework for recycled water, although some areas are slightly less defined in Idaho. For example, groundwater replenishment systems in California and Nevada have specific overall log reduction value (LRV) target requirements for *Cryptosporidium*, *Giardia*, and viruses, and California also has a requirement for total organic carbon (TOC), among other criteria. Storage and travel time is an important consideration in the California framework for meeting virus LRV targets and leveraging the benefits of the environmental buffer for aquifer recharge. Even if the Idaho regulations do not specifically require these elements, it may be beneficial to use the expanded California criteria to evaluate the proposed aquifer recharge system.

At present, the project is described as "industrial discharge only, with no human sewage contribution." For aquifer recharge, the current treatment train may not include a sufficient level of treatment for pathogen removal/inactivation. The Panel recommends the City meet with IDEQ to determine if the proposed level of treatment is appropriate for aquifer recharge. Although the source water may contain lower concentrations of viruses, protozoa, and bacteria compared to typical domestic sewage, Idaho regulators may be very cautious and require a robust treatment approach for pathogen removal/inactivation, especially considering this would be the first permitted Class A recycled water aquifer recharge project in the state.

RS-2: Are there additional topics that should be considered as the Program begins?

The Panel feels it is necessary to engage more stakeholders and to understand their concerns before other topics can be identified. In addition, the Panel has other questions, which include:

- The Panel would like a clearer definition of treatment goals. What does the project consist of? Regulatory constraints will depend on treatment process details.
- The Panel would appreciate more well-defined objectives for aquifer recharge. For example, would the City recover the recycled water for a specific use? For example, is a project objective recovering a specific quantity of groundwater water by a water purveyor, such as Suez? This level of specificity will help drive the hydrogeologic and treatment technical workplans. If specific quantities of water would be extracted from the aquifer, what rules will govern this? Would Idaho Underground Injection Control (UIC) regulations apply? From discussion about the Snake River, it appears Idaho has aquifer storage and recovery (ASR) regulations, which may provide the regulatory framework for the City's aquifer recharge initiative if recovery or reuse of recharged water is a goal.
- The Panel cannot determine if the City would pursue aquifer recharge by infiltration basins, vadose zone wells, or direct deep well injection. While infiltration basins are effective in some areas, extensive hydrogeologic and geologic studies are needed. The Panel sees advantages to establishing specific goals, for example, to recharge the aquifer with recycled water for long-term storage and possible recovery. It's not clear that infiltration to the shallow aquifer would meet this objective. If the water is intended for deeper aquifer recharge, then advanced treatment and deep well direct injection may be necessary, which will result in far more complex treatment, operations, and permitting; however, it may be the best option for water rights, recovery, and long-term availability of the stored water.

The addition of aquifer injection dramatically expands the social, political, and legal challenges this project must overcome. Those challenges also represent real opportunities to build new relationships and partnerships that will ultimately benefit the City's future water security. The Treasure Valley aquifer is central to the extensive and complex managed hydrologic system.

There will be a long list of interested and influential stakeholders who want to be informed, want a specific outcome, want a seat at the table, and who have social, political, or legal standing. A successful plan will require an expansive collaborative approach.

Water Quality Summary

WQ-1: Based on our proposed source water and existing data, what additional testing/sampling would you recommend to ensure public/environmental safety?

The Panel recommends that the Project Team identify constituents that are commonly found in the industrial wastewater that will contribute to the proposed advanced treatment system. It is also important to seek close collaboration with industrial partners to identify chemicals that could potentially affect the treatment train.

One of the most important aspects of the early phase of this project will be fully characterizing feed water for expected contaminants, concentrations, and variability over time, as well as the water quality needs of the industrial users. The end users may be open to collaboration because they will receive high quality water. The City may also find that an alternative treatment train is better suited to the source water quality.

The proposed industrial reuse application appears to be novel in the sense that the feed water will be entirely industrial and the recycled water will return to the industrial users that generated the wastewater. It is, essentially, a closed-loop system. In such a small system, with such a limited number of contributing flows, there is potential for extremely variable feed water quality, which can pose challenges for treatment efficiency and ensuring compliance with water quality goals.

The current water quality monitoring plan is commendable because it casts a wide net to capture constituents that are likely to be detected in typical municipal reuse systems. However, given that this system is expected to be entirely industrial, the current target compound list may not be appropriate. For example, a pre-meeting review document heavily emphasized trace organic compounds that are typically observed in municipal wastewater, yet the proposed project is not expected to have a municipal wastewater contribution.

The municipal wastewater constituents, such as sucralose, may be valuable indicators in the future to ensure that the feed water is sourced entirely from industrial processes and there is no raw sewage contribution. However, it likely isn't necessary to focus on common municipal constituents.

After treatment, it is likely that aquifer recharge water will require conditioning that is substantively different from water for industrial reuse. For example, pH and total dissolved solids (TDS) may need to be adjusted.

The Panel notes that the scope of the water quality effort could be more expansive. The question of water quality sampling is important, but there is a lot more on this topic that will likely need to be addressed. The broader question should be what are the potential water quality challenges this project will face? The following are three examples:

- **What is the likely water quality characteristics of the influent water from the industrial partners to the treatment system?** What are the unique chemical/biological characteristics of the water? What challenges and opportunities do those characteristics pose to the project? How will that change over time, both within the natural cycle of the current industrial processes (hourly, daily, monthly, and yearly) but also as industrial partners change (over years and decades).
- **What are the desired water quality characteristics of effluent received by the industrial partners from the treatment system?** What are their minimum expectations now, and in the future, and what could bring value to them?
- **What are the desired water quality characteristics of the effluent from the treatment system for groundwater recharge?** The answer to this question remains highly uncertain and will likely evolve over time as understanding of the system improves. Triggering geogenic contamination in the aquifer is a very real risk, which can be substantially mitigated both theoretically and empirically as the program progresses.

Each of these three questions will inform sampling and monitoring approaches but—more importantly—may inform design criteria for both the treatment facility and the groundwater injection approach/technology. Depending on the final treatment train that is selected, there will be a suite of sampling and monitoring parameters to adopt. Sampling and monitoring programs used by other successful projects and the results of pilot testing will inform the Project Team's choices.

WQ-2: Are there any recommended modifications to the source water quality monitoring plan, such as frequency or other analytes?

Based on existing information, the Panel does not have specific feedback. The Panel may have comments once more information is developed and available.

The Panel recommends shifting focus to the effluent water quality coming from the industrial users to better understand treatment and monitoring needs. Potential downstream uses of the industrial effluent (recharge) might require additional on-site monitoring at each of the industrial effluent generators over time. Long-term water quality testing could be useful.

The Panel suggests that the City should conduct total nitrogen analysis instead of TKN and be open to expanding the monitoring program to include potential new constituents and not limit monitoring to typical programs used in the past. The City may also want to consider the following:

- In addition to understanding source water, carefully and regularly evaluate the water quality needs of the industrial user.
- The City should consider developing a source water quality monitoring plan that encompasses a wide range of sampling sources and contaminants to direct resources where they are most appropriate and create the best value/impact.
- Source control and effluent quality must be integral to an ongoing program, particularly as new industries are established in Boise.
- Sampling programs(s) should be carried out over extended time periods (two to three years), which can be concurrent with other program activities.
- The City should review programs in other communities that have a wide variety of industrial users and dischargers.

Preliminary Pilot Test Plan

PP-1: Does our proposed approach to pilot testing accomplish the following goals:

c. Evaluate treatment train performance for demonstration of program objectives for water quality and regulatory compliance.

d. Provide opportunities to engage and educate the public about water safety.

Panel responses are under PP-2.

PP-2: Are there any recommendations for additional evaluation or objectives for pilot testing?

The Panel suggests that the City should be prepared to extend the pilot test/demonstration phase beyond the proposed one-year timeline. The Project Team currently has an ambitious timeline for the pilot testing phase of the project. Inevitably, there will be delays due to maintenance, repairs, repeat experiments, and other factors., It is unlikely that all the proposed tasks will be completed within one year.

Beyond those constraints, there is tremendous value in operating the pilot beyond one year in terms of community engagement, workforce development, regulatory development and permitting, and even understanding seasonal changes in feed water quality and operational performance. Additionally, running the pilot for multiple years can provide data for community engagement and training.

One of the major challenges for this project is adhering to a fit-for-purpose model while maintaining flexibility to pursue the preferred industrial reuse option and the alternative aquifer recharge option. These options could potentially require very different treatment trains to achieve the necessary product water quality. The treatment train might not be the right one for the specific application/single user.

By continuing to allow for both options, the treatment train may ultimately be overdesigned, compromising the sustainability goals of the project. If possible, the City should select a single end use and design for the intended purpose. If flexibility is identified as the overarching goal, the proposed treatment train is a robust option with a long record of success and may be the best option. Another potential option is an effluent side stream that receives a different treatment approach. While not ideal, this could balance meeting the ultimate end use goals of the treated water while providing as much project flexibility as possible.

The City should consider to what degree the industrial user is responsible for their specific water quality needs. It may be beneficial for the City to deliver a very high-quality product water and anticipate/encourage end users provide supplemental treatment.

There is potentially a disconnect between the primary interest of the general public (i.e., protecting the Boise River) and the plan for handling the reverse osmosis (RO) concentrate. In one treatment configuration, chemical constituents (potentially per- and polyfluoroalkyl substances [PFAS]) will be concentrated in the RO brine, which will then be piped to one of the existing water renewal facilities that discharge to the Boise River. In effect, some of the more persistent compounds from the industrial wastewater will then wind up in the Boise River, which conflicts with the general public's goals.

The alternative treatment approach is to first adsorb these constituents onto granular activated carbon (GAC) before they reach the RO membranes. However, some of the target constituents may experience rapid breakthrough and necessitate frequent replacement/regeneration of the GAC. Therefore, RO with downstream GAC may still be preferred, but there may be a need to evaluate a more advanced approach for managing the RO concentrate (for example, zero liquid discharge).

Product water stabilization is a critical consideration, either for product water that will be piped to an end user for industrial reuse or recharged into an aquifer and potentially inducing undesired leaching of natural constituents. Product water stabilization should be integrated into the pilot-scale treatment system at some point in the project, along with additional research to evaluate the impacts of the final water quality on the distribution system or aquifer.

The role of the City relative to the industrial end users should be better characterized to ensure that the proposed treatment train is actually fit-for-purpose. Specifically, the City should determine whether an RO-based treatment train is actually warranted to achieve the desired water quality objectives. If the industrial stakeholders are accustomed to receiving local groundwater, those stakeholders might already have their own on-site advanced treatment system to generate water of sufficient quality for their process streams. In that case, RO may not be warranted for the City's treatment train, particularly since the TDS of the expected feedwater (580 mg/L) may already be lower than the desired TDS of some industrial end users (the 700 mg/L identified in Table 5 of the briefing document).

Even in the groundwater replenishment approach (assuming spreading), the TDS of non-RO-treated recycled water may be sufficient if the natural background level of the groundwater exceeds the standard of 500 mg/L. A non-RO-based treatment train would presumably be less costly and more sustainable while still achieving required water quality objectives. RO-based treatment may ultimately be the best option, but that is not yet clear at this stage, particularly since the feed water quality has not been fully characterized and the industrial partners have not been engaged in the process.

For Clarification

The Panel had a number of questions for the City that were addressed in a letter provided by the City. To see the City's responses, see the letter in **Appendix F**.

- Will the public be allowed to drink water from a demo facility?
- The Panel suggests the City refine its objective and timeline for the two main elements: industrial reuse and aquifer recharge.

Questions Posed by Public Participants

Question 1

If Boise moves to aquifer replenishment with recycled water, how can we be certain that this aquifer is isolated from the drinking water supply? If that is not possible, what regulatory standards in effect today for aquifer recharge anticipate the issues with PFAS and other recalcitrant contaminants that are known to travel to aquifers?

A system to isolate water is possible, but this may not represent an efficient use of recycled water for the region. For the aquifer recharge alternative, the City should plan on water being treated to a level that is consistent with the needs of indirect potable reuse. This water may be a valuable drinking water source in the future, and even if that is not the case, there is still the possibility that the recycled water will have some degree of beneficial influence on existing water supplies. Therefore, it is important to consider how emerging water quality issues (e.g., PFAS) may affect engineering and treatment decisions.

Currently, the US EPA has a drinking water health advisory of 70 ng/L for the combined concentration of PFOS and PFOA and some states have more stringent requirements. For example, California established response levels of 40/10 ng/L and notification levels of 6.5/5.1 ng/L for PFOS and PFOA, respectively. Massachusetts established a state maximum contaminant level (MCL) of 20 ng/L for the sum of six different PFAS compounds. But even the more comprehensive Massachusetts MCL does not capture the full suite of PFAS compounds known to occur in some water, wastewater, and recycled water supplies. Therefore, a robust monitoring plan is needed to address PFAS concerns, including establishing a baseline before the addition of recycled water, monitoring the feed and product water for any advanced treatment system, and then monitoring the groundwater over time.

One of the major benefits of the City’s proposed treatment approach, specifically the combination of reverse osmosis (RO) and granular activated carbon (GAC), is that these are best available control technologies for a wide variety of PFAS compounds. Therefore, the City is taking a proactive approach to addressing PFAS concerns in the event that groundwater replenishment is pursued in the future. However, it will be important to focus on emerging contaminants as more information becomes available or regulations change. The Orange County Water District’s Groundwater Replenishment System is a great example of how a utility has successfully worked with regulators to identify and respond to contaminants of emerging concern in recycled water.

Question 2

What are the regulatory standards in effect today re: aquifer recharge, PFAS, and recalcitrant constituents?

Water quality requirements for aquifer recharge can vary. For example, regulations may allow the recharge water quality to closely match the quality of the local groundwater. This is more applicable if the aquifer is impaired; for example, the background TDS is exceedingly high. If the aquifer is used for drinking water, Federal primary and State secondary drinking water standards will likely be applied, as well as specific pathogen limits for the recharge water. Additional site-specific, IDEQ, and local public health criteria may apply.

Water quantity regulatory requirements are important when considering aquifer recharge projects. IDWR should be consulted early to assist the City determine the regulatory framework for maintaining ownership and control of the recharged water. The Panel understands there are existing ASR projects in Idaho. If the City intends to recover the recharge water for future beneficial use, ASR may be a viable practice to investigate with the Idaho regulators. With respect to PFAS, groundwater standards are still being sorted out. It’s such a large group of compounds that the list of regulated compounds will be expanded.

Question 3

How would the Panel recommend evaluation of CECs in a permit requirement? In public reporting?

Most CECs are unregulated at both the federal and state levels, which generates uncertainty for many recycled water projects. In the absence of MCLs for individual CECs, many projects/regulators take a tiered approach to addressing the uncertainty surrounding CECs. For example, projects can maintain a robust water quality monitoring program that encompasses a wide range of CECs, with the target compound list evolving over time in response to the state of the science. Through historical monitoring, the project can identify any CECs that pose potential public health concerns based on ratios of observed concentrations to various public health/toxicological thresholds.

Finally, a project can implement a treatment-based approach in which a single or group of recalcitrant compounds must be reduced to a certain concentration or by a certain extent at a critical control point. For example, for full advanced treatment in California, the advanced oxidation process must achieve 0.5-log destruction of 1,4-dioxane. 1,4-dioxane also has a notification level that must be satisfied, but in this treatment context, the target compound serves as a surrogate for the various compounds that might persist through RO membranes. In any case, it is important to maintain full transparency by sharing all water quality data, even for target analytes that are unregulated, with critical parties (e.g., regulators) and the general public (e.g., through an online database or website).

Question 4

How should flexibility for state of the science be considered?

These types of projects have goals/objectives and regulatory requirements. Absent applicable regulations, the project proponent often has to conduct scientific studies and testing, in conjunction with stakeholders and other experts in a consensus-building framework.

The state of the science is always evolving, which is why it is critically important to make research a priority—either research conducted by the utility in question or utility participation in research conferences. In other words, a utility should not become complacent and must continue to follow the science as it progresses and be able and willing to make necessary process changes. Taking a proactive stance on science and R&D minimizes the likelihood that a utility will be caught off-guard by emerging concerns (e.g., PFAS). Many of the most successful recycled water systems have ultimately developed in-house R&D capabilities or have engaged partners to conduct research in a collaborative manner.

Question 5

What is important to measure with PFAS concerns?

There are about 18 compounds that are regularly monitored, yet there might be up to 9000 more that are not easily measured. Current EPA-approved testing methods fall short. The total methods may have greater value, such as Total Oxidizable Precursors Assay (TOPA) or Total Organic Fluorine (TOF). While they don’t give compound-specific concentrations, they tell much more about the amount of PFAS present. This is important as some PFAS are well removed by best available treatment (e.g., GAC) whereas some are not. Just measuring 18 compounds may not give an accurate picture of overall PFAS removal.

Question 6

What sampling points in the unit processes are the most important?

In general, monitoring is broken into two different groups: validation monitoring before/after a unit process to calculate the appropriate log reductions of a specific analyte and verification monitoring using online sensors to verify that a unit is on and operating correctly as designed. Engineering teams talk about Critical Control Points or CCPs, which are defined as points in the process where decisions can be made. CCPs signal if a process is meeting the required limits (log reduction values), which allows operators to decide where to send the water if log reduction goals aren’t met. In general, it will be important for the City to work with engineers to identify the treatment process that will generate the desired end water quality and then design a sampling plan that can be used to confirm the log reduction values as designed. Sampling plans will look different for the piloting stage of this project than they will for full scale. Ultimately, sampling plans help provide confidence in the engineering.

Question 7

Is the post-treatment step adequate to maintain water quality through distribution system?

End of the pipe post-treatment may be needed to assure a specific water quality for an industrial end-user or prior to aquifer recharge. For example, a Reno, Nevada, indirect potable reuse project for augmenting groundwater, includes end-of-pipe treatment provides additional treatment barriers to meet water quality criteria prior to injecting the advanced treated water directly to the groundwater aquifer. The City's treatment technology pilot testing program and aquifer recharge evaluations will inform if this specific program requires additional post-treatment to maintain water quality throughout the recycled water distribution system.

Question 8

Would Boise need to be prepared for challenges from water suppliers who might want to blame aquifer storage for difficulty meeting their regulatory requirements?

The regional water purveyor and domestic well owners must be engaged throughout any aquifer recharge initiatives and activities. Water quality monitoring, operator training, regular reporting, and regularly attending community meetings will help build trust and transparency. Including the water purveyors, domestic well users, and regulators early in the project process is beneficial. The Panel encourages the City to establish clear project objectives, transparent work plans, effective communication strategies, and establish partnerships with stakeholders.

Question 9

Should Boise be doing background monitoring of aquifer or Boise River to determine any impacts from other development in the region, to compare to aquifer augmentation?

It is important to monitor the system before and create models to predict future impacts. The City will need to track any changes that occur.

Question 10

How do you approach the treatment objectives and requirements for aquifer recharge, groundwater movement? How do you define the hydrogeological characteristics – travel

times, impact zones, etc.? And the kind of exploratory drilling or other factors that you should be considering while you're looking for a site.

For overall governance, IDWR and IDEQ will impose criteria on the project to protect water quality and public health. The process of gathering data is three steps: characterization, modeling, and pilot testing. The Project Team needs to understand the geology of the aquifer, the hydrogeology—how water moves, and hydrogeochemisty—the chemical characteristics of the groundwater. That information will form the basis for modeling different scenarios. Data from the modeling process then forms the basis for the pilot project.

The Panel recommends that the City establish clear objectives for the aquifer recharge program. Specific goals will drive the overall level of treatment. The aquifer characteristics and underground geology often determine if spreading basins or deep well direct aquifer injection is needed to transport the recycled water to its intended destination. For example, spreading basins may not have a direct hydraulic connection to a deeper aquifer. If the City has no intention to recover the water applied to a spreading basin, this could be an effective application. Whereas, if the City intends to store and recover the recycled water, then a direct aquifer injection method may be preferred.

The Panel recognizes the need for the City to better define the goals for the aquifer recharge program. With a better knowledge of the underground conditions and end-use objectives, the City will be in a better position to evaluate advanced treatment requirements. An example of state-specific criteria is that California has specific requirements for the length of storage/travel time that must be demonstrated for a groundwater replenishment project. This time is used as a means of awarding virus LRV credits, or even *Cryptosporidium*/*Giardia* credits in some scenarios, and it also ensures that the project is sufficiently leveraging the benefits of the environmental buffer, specifically in the context of response retention time.

The Treasure Valley (TV) Aquifer is the one of the best understood aquifers in the state. USGS is in process of developing a basin-scale, high-resolution, numerical flow model of the TV Aquifer. This model will likely be a useful tool for assessing the potential impacts of aquifer recharge plans.

Appendix A · About NWRI

For more than 20 years, NWRI—a science-based 501c3 nonprofit located in Fountain Valley, California—has sponsored projects and programs to improve water quality, protect public health and the environment, and create safe, new sources of water.

We assemble teams of scientific and technical experts that provide credible independent review of water projects, develop recommendations that support investment in water infrastructure and public health, and enable water resource management decisions grounded in science and best practices.

We have administered more than 50 panels and hundreds of panel meetings on topics that include water treatment and reuse infrastructure planning; design, commissioning, monitoring, and operations; groundwater quality and recharge management; surface water quality and reservoir design improvements; and a substantial and growing body of potable reuse policy guidance for states across the country.

We fund fellowships to support the water scientists of tomorrow, and we award the Clarke Prize, one of the world's leading water-industry prizes, to water scientists, researchers, and policy experts that are making a difference today.

About NWRI Panels

NWRI Independent Expert Advisory Panels are independent teams of internationally recognized experts that review challenging water resources management, policy, and investment issues. This process leads to decisions that are grounded in science and best practices. NWRI-facilitated panels serve cities, counties, special districts, joint powers agencies, regional and state agencies, nongovernmental organization partners, and private firms.

NWRI Panels consist of academics, industry professionals, government representatives, and independent consultants who are experts in their fields.

The NWRI Panel process provides numerous benefits, including:

- Third-party review and evaluation.
- Scientific and technical advice by leading experts.
- Assistance with challenging scientific questions and regulatory requirements.
- Validation of proposed project objectives.
- Increased credibility with stakeholders and the public.

- Support of sound public-policy decisions.

NWRI has extensive experience in developing, coordinating, facilitating, and managing expert Panels. Efforts include:

- Selecting individuals with the appropriate expertise, background, credibility, and level of commitment to serve as Panel members.
- Providing written report(s) prepared by the Panel that focus on findings and recommendations of various technical, scientific, and public health aspects of the project or study.

Many of our Panels have focused on projects or policies involving groundwater replenishment and potable (indirect and direct) reuse. Specifically, these Panels have provided peer review of a wide range of scientific and technical areas related to water quality and monitoring, constituents of emerging concern, treatment technologies and operations, public health, hydrogeology, water reuse criteria and regulatory requirements, and outreach, among others.

More information about the NWRI Independent Advisory Panel Program can be found on the NWRI website.

Appendix B · Panel Biographies

Panel Chair: Rick Warner, PE

President, Warner and Associates

Rick Warner, PE, is the founder and president of Warner and Associates, a company focused on bringing communities together to solve complex water challenges. As a passionate and recognized water leader, Rick has served in several national leadership positions, including as president of the Water Environment Federation and director for the Water Research Foundation. He has also traveled globally to share his expertise, insights, knowledge, and enthusiasm for water. Rick is a recipient of the National Advocacy Achievement Award from the WateReuse Association.

Warner has devoted his 35-year career to drinking water, wastewater treatment, and water recycling. His expertise includes policy development, strategic planning, design, project management, construction management, permitting, commissioning, and optimizing operations. In addition, he has essential experiences in non-potable reuse systems for municipal and industrial uses and is a Program Manager for OneWater Nevada, a regional sustainable water management initiative. Warner has a BS in Civil Engineering and an MS in Civil and Environmental Engineering from the University of Nevada, Reno.

Shawn Benner, PhD

Associate Dean in the College of Innovation and Design and the Director of the Human-Environment Systems Program, Boise State University.

Dr. Shawn Benner has more than 25 years' experience in the environmental field, with a disciplinary emphasis in the hydrologic sciences. He has published over 50 peer-reviewed articles and his work has been cited 6000 times. He has received funding in excess of 24 million dollars from competitive national funding agencies and works closely with local organizations to help solve challenges facing the community.

Dr. Benner was an active educator for 15 years, teaching undergraduate and graduate courses in hydrologic and environmental sciences. He is the founding Director of the Human-Environment Systems Program that strives to find collaborative solutions to our most difficult environmental challenges.

Benner has a BA in Geology from Colorado College, an MS in Geology from the University of Montana, and a PhD in Earth Sciences from the University of Waterloo.

Daniel Gerrity, PhD

Principal Research Scientist, Southern Nevada Water Authority

Daniel Gerrity is an expert in water and wastewater treatment technologies,particularly in using recycled water to augment drinking water supplies. His recent focus has been the sustainability of advanced treatment trains for potable reuse applications, including the life cycle costs and public health protection of indirect versus direct potable reuse. His research covers both chemical (e.g., trace organic compound attenuation through ozone-biofiltration) and microbiological issues (e.g., pathogen attenuation and quantitative microbial risk assessment).

He has experience as a consulting engineer, a research scientist, and an academic. From 2012-2019, Gerrity was on the faculty of the Department of Civil & Environmental Engineering and Construction at the University of Nevada Las Vegas. Currently, he is a Principal Research Scientist in Water Quality R&D at the Southern Nevada Water Authority, where he researches emerging microbiological issues relevant to the water industry. He has authored or co-authored more than 40 peer-reviewed articles and many textbook chapters, white papers, and reports. He received his BSE, MSE, and PhD in Civil and Environmental Engineering from Arizona State University.

David Reckhow, PhD

Research Professor, Department of Civil and Environmental Engineering, University of Massachusetts, Amherst

David Reckhow has been on the Faculty of the University of Massachusetts since 1985 and is currently research professor of Civil & Environmental Engineering. His teaching and research areas include general aquatic chemistry, chemical oxidation of organic compounds in water, coagulation processes, removal of chemical pollutants in water, and aquatic organic matter in natural systems and drinking waters.

Reckhow has recently served as Director of an EPA drinking water center, the Water Innovation Network for Sustainable Small Systems (WINSSS) and is Principal Investigator for many projects on natural organic matter and anthropogenic contaminants in water, including PFAS and disinfection byproducts.

Reckhow has a BS and MS in Civil Engineering from Tufts University and Stanford University, respectively. His PhD in Environmental Engineering is from University of North Carolina.

Channah M. Rock, PhD

Water Quality Extension Specialist and Professor, Department of Environmental Science, University of Arizona, Tucson

ChannahRock is a Water Quality Extension Specialist and Professor in the Department of Environmental Science at the University of Arizona.Her background in both microbiology and civil and environmental engineering has focused her work on better understanding how pathogens and indicators survive water treatment and what factors can affect their persistence in the environment.Her research interests include microbiology, parasitology, virology, molecular biology, wastewater, and biosolids.

Rock has a BS in Microbiology from New Mexico State University, and both an MS and PhD in Civil and Environmental Engineering from Arizona State University. Her post-doctoral research was at the US Department of Agriculture, Agricultural Research Service.

Rupam Soni, PE

Community Relations Manager, The Metropolitan Water District of Southern California

Rupam Soni is Community Relations Manager with The Metropolitan Water District of Southern California. She is a community liaison and engages the public for many Metropolitan facilities, initiatives, and infrastructure projects. Much of her work involves outreach for the Regional Recycled Water Program, Metropolitan’s first in-region water supply project. She is dedicated to making a difference in California’s water future through her work.

Rupam is an active member of the WateReuse Association and leads their Communications Collaborative Group. Rupam is also a member of the Board of Advisors for Grades of Green, an environmental nonprofit organization. Rupam has over 20 years of work experience in the water and wastewater industries. She is a registered Civil Engineer and has a BS from UCLA and an MS from UC Berkeley in Civil Engineering.

Appendix C · Meeting Agenda

NATIONAL WATER RESEARCH INSTITUTE

Independent Advisory Panel for the City of Boise Recycled Water Program

September 9, 2021

Meeting Location

University of Boise Idaho
Idaho Water Center Building
322 E. Front Street
Remote Access: See Outlook invitation

Contacts

Suzanne Sharkey: (949) 258.2093
Mary Collins: (206) 380.1930
Kevin Hardy: (760) 801.9111

Meeting Objectives

- Reflect on the framework, end water quality goals, and initial implementation approaches.
    - Vet program's potential scientific, technical, and policy concerns.
    - Inform pilot project design.
    - Recommend strategies to optimize the program implementation and operation.
- Provide time for the Panel to begin writing the draft recommendation report.

Time	Topic	Presenter
8:30 a.m.	Welcome, Introductions, Review Agenda and Panel Charge	Kevin M. Hardy, NWRI
8:45 a.m.	Overview of the City of Boise Recycled Water Program	Haley Falconer, City of Boise
9:15 a.m.	Community Engagement	Natlie Monro, City of Boise
9:45 a.m.	Regulatory Summary	Haley Falconer
10:15 a.m.	Break	
10:30 a.m.	Water Quality	Haley Falconer
11:00 a.m.	Preliminary Pilot Testing	Haley Falconer

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NWRI Panel for the City of Boise Recycled Water Program: Meeting 1 Agenda

11:30 a.m.	Break	
11:45 a.m.	Public Question Cards	Facilitated by Kevin Hardy
12:15 p.m.	Final Panel Questions	Facilitated by Kevin Hardy
12:30 p.m.	Panel-Only Working Lunch and Report Drafting Session	Facilitated by Panel Chair
2:00 p.m.	Adjourn	

Questions for the Panel

Community Engagement Plan

- Does the community engagement plan confirm the goals and objectives of the Recycled Water Program?
- Are there any recommendations for our outreach approach?
- Are there any best practices that have helped communities effectively engage their community in the early stages of recycled water programs that we ought to consider?

Regulatory Summary

- Does the current regulatory and permitting approach consider appropriate environmental and public health compliance for the envisioned Recycled Water Program?
- Are there additional topics that should be considered as the Program begins?

Water Quality Summary

- Based on our proposed source water and existing data, what additional testing/sampling would you recommend to ensure public/environmental safety?
- Are there any recommended modifications to the source water quality monitoring plan, such as frequency or other analytes?

Preliminary Pilot Test Plan

- Does our proposed approach to pilot testing accomplish the following goals:
    - Evaluate treatment train performance for demonstration of program objectives for water quality and regulatory compliance.
    - Provide opportunities to engage and educate the public about water safety.
- Are there any recommendations for additional evaluation or objectives for pilot testing?

National Water Research Institute 2

Appendix D · Meeting Attendees

Independent Advisory Panel Members

Chair: Rick Warner, PE

Shawn Benner, PhD

Daniel Gerrity, PhD

David Reckhow, PhD

Channah Rock, PhD

Rupam Soni, PE

City of Boise Staff and Consultants

Steve Burgos, City of Boise

Haley Falconer, City of Boise

Natalie Monro, City of Boise

Melanie Holmer, Brown and Caldwell

Emily O'Morrow, Brown and Caldwell

NWRI Staff

Kevin Hardy, Executive Director

Mary Collins, Communications Manager

Natalie Roberts, Project Assistant

Suzanne Sharkey, Project Manager

Appendix E · Harris-Lovett et al. (2015)

Environmental Science & Technology

Policy Analysis

pubs.acs.org/est

Beyond User Acceptance: A Legitimacy Framework for Potable Water Reuse in California

Sasha R. Harris-Lovett,*[†,‡] Christian Binz,[†,§,#] David L. Sedlak,[†,∥] Michael Kiparsky,[†,⊥] and Bernhard Truffer[†,§,∇]

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S *Supporting Information*

ABSTRACT: Water resource managers often tout the potential of potable water reuse to provide a reliable, local source of drinking water in water-scarce regions. Despite data documenting the ability of advanced treatment technologies to treat municipal wastewater effluent to meet existing drinking water quality standards, many utilities face skepticism from the public about potable water reuse. Prior research on this topic has mainly focused on marketing strategies for garnering public acceptance of the process. This study takes a broader perspective on the adoption of potable water reuse based on concepts of societal legitimacy, which is the generalized perception or assumption that a technology is desirable or appropriate within its social context. To assess why some potable reuse projects were successfully implemented while others faced fierce public opposition, we performed a series of 20 expert interviews and reviewed in-depth case studies from potable reuse projects in California. Results show that proponents of a legitimated potable water reuse project in Orange County, California engaged in a portfolio of strategies that addressed three main dimensions of legitimacy. In contrast, other proposed projects that faced extensive public opposition relied on a smaller set of legitimation strategies that focused near-exclusively on the development of robust water treatment technology. Widespread legitimation of potable water reuse projects, including direct potable water reuse, may require the establishment of a portfolio of standards, procedures, and possibly new institutions.

INTRODUCTION

Limited water resources and increasingly complex societal demands require water managers to develop innovative solutions to water challenges.[1] However, changing practices in the water sector is notoriously difficult because the social and institutional contexts, including the rules, norms, and conventions that govern decision-making, often hinder diffusion of innovative technologies or new systems of governance.[2] Water recycling, and in particular recycling for potable water reuse, illustrates the ways in which social and institutional concerns can affect technology adoption.[3,4] Potable water reuse is defined here as the practice of intentionally returning highly treated municipal wastewater to the public water supply.[5,6]

Some water resource managers and consulting engineers tout the potential of potable water reuse to provide a local, reliable water supply in water-scarce regions.[7−10] Potable water reuse can be less costly than alternatives, such as desalination or importing additional water, and can meet or exceed existing water quality standards.[5] However, these factors are not always sufficient for obtaining public support.[11] Proponents of potable water reuse have mainly framed this issue as one of a lack of public acceptance,[12−14] which can be defined as the public's passive acquiescence to the expert knowledge of water managers and engineers.[15]

Previous research has addressed the lack of public acceptance of potable water reuse[7,10−16] by focusing on the benefits of selecting positive terminology to describe the practice, development of communication strategies, characterization of populations that accept potable water reuse, and development of public education campaigns.[11,13,16−21] This research has yielded an improved

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understanding of the language and strategies for marketing potable water reuse. Nonetheless, in several high-profile cases, technologically sound potable reuse projects have floundered when actors outside of the control of the project's advocates used terminology that was unfavorable.[11]

Research based on public acceptance does not incorporate the full complexity of the issues surrounding new technology adoption,[22] and may overestimate the ability of project proponents to affect community support by targeting individual perceptions of water reuse.[23] Previous studies have shown that water authorities and developers tend to approach public acceptance by attempting to persuade the public to accept water reuse by providing more technical information. This occurs despite evidence that members of the public are interested in a broad range of information about the project including social and environmental costs and benefits, institutional structure, risk comparisons to other activities, regulatory systems, and analysis of alternative solutions.[24] Previous research suggests a public acceptance paradigm for understanding perceptions of potable water reuse is too narrowly framed, but stops short of proposing an empirically grounded, comprehensive framework.[15,25] Other scholars place a public acceptance mode of expert outreach for water management, in which experts choose what they perceive as the most desirable solution and convince the community of its relevance and importance, as a hallmark of an old paradigm of unsustainable water systems that is no longer useful in the twenty-first century.[26]

A more robust framework for engaging the public in issues of potable water reuse based on societal legitimacy[27] may address some of the shortcomings in public acceptance research. Legitimacy—a key concept in sociology and innovation studies—acknowledges that creating widespread trust in an innovation depends on strategies that not only target individual psychology, but that also address aggregate sectorial and societal rules, norms and conventions.[27−29] Sociology scholars define legitimacy as "a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions".[30] In its sociological definition, legitimacy can be assessed by the "taken-for-grantedness" of a particular technology, implementing organization, or process.[28]

Establishing legitimacy involves embedding a new technology in the shared social belief systems, moral standards and cultural conventions of a given group,[28,31,32] through a set of strategies that go beyond traditional public relations or educational outreach. Establishment of legitimacy may require the implementing organizations to undergo fundamental changes. Some of these changes may challenge the traditional authority of water providers, as they may require sharing power through collaborative decision-making and consideration of heterogeneous public values. Water utilities cannot build legitimacy for potable water reuse based on hollow promises. Superficial interventions undertaken to approximate the legitimacy framework presented in this paper and manipulate public perceptions of legitimacy will likely not create stable legitimacy, but rather foster mistrust in the management's true intentions. Because legitimation is a societal process, it is most stable when it is established in public discourse.

It is important to note that establishment of legitimacy for a particular technology, like potable reuse, may not be possible in places where the technology does not mesh with the values and social beliefs of a given community. A deeper understanding of legitimacy and the legitimation process can, however, help water engineers find solutions for water supply and wastewater disposal that are most appropriate for a given community. It can also help prevent investment in technological infrastructure that will encounter stark public opposition.

The case of potable water reuse in California illustrates the process of legitimation, which has relevance to a wide range of emerging environmental technologies. California has a long history of potable reuse,[33] from which we draw and examine examples of both successful and unsuccessful attempts to legitimize the practice. We extend the sociological definitions of legitimacy to include innovative technologies and the institutional systems surrounding them[27] and define a comprehensive analytical framework for the legitimation process of potable water reuse and innovations in general (see Table 1). The present paper complements another publication (Binz et al., submitted), which focuses on a detailed process account of technology legitimation in an innovation system context.[3]

■ ANALYTICAL FRAMEWORK FOR LEGITIMACY

Legitimacy is a multidimensional phenomenon that can be differentiated into several key types. Suchman's comprehensive framework (1995) divides legitimacy into three generic types: pragmatic, moral and cognitive,[28] which we term Type 1, Type 2, and Type 3 legitimacy, respectively. Each of these types can be further grouped into several distinct dimensions. Table 1 illustrates our application of legitimacy concepts to innovative technologies in general and potable reuse in particular.

Pragmatic Legitimacy (Type 1 Legitimacy) is based on the end user's self-interested calculations about the direct benefits that can be derived from the innovation.[28] Its first component, *exchange legitimacy*, is derived from the end user's perceived gain of a good or service from the innovation (e.g., support for a water reuse project based on the notion that adoption of the technology may provide a means for maintaining golf courses without restrictions on water use). The second component is *influence legitimacy,* which occurs when end users perceive an implementing organization to be responding directly to their personal interests[28] (e.g., support of a potable reuse project arising from the participation of community members on the project's advisory board). The third component, *dispositional legitimacy*, occurs when an innovation is managed by an established, trustworthy entity (e.g., faith in a water utility with a professional reputation to responsibly manage a potable reuse project).

Moral Legitimacy (Type 2 Legitimacy) is established when an innovation corresponds to societal values and broader societal welfare.[28] The first component, *consequential legitimacy,* occurs when proponents of an innovation demonstrate that it has a strong record of providing beneficial outcomes for society (e.g., support for potable water reuse systems that have operated for a long time without problems). The second component, *procedural legitimacy,* is defined by the quality and validity of the procedures and protocols used to implement the innovation (e.g., trust in potable water reuse systems based on end user's awareness of consistent, comprehensive water quality monitoring). The third dimension, *structural legitimacy,* is related to the physical attributes of the innovation that enhance its safety and reliability (e.g., endorsement of a reuse project based on the presence of a state-of-the-art water quality lab). The final component of Type 2 legitimacy, *personal legitimacy,* is related to the perceived trustworthiness and integrity of the implementing organization's leadership.

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Table 1. Definitions of Key Dimensions of Legitimacy and Corresponding Strategies in Potable Reuse (Source: Adapted from Suchman (1995))

legitimacy types	dimension	definition	legitimation strategies in potable water reuse
Type 1. pragmatic evaluation based on self- interest	1.1 exchange	support for an innovation based on its perceived value to the end user	public outreach campaigns, explaining the innovation's benefits to different users
	1.2 influence	support of an implementing organization because it shares decision-making power with end users	user involvement in planning and management, focus groups and surveys, user representatives on decision-making bodies
	1.3 dispositional	support for an implementing organization based on a belief that the organization is acting in the end user's best interest, has "good character"	transparent information policies, cooperation with external evaluators and regulators, developing a "quality brand" for the proponent utility
Type 2. moral evaluation based on norms/societal values	2.1 consequential	support based on evaluation of the implementing organization's accomplishments	publicizing data indicating consistently high water quality, building a success story about the innovation
	2.2 procedural	support based on an evaluation of the implementing organization's specific procedures	adopting strict quality control and monitoring procedures, standardized emergency intervention plans, and professional training for operators
	2.3 structural	support based on an evaluation of the implementing organization's physical characteristics	having advanced water treatment technology, water quality management department, 24/7 monitoring technology, and emergency shut-off valves
	2.4 personal	support based on an evaluation of an implementing manager's charisma	water utility managers talking directly to the end users
Type 3. cognitive evaluation based on deeply held customs and beliefs	3.1 comprehensibility	support because an innovation meshes with the end user's daily life experiences and cognitive frames	organizing water tastings, providing bottled recycled water, developing comprehensible vocabulary
	3.2 taken-for-grantedness	support based on seeming inevitability, in which alternatives are "unthinkable"	relating potable reuse to other taken-for-granted activities (e.g., recycling)

Cognitive Legitimacy (Type 3 Legitimacy) is not based on conscious evaluation, but rather on compliance with taken-for-granted routines and cultural beliefs ("the way we do things").[28,31] It includes two main components: The first, *comprehensibility*, occurs if an innovation fits into prevailing cultural assumptions and daily life habits of end users (e.g., support for bottled recycled water if it looks and tastes like established bottled water brands). The second component, *taken-for-grantedness*, occurs when the innovation meshes with end users' deep cognitive frames that are not consciously questioned (e.g., people familiar with solid waste recycling may think of potable water reuse as another desirable form of recycling).

An innovation is considered wholly legitimized when a majority of the population takes it for granted, and any opponents are no longer able to achieve a serious response from community members. Nonetheless, individual projects may lose credibility even after legitimacy is established for the sector if they do not continue to employ legitimation strategies for their specific project.[28]

Achieving legitimacy for new technologies requires development of all three types of legitimacy: if only Type 1 legitimacy is established, as is often done in acceptance-based public outreach campaigns, the project might be accepted temporarily, but legitimacy will likely erode when end users start questioning whether or not the Type 2-related procedures and institutional structures that support the innovation are legitimate. Similarly, if only Type 2 legitimacy is emphasized, the public may trust that the innovation is managed with competency, but end users may question the usefulness of the innovation to the community. Complete legitimacy thus requires a comprehensive portfolio of legitimation strategies that address each of these dimensions.

We hypothesized that the more complete the legitimation portfolio of a utility involved in potable water reuse projects, the more likely the project will be to avoid organized public opposition or rejection by the community. We assessed the legitimation portfolio of California's potable water reuse projects—and identified gaps therein—to provide insight into the ways in which communities support or reject technological innovation in the water sector.

■ MATERIALS AND METHODS

To address the legitimacy of potable water reuse we examined a case study of legitimated potable reuse, and compared it with cases of several other projects in which California water utilities failed to implement potable water reuse.

The Orange County Water District (OCWD), in Orange County, California, was chosen as a case of legitimate potable water reuse. The water district has practiced potable water reuse since 1976, when it began to inject highly treated municipal wastewater into the region's groundwater aquifer.[33−36] This system was expanded from 15 MGD (57 000 m^3/day) to 70 MGD (265 000 m^3/day) in 2008. The present advanced treatment system configuration, called the Groundwater Replenishment System (GWRS), sources municipal effluent from a nearby wastewater treatment plant, then uses microfiltration, reverse osmosis, and an advanced oxidation process to further treat the water. The treated water is then pumped into recharge basins and injection wells, where it mixes with local groundwater.[37] The GWRS contributes to drinking water supplies for more than 2 million people.[37] There has been no organized public opposition to GWRS (Interview 19). The GWRS is considered a best practice in the potable water reuse community and serves as the basis for the technological design of several other potable water reuse projects.[3]

Other cases considered include the Dublin-San Ramon Services District's proposed potable reuse project, which failed due to public opposition after the facility was built; San Diego's water recycling project, which the public vehemently opposed in the 1990s; and the Santa Clara Valley Water District's proposed potable water reuse project.

We conducted in-depth semistructured interviews with 20 key, expert stakeholders who were deeply involved with implementing potable water reuse in California (as well as nationally and globally). Interviewees included managers and executives of water and wastewater utilities, public relations consultants,

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regulators, academics, and engineering consultants. We used respondent-driven sampling techniques,[38] including snowball sampling,[39] to identify and interview the small group of people who have been most influential in the development of potable water reuse systems in California. We designed interview questions to elicit responses about the legitimation strategies applied in single projects as well as in the wider potable water reuse community (see Supporting Information, section 1). We transcribed interviews, then codified them using MaxQDA qualitative data analysis software and analyzed them for mentions or allusions to dimensions of legitimacy. We triangulated interview data with relevant reports and white papers, utility public outreach information, scientific publications, and newspaper articles (see Supporting Information, section 2). We grounded the case studies in historical research regarding local experiences with and attitudes toward water use and reuse. We used perspectives presented in local news articles and editorials as well as the presence or absence of organized public opposition groups as proxy measures for user opinion.[40] Both are standard proxy measures for user legitimacy in institutional sociology literature (see e.g., Geels and Verhees 2011).[41] Cases like San Diego where several end-user driven opposition groups and intense, controversial newspaper coverage emerged, indicate limited societal legitimacy. Cases like Orange County that never triggered organized public opposition and mostly positive newspaper coverage, would in turn indicate stable end user legitimacy. These measures were used because many of the cases occurred in the past, so it was not possible to interview users directly.

RESULTS

Orange County Water District's Potable Water Reuse Program. Since it began its first potable water reuse program in 1976, OCWD has employed a diverse portfolio of legitimation strategies. Some of these strategies were deliberate attempts to foster trust in potable reuse, while others emerged during the development of their potable water reuse system. Each dimension of the project's legitimation portfolio is summarized below and in Table 2.

Table 2. Summary of OCWD's Legitimacy Portfolio for Potable Reuse[a]

legitimacy type	dimension	strategies
Type 1: pragmatic	1.1 exchange	+ targeted outreach and education campaigns
	1.2 influence	+ elicited feedback from community leaders
	1.3 dispositional	+ demonstrated the utility's trustworthiness
Type 2: moral	2.1 consequential	+ consistent track record of high water quality
	2.2 procedural	+ emergency intervention and quality monitoring plans
	2.3 structural	+ state-of-the-art technology, sophisticated laboratory
	2.4 personal	+ management personally involved in outreach work
Type 3: cognitive	3.1 comprehensibility	+ serving visitors purified water from a tap
	3.2 taken-for grantedness	+ framing potable reuse as recycling, groundwater protection

[a]+ traits contributing to legitimacy portfolio, - traits detracting from legitimacy portfolio.

Type 1. Pragmatic Legitimacy. OCWD's management team invested considerable time and resources into explaining how potable water reuse was in the public's best interest (Interview 17), which resulted in the creation of *exchange legitimacy* for the GWRS. The utility targeted community and business group leaders within their 2.4 million customer service area and informed them about the benefits of the potable water reuse system in simple language (Interview 4) with more than 1200 presentations (Interview 19) that were translated in Spanish, Vietnamese, and Chinese (Interview 17). The talks were targeted to the interests of their specific audience, and emphasized the idea that the technology would guarantee a safe, reliable water supply into the future, which was a key interest of all inhabitants of Orange County (Interview 19).

> *"We would just go out and talk about what the water district does, what the need was for future needs. And how this project, the Groundwater Replenishment System, meets those needs." (Interview 17)*

OCWD established *influence legitimacy* by soliciting and accepting feedback from the public through citizen's advisory committees, focus groups and in discussions with community leaders (Interview 16). OCWD relied on the citizen's advisory committees to inform certain aspects of the project, including improvement of the project's outreach materials:

> *"We had a Citizens' Advisory Group, made up of community leaders… So all of these different groups were working together to make sure that needs were met, that we were on point, that we were spending money wisely, and that we were meeting the needs of the community." (Interview 17)*

While OCWD carefully planned the above legitimation strategies, others emerged as a result of the district's responses to technical challenges. In particular, in the year 2000, OCWD detected *N*-nitrosodimethylamine (NDMA), a potent carcinogen, in their treated water,[42] and realized that some of this compound had actually been created in their water treatment process. Though this situation could have threatened the legitimacy of OCWD's potable reuse efforts (Interview 6), the response of the utility to the incident ultimately enhanced its *dispositional legitimacy*: Instead of hiding the problem, the management decided to publicly disclose it, and proved to both regulators and the public that they were competent in dealing effectively with the contamination (Interview 5).

> *"We were actually causing the problem in the water we were injecting. Some of us on the water quality end of the business wanted to get answers to the problem. See what can we do to fix it, first. [The public relations specialist] said no, that we needed to talk to the public, we needed to actually call the media in and do press briefings… His instincts were right. If the media and the public perceive you as having nothing to hide, if you've got something that goes wrong, you're going to tell them about it. [...] I think that really earned us a lot of trust." (Interview 19)*

In a press conference, OCWD representatives explained what had happened and how they were working to address the problem. They also set the NDMA exposure in context by explaining how people are routinely exposed to the compound in food and beverages (Interview 17).

As a result of the utility's transparent communication strategy, the media described the story as a minor incident that was in the process of being fixed, rather than as a severe threat to public health. In describing the NDMA problem, the Los Angeles Times reported:

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"NDMA [...] is a ubiquitous chemical that occurs naturally, but also is a byproduct of chlorinating water supplies to disinfect them. It is found in rocket fuel, pesticides, lubricants, cosmetics, and all kinds of food, from bacon to beer and at far higher levels than turned up in local water tests… There is believed to be no threat to public health, district officials said."[43]

Overall, OCWD's Type 1 legitimation activities addressed all relevant subdimensions. They successfully educated people about the need for potable reuse and convinced them potable water reuse would meet their needs more effectively than the alternatives; they engaged community members in improving outreach by addressing public concerns about potable reuse; and they proved that the OCWD was transparent and proactively engaged in serving the public interest (Interview 2).

Type 2. Moral Legitimacy. Many of OCWD's activities promoted Type 2 legitimation by embedding potable water reuse into wider moral belief systems. First, OCWD used its long experience with potable water reuse (through injection of treated wastewater into the aquifer) and its reputation in the community to establish *consequential legitimacy,* or faith in the organization's capacity to responsibly conduct potable reuse (Interview 12). When the utility introduced plans to expand their potable reuse system in the late 1990s, they could show the public a three-decade-long track record of safe and reliable operations:

"[OCWD] already had that plant running, they were operating it, they were doing all the monitoring. They had developed a reputation. They developed the confidence of the community… Once they wanted to expand, they were expanding on a base of success and reputation." (Interview 20)

Regular testing for a suite of contaminants at OCWD also became an important element of creating *procedural legitimacy*. When confronted with a complex, new technology the public often forms opinions about it by asking whether the organization running it is applying the right procedures to guarantee safety.[28] OCWD was addressing this issue by establishing strict water quality testing procedures and monitoring for 335 chemicals, instead of just the 122 compounds required of them by the regulator.[44]

In addition, OCWD developed standard operating procedures for their water reuse system. They established protocols for routine operating conditions and in the event of an upset and explained these to end users in tours (Interview 1). In addition to providing clarity to the plant's operators, this further improved *procedural legitimacy* of the organization.

Third, OCWD consistently emphasized that it had the right physical infrastructure in place to guarantee safe operations (*structural legitimacy*). Other professionals were impressed with how the utility maintained cutting-edge technologies for water treatment and source control, employed more than 200 staff, operated 24/7 and built a state-of-the-art water quality laboratory directly on-site (Interviews 1, 2, 15). Interviews reveal the existence of a lab inside the utility was effective in signaling structural legitimacy to the general public (Interview 17).

OCWD's management staff also reinforced *personal legitimacy* by personally speaking to the public in outreach campaigns:

"It wasn't the consultants who did the speeches. It was staff or board members. We found that the people, the general public, gravitate much more to the personal touch, when it's someone actually affiliated with the project." (Interview 19)

In doing so, OCWD managers established themselves with members of the public as trustworthy and competent experts (Interview 16) who could handle the complex water reuse system.

Type 3. Cognitive Legitimacy. OCWD worked to deliberately establish Type 3 legitimacy. OCWD's choice of name for their potable water reuse technology, the "Groundwater Replenishment System," made the public associate what the utility was doing with Orange County's half-century-long practice of augmenting groundwater with fresh water in order to prevent saltwater intrusion into the aquifer, rather than with a new, unfamiliar technology (Interview 12). The name "Groundwater Replenishment System" had positive cognates to protecting groundwater from contamination and ensuring a safe water supply, and was a familiar reference to end users, thus improving the *comprehensibility* of the project. West Basin Water District also adopted this strategy to enhance comprehensibility, calling the agency that injected recycled water back into the aquifer the "Water Replenishment District" (Interview 4).

Second, OCWD tried to mesh the idea of potable water reuse with frames[45] that were *taken-for-granted* by their constituents. Use of the term "water recycling" exemplified this effort; framing the GWRS as potable "reuse" and water "recycling" (Interview 4) allowed OCWD to enlist the support of environmentalists who were favorably disposed toward recycling in general:

"The first groups to be supportive were environmental groups. I think they saw recycling as just making good environmental ethical sense, so they were supportive early on." (Interview 19)

As a result of these comprehensive efforts, potable water reuse reached a level of legitimacy in Orange County that made it improbable that voices of opposition would gain traction within the community.[3] Available evidence suggests that local media is not particularly interested in the OCWD's water reuse project anymore because it has become routine (Interviews 19, 20).

OCWD is one of a limited number of utilities that have successfully introduced potable water reuse. Other utilities that have achieved a similar level of legitimacy include the West Basin Municipal Water District and Inland Empire Utilities Agency.[5] When managers of West Basin Municipal Water District began their potable water reuse project, they mimicked both OCWD's technology and outreach approach, which they institutionalized by hiring some of OCWD's experienced personnel (Interviews 4, 10).

Legitimation Portfolio of Other Utilities in California's Water Reuse Sector. Despite the legitimacy of the potable reuse projects in Orange County, West Basin, and the Inland Empire, public opposition has halted similar projects at the Upper San Gabriel Water District, the City of San Diego, Dublin-San Ramon Services District (DSRSD), and the City of Los Angeles. In response to these failed projects, an advocacy coalition of utilities, consulting engineering firms, academia and NGOs has emerged to work toward legitimizing potable water reuse in general.[3,46] Internal networks like the WateReuse Association and the National Water Research Institute[3] increasingly coordinate legitimation strategies and recently began lobbying the state government to streamline the implementation of direct potable water reuse policies (i.e., potable water reuse without an intervening natural barrier like an aquifer or a lake).[47] The process is described in more detail in another publication.[3] In the following section, we use the legitimacy framework to analyze the legitimation strategies that have been used by failed potable reuse projects as well as by the coalition of proponents of potable water reuse.

Type 1. Pragmatic Legitimacy. The cases of several proposed potable reuse projects that were halted by public opposition

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in the 1990s show that a lack of *exchange legitimacy* can spur public resistance to potable water reuse (Interviews 7, 20). An illustrative example is a potable reuse system in Dublin−San Ramon Services District (DSRSD) that was halted by public opposition. In retrospect, experts close to the project believed that DSRSD's board made a mistake by advertising their potable reuse project as a wastewater management strategy, rather than as an improvement in drinking water supply (Interviews 12, 20). The result was a lack of exchange legitimacy for water users—only wastewater managers, and not the general public, could see a direct benefit from the potable water reuse system.

In addition, what water managers touted as a benefit of the recycled water in the Dublin−San Ramon area—that it would enable economic growth and suburban development, an argument that seemed to have worked in Orange County—was not favorably received in the Northern California social context (Interview 20). Public opposition quickly emerged in the Dublin−San Ramon area as groups questioned whether there was an actual need to make the public "drink wastewater". A local newspaper, the Pleasanton Weekly, reported:

> *"DSRSD representatives said they need to have a way to dispose of treated wastewater if and when it exceeds the capacity of the LAVWMA pipeline. "We're not in love with injection," said DSRSD board director Georgean Vonheeder-Leopold, "It's just that it makes the most sense… and it's economical that way. We just don't want to put it in the creek or irrigate with it."*[48]

Potable water reuse advocacy coalitions subsequently funded several research projects on ways to improve exchange legitimacy for potable reuse (Interview 7).[49] Research results suggested that framing planned potable reuse as an improvement over existing water supplies, many of which employ de facto reuse (i.e., a practice in which water from a municipal wastewater treatment plant discharges into a river or lake that is used as the drinking water source for a downstream community)[5] was an effective means of increasing exchange legitimacy and public support.[46,50] In conjunction with the research projects, the WateReuse Association created an educational video, called "Downstream," to explain de facto water reuse and try to create exchange legitimacy for the broader potable water reuse sector.[50,51]

Some water agencies have begun to integrate elements of *influence legitimacy* into outreach campaigns. Recent potable water reuse projects in West Basin, San Diego, and Santa Clara employed focus groups to address public concerns (Interview 4). Despite these efforts, many water utilities only allow limited public involvement in planning and decision-making. Water managers often lack a commitment to implementing suggestions raised by focus group participants (Interview 7), effectively negating their efforts to establish influence legitimacy for potable reuse projects.

> *"[Water utility managers] talk about public involvement. They don't really want involvement, because they know what they want to do, and they want to just go do it and want everybody to like it." (Interview 16)*

Many water utilities also did not focus on *dispositional legitimacy* as part of their legitimation strategy. For example, opposition to Dublin−San Ramon Services District's proposed potable reuse project cited a lack of trust in the organization's integrity and the utility's "maverick" reputation, which stemmed from its perceived support of a controversial suburban expansion project (Interview 20). A passionate editorial in the local newspaper about the ballot measure to implement potable reuse further demonstrates this lack of trust in the utility:

> *"Why would we trust the stewardship of our most precious resource to a sewer company?… The proponents of this measure have intentionally tried to mislead the public into thinking this is a vote for recycling. Their slick propaganda campaign has been less than straightforward… Why would we trust them to be forthcoming if an accident or human error occurred that permanently contaminated our groundwater basin?"*[52]

To address the poor image of water and wastewater utilities like DSRSD, advocates for potable water reuse in Southern California began collaborating to improve water and wastewater agencies' reputation, and thereby their *dispositional legitimacy*, by creating a "utility branding network" in 2007.[53] The network's activities focused on competitive branding strategies at the regional potable water reuse sector-wide scale[54] in an attempt to show utilities how to avoid the type of resistance which DSRSD met. Building trust in a utility is a long-term process and it is difficult to assess whether the utility branding network has improved dispositional legitimacy for water and wastewater utilities in California.

Type 2. Moral Legitimacy. Several projects with long-term track records like Orange County and West Basin have shown that potable reuse systems can be operated to meet water quality regulations and provide benefits in terms of water supply and wastewater disposal to communities, resulting in *consequential legitimacy*. Proponents of water reuse often reference these examples. However, existing water reuse advocacy coalitions and many water and wastewater utilities in California did not emphasize other key dimensions of Type 2 legitimacy.

Procedural Legitimacy is a case in point: Water utility managers and consultants have invested in research and development related to the operation of specific engineered treatment trains, but few resources have been devoted to developing sector-wide procedures to ensure safe water reuse operations. Experts within the potable water reuse sector have identified the need for a number of sector-wide procedural standards,[55] including regulatory oversight,[56] operator training (Interview 1), source control (Interview 4), and emergency procedures (Interview 5). Currently, responsibility for developing these procedures falls on individual water utility managers on an ad-hoc basis (Interviews 6, 14). To address this apparent shortcoming, the WateReuse Foundation has recently initiated a project to develop training and certification schemes for utilities that run direct potable reuse plants.[46,47,57] The development and diffusion of such standards may improve procedural legitimacy for potable water reuse.

Structural Legitimacy, in contrast, has recently become a strong current focus of the potable water reuse community. Experts in academia, engineering consulting groups, and industry have been working to develop cutting-edge technologies to improve treatment processes, monitor systems online, or engineer buffers that extend response time in case of system failures.[12,46,47,58−60] Currently, no clear structural standards exist for potable reuse systems. Due to the lack of public opposition to its project, OCWD's treatment train for potable reuse has developed into an unofficial sector-wide best practice (Interview 1), which has been replicated in several new projects.

Personal Legitimacy, finally, was not an important element in many contentious potable reuse projects. In some cases, the managers of the utility lacked the public speaking experience or interest in serving as public communicators about potable reuse (Interview 16). In an attempt to get charismatic leaders to speak publicly about potable reuse projects, some utilities attempted to enlist local politicians to speak in support (Interview 8)—yet this

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strategy sometimes backfired when politicians neared the ends of their terms and actively tried to garner votes by appealing to public sentiments against potable reuse (Interview 18).

Type 3. Cognitive Legitimacy. Following public opposition to potable reuse projects in the 1990s, advocacy coalitions for potable reuse have begun to address *comprehensibility* by improving education activities and adapting them to different audiences (Interview 7). Some water agencies strategically dispatched people to conduct outreach programs whose racial background matched that of the communities they spoke with

"There are [utilities] who hire a Latino consultant to work with the Latino community, hire an Asian-American consultant to work with the Asian-American community, hire an African-American consultant, because then people are hearing this from people who look like them, who've had similar experiences." (Interview 16)

Advocates for potable water reuse also developed vocabulary and imagery that related potable reuse to positively connote cognitive frames like "recycling", and attempted to standardize these terms across engineers and utilities advocating for potable reuse (Interview 7).[14] While environmentalists tend to oppose desalination projects,[61] in part because of a perception that creating new water sources in arid regions will encourage growth in areas that ecologically cannot support an increasingly large population, they tend to support water recycling because it ties in with their ideals of living in closed-loop systems—though potable water reuse projects also effectively create a new water source that could have the same growth effect in water-scarce regions (Interview 11).

In addition, the WateReuse Foundation employed surveys and focus groups to understand which vocabulary words and images would resonate well with cognitive frames of water users. They found that wording related to the origin of the water (i.e., wastewater, sewage, treated wastewater) resonated poorly, whereas terms that emphasize the high quality of the produced water (e.g., purified water) were more acceptable.[14] However, proponents of potable reuse at different water utilities continue to use a variety of terms to describe the practice (Interviews 7, 11).

Most potable water reuse projects in California have not reached a *taken-for-granted* level of legitimacy. Advocacy coalitions for potable water reuse have begun to implicitly address this issue, mainly through describing potable water reuse as part of the natural water cycle (Interview 7), and by framing potable reuse as "water recycling," which associates the practice with the taken-for-granted frame of converting something used into something new and fresh. See Table 3.

Table 3. Legitimation Portfolio of Other California Potable Reuse Projects[a]

legitimacy	dimension	examples
Type 1: pragmatic	1.1 exchange	+ outreach campaigns to establish controlled potable reuse as an improvement over *de facto reuse*
	1.2 influence	± weak public involvement in planning and decision-making about potable reuse
	1.3 dispositional	− little proof of the sector's "good character", despite branding efforts
Type 2: moral	2.1 consequential	+ successful track record with indirect potable reuse systems in some places
	2.2 procedural	− incomplete procedural standards for water reuse plants
	2.3 structural	+ research on infrastructure and technology development
	2.4 personal	± few knowledgeable spokespersons for potable reuse
Type 3: cognitive	3.1 comprehensibility	+ development of vocabulary that meshes with cognitive frames
		− inconsistent use of terminology
	3.2 taken-for-grantedness	± relating potable reuse to the water cycle

[a]+ Traits contributing to legitimacy portfolio, − traits detracting from legitimacy portfolio.

■ DISCUSSION

Several key observations stand out when comparing legitimacy of potable water reuse at OWCD and other potable water reuse projects in California. First, a legitimacy framework for assessing potable water reuse projects, in combination with an understanding of the history and values of local residents in the project area, appears to be useful in explaining adoption of potable water reuse. OCWD's success in establishing legitimacy for potable water reuse cannot be ascribed purely to its innovative technological approach or to its constituents' passive acceptance of expert opinion. OCWD employed a comprehensive portfolio of legitimation strategies both deliberately and by chance, which fostered public trust in the utility and in the practice of potable reuse.

When the practice of potable water reuse began to spread beyond OCWD, many engineers assumed building structurally sound treatment and monitoring systems would suffice for establishing public trust in potable reuse. This approach did create structural legitimacy, but this attribute could not compensate for other shortcomings in the legitimacy portfolio such as the lack of community representation in decision-making and the lack of trust in the utility's ability to manage risk. These experiences show that potable reuse projects seeking societal legitimacy cannot establish it by simply copying the treatment train from OCWD; they must also adopt a comprehensive legitimation portfolio approach.

In contrast to OCWD, many other potable water reuse projects in California have had substantial gaps in their legitimation portfolios. Overall, proponents of potable reuse have often categorized opposition to potable water reuse in a narrow technology-focused and social-marketing-based "public acceptance" paradigm. Important gaps in the legitimation portfolio occur if this paradigm is used—dispositional and procedural legitimacy, and to a lesser degree influence and personal legitimacy, are usually absent. Sociological theory and our interviewees identified the importance of covering these dimensions if potable reuse is to attain a "taken-for-granted" level of legitimacy. This need becomes even more pertinent when considering the recent advocacy efforts for direct potable reuse, which is likely to provoke wider attention and therefore additional questions on whether the current industry is "right for the job."

For potable water reuse to be legitimate, potable water reuse projects must demonstrate how they will benefit the end users of the water (*exchange legitimacy*), strengthen public involvement in planning and decision-making (*influence legitimacy*), incorporate transparent communication procedures and develop an organizational reputation for high quality (*dispositional legitimacy*), and have reliable risk management procedures and emergency intervention procedures in place (*procedural legitimacy*). The legitimacy portfolio also requires involvement

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of experienced utility managers in public outreach (*personal legitimacy*) and relation of potable reuse to established social practices (*taken-for-grantedness*).

The current lack of standardized operational procedures for potable water reuse systems is especially striking. Training and certification programs specific to potable water reuse operators, with creation of a sector-wide standard, could be useful for establishing *procedural legitimacy*. A promising strategy might be to emulate risk management and emergency procedures from similar low-probability, high-consequence industries like aviation. The oversight of an independent, possibly governmental organization to investigate system failures, similar to the Federal Aviation Administration and the National Transportation Safety Board, could be beneficial for establishing procedural legitimacy. This would make the innovation more understandable by relating it to standards and procedures that have already gained legitimacy in other established sectors.

The legitimacy portfolio perspective presented in this paper is relevant beyond the California potable water reuse case. It can be applied to potable reuse systems worldwide, to other innovations in the water sector (e.g., point-of-use treatment or on-site water recycling) or potentially to innovation in other sectors, like energy or transportation. Our findings suggest that establishment of legitimacy for an innovation like potable water reuse relies upon a balanced and comprehensive portfolio of strategies that address all three types of legitimacy. These legitimation strategies include elements like collaborative public engagement in planning and decision-making, which are outside the realm of the "public acceptance" paradigm traditionally employed in water projects. A fourth type of legitimacy, regulatory legitimacy,[31] has not been explicitly separated in this research from the other three types. The role of regulatory legitimacy in potable water reuse merits future research.

These findings do not imply that there will never be opposition to potable water reuse projects if all legitimacy dimensions are addressed. In fact, potable water reuse may turn out not to be legitimate in some communities, especially if it does not satisfy the community's criteria for meeting all three aspects of legitimacy, and other options for water supply and/or wastewater disposal may be more appropriate. Rather, the broader the legitimacy portfolio, the lower the probability that potable water reuse projects will move forward to a level of financial investment in physical infrastructure in places where opposition to the project will prevent it from coming to fruition. These results also show that many dimensions of legitimacy cannot be created by changes in vocabulary or promotional campaigns alone, which are hallmarks of marketing in a public acceptance paradigm. Establishing legitimacy may require wide-ranging structural, procedural or institutional changes, which ideally emulate prelegitimized practices from other sectors.

It is important to note that ideas of legitimacy are culturally specific. What constitutes exchange legitimacy in one place may not be considered valid elsewhere. For example, having more water to enable suburban growth was legitimate in southern California but it helped create opposition to the Dublin San Ramon water reuse project in northern California. Also, this analysis focused on legitimacy among members of the general public, mainly in an attempt to complement existing acceptance studies. Legitimation strategies to engage other groups (e.g., politicians, regulators or experts) might be equally important and should be addressed in future studies. Future research to survey potential potable water reuse users with regard to pragmatic, moral, and cognitive legitimacy in contemporary cases of utilities considering implementation of potable water reuse would be useful to supplement the historical perspective given here. Finally, the present case studies should be complemented with research in other sectors like energy or transportation to improve the concept's generalizability.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge on the ACS Publications website at DOI: 10.1021/acs.est.5b00504.

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Notes

The authors declare the following competing financial interest(s): The authors of this paper are affiliated with the Engineering Research Center for Re-Inventing the Nation's Urban Water Infrastructure (ReNUWIt), which has an Industrial Advisory Board that provides advice on strategic research direction and includes organizations represented by interviewees in the study. ReNUWIt also receives membership funding (between $2,000 and $25,000 per year) from all Industrial Advisory Board members, including organizations represented by interviewees in the study. One of the authors of this paper (D.L.S.) was awarded a $50,000 honorarium for receiving the Clarke Prize in 2014 by the National Water Research Institute, one of the interview partners in the study.

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Appendix F · NWRI Response Letter

PUBLIC WORKS DEPARTMENT
MAYOR: Lauren McLean | DIRECTOR: Stephan Burgos

November 12, 2021

NWRI Response Letter

NWRI Independent Advisory Panel
c/o Suzanne Sharkey
18700 Ward Street
Fountain Valley, CA 92708

Dear NWRI Independent Advisory Panel,

Thank you for providing summary recommendations for the City of Boise Recycled Water Program based on the Independent Advisory Panel Meeting on September 9, 2021. Please find below clarifying comments and responses to questions from the panel.

The City of Boise Recycled Water Program (Program) is built on direction-setting input from community engagement through the multi-year utility planning effort. The effort culminated in a multi-faceted approach to improving water quality in the Boise River, balancing needed system improvements and affordability, and providing long-term water resiliency. A crucial part of Water Renewal Utility Plan (Utility Plan) included the beneficial use of recycled water through industrial reuse and aquifer recharge. The direction established in the Utility Plan was unanimously approved by Boise's City Council in 2020. While the Program is in its early development, it will align with the goals and objectives identified through the utility planning process. The city appreciates the panel's perspective on the preferred end uses of recycled water. The end uses discussed during the panel are in alignment with the Utility Plan and meet community expectations.

Additionally, the city submitted the NWRI Briefing Packet in advance of the Independent Advisory Panel Meeting which included multiple detailed appendices. Some of the questions posed by the Panel in the report were addressed in the Briefing Packet. Please let the city know if there are specific areas that were not clear or did not have substantial detail to answer those questions. The NWRI Panel requested additional information through specific panel requests for clarification. The city offers the following responses to these requests.

BOISE CITY HALL: 150 N. Capitol Boulevard | MAIL: P.O. Box 500, Boise, Idaho 83701-0500 | P: 208-608-7150 | F: 208-384-3905 | TDD/TTY: 800-377-3529

CITYOFBOISE.ORG/PUBLICWORKS

Public Engagement: Request to explain alternatives evaluation work performed to identify end use objectives through Utility Plan.

Water Renewal Utility Plan Section 3: Water Products, and specifically Section 3.2.1 Alternative Assessment, describe the alternatives evaluation process conducted with community stakeholders during utility planning.

Public Engagement: Request for more information related to concerns raised about the potential 2014 Farmer's Union Canal Project and how that influences decision making by the city.

The city initially considered recycled water as a means to meet stringent in-stream temperature requirements for the Boise River. Seeing an opportunity to both improve the Boise River and enhance local water supplies, the city considered an initial concept to produce recycled water at our Lander Street facility and discharge it to an irrigation canal. A contract with Farmers Union Ditch Company was signed and approved through Council in 2014 and initial conversations surrounding permitting for this concept were pursued without engaging the community on the concept. The city recognizes trust was not built through this process and led to the city halting consideration of this concept. There is no further activity happening on this project and the city has issued notice of termination of the contract with the irrigation district. If the city were to consider this option again in the future, we have committed to a robust and transparent community engagement process.

Moving forward, the city and the Recycled Water Program aim to put transparency at the forefront of Program development. The Program aims to prioritize community input and the best available science, both now and in the future, to create a Program that reflects the values of the community.

Preliminary Pilot Test Plan: Request to address if public will be able to drink water from the pilot demonstration facility.

Drinking from the final demonstration facility has been considered, however no final decision has been made. If implemented this would be conducted toward the end of the pilot timeframe, or if the pilot duration is extended, after the initial year of pilot data has been collected and primary pilot goals have been reached. It would also require additional permitting. Delay of this decision will allow the city to develop thorough characterization of the recycled water produced and implement additional treatment requirements that may be identified by the Idaho Department of Environmental Quality (IDEQ) governing a potential tasting station at the pilot facility, such as additional primary disinfection and granular activated carbon. The decision to produce drinking water will also consider the degree to which drinking water ties to the end uses of our recycled water program. While we are not planning a direct potable reuse program, the uses we are considering could potentially impact drinking water supplies.

Preliminary Pilot Test Plan: Request to refine objectives and timeline for industrial reuse and aquifer recharge.

In response to community expectations, the Program was established in part to enhance water resiliency for the community by recycling water within the City of Boise service area. It was also important to our community to provide flexibility in the Program to adapt to changing conditions and expectations.

The community indicated preference for increasing water supply in the aquifer because water supply in the aquifer already provides broad community benefit. Currently, the aquifer is used for a range of uses including agricultural irrigation and to augment drinking water supplies. Diversifying water supply sources for industry relieves pressure on potable water supply sources used for non-drinking water demand.

The Utility Plan, and accompanying Recycled Water Master Plan (included in pre-meeting review materials), help the city meet the following level of service goals:

- Help sustain the Lower Boise River's quality to support multiple community uses
- Support a robust, vibrant economy consistent with the city's visions.
- Protect the health and safety of our community and staff
- Recover, recycle, and renew water, energy, and other products from the materials we receive
- Operate cost-effectively and maintain a resilient utility
- Develop partnerships to effectively solve community issues
- Attract and retain engaged, thriving employees
- Provide high-quality customer service

The Recycled Water Program development aims to maintain alignment with these outcomes established through the Utility Plan. This direction is also in alignment with state priorities established in the last decade. One example of this synergy with state goals is found in the Idaho State Water Plan (ISWP). The ISWP identifies aquifer stabilization as a statewide priority to be accomplished, in part, by managed aquifer recharge. The ISWP states that aquifer recharge should be promoted and encouraged to; 1) enhance ground and surface water supplies, 2) optimize existing water supplies by changing timing and availability of water supply to meet demand, and 3) employ adaptive mechanisms to minimize the impacts in variability of climate conditions. In addition, the ISWP outlines continued evaluation of additional strategies to enhance Domestic, Commercial, Municipal, and Industrial water that includes aquifer storage and water reuse (IDWR, 2012).

The panel also requested clarification of eventual water recovery from the aquifer on page 16 of the Draft NWRI Report PDF. The city is considering water quality objectives required for current groundwater uses within the basin, which range from irrigation to domestic and municipal wells. The city requests recommendations and input from the panel on water quality and treatment to potentially meet that range of future end uses. Community and stakeholder engagement concerning when and how water is extracted is ongoing and will require further focus on water rights.

With respect to infiltration basins or injection, the Program intends to conduct detailed hydrogeologic characterization to identify the aquifer recharge location(s) and method(s). The evaluation will utilize a tiered approach with an initial high-level GIS desktop evaluation using publicly available information. The desktop analysis will inform the subsequent site-specific characterization that will then be conducted at favorable locations with geologic, hydrogeologic and geochemical testing compatible with both infiltration and injection recharge methods. Information gained from site specific characterization will be used in groundwater and geochemical modeling to inform the appropriate recharge method and support permitting. This approach is described in Figure 3 of the Recycled Water Program NWRI Briefing Packet provided in the pre-reading material.

The city looks forward to continuing the partnership with NWRI and appreciates the opportunity to respond to request for clarification.
Respectfully,

The City of Boise Recycled Water Program