THE Water Research FOUNDATION

Potable Reuse

THE CHALLENGE

All communities need a supply of clean, safe water. Some communities, and the utilities that serve them, have the luxury of tapping into additional water sources when their primary supplies face quality or quantity issues. However, because traditional water sources, such as surface water and groundwater, are highly dependent on location, many utilities don't have easy access to contingency supplies. As increased pressures from drought, extreme weather, and shifting populations make backup supplies more critical, many utilities are looking beyond traditional sources to diversify their supplies. Many communities are also grappling with political and institutional issues, like local control of water supplies, driving the need to identify new, local options to avoid the need to import water.

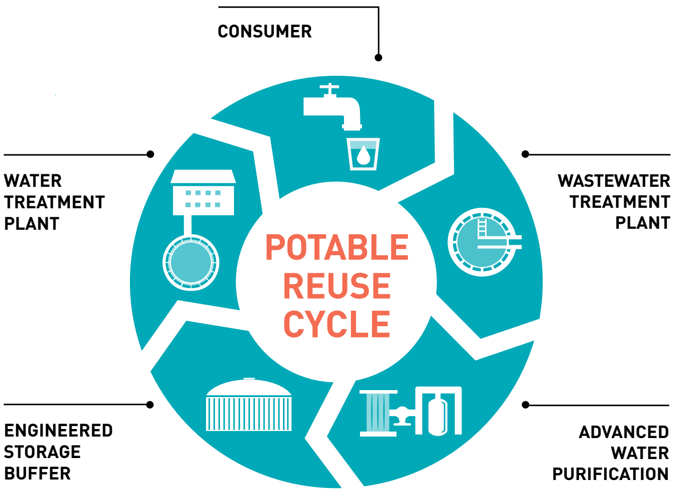
All of these circumstances make potable reuse an attractive option—purifying water from wastewater treatment plants through advanced treatment methods to meet drinking water standards. Potable reuse can help meet current and projected water demands and provide reliable locally based water supplies. While the need for potable reuse is apparent, challenges such as a lack of clear guidance on how to implement these solutions and negative public perception can make it difficult for utilities to integrate this option into their water portfolio.

THE RESEARCH

Since the mid-1990s, WRF has led the industry in water reuse research. At the time, U.S. municipalities were starting to recognize the potential benefits of supplementing drinking water supplies with water reuse. WRF joined forces with the National Research Council (NRC) on a first-of-its-kind study on the long-term viability of potable reuse. The resulting report, *Issues in Potable Reuse* (371), published by NRC in 1998, answered critical questions on toxicity, contaminants, and treatment options—and found that it could be a viable option. Since then, WRF has built a comprehensive body of research exploring both indirect potable reuse (IPR), where treated wastewater passes through an environmental buffer before rejoining the drinking water supply, as well as the shift toward direct potable reuse (DPR), where purified wastewater is introduced into a drinking water treatment facility or directly into the water distribution system. Because WRF's research covers wastewater, drinking water, stormwater, desalination, and water reuse, it is uniquely positioned to target this integrated effort.

Through strategic partnerships with state, federal, and international agencies, WRF has leveraged more than $100M to advance the science of water reuse, with over half directly funding potable studies. This research covers a full range of community, utility, and regulatory topics to help develop more cost-effective, secure potable reuse systems. Key collaborations include efforts with the National Water Research Institute, the Water Services Association of Australia, the Singapore Public Utilities Board, as well as a nearly two-decade long collaboration with the U.S. Bureau of Reclamation to advance water reuse and accelerate the adoption of transformative technologies at water and wastewater utilities. This joint effort with Reclamation resulted in 124 research projects valued at $53M.

In 2009, WRF furthered its collaborative efforts in potable reuse, partnering with WateReuse California to release one of the first comprehensive reports on the state of DPR, *Direct Potable Reuse: A Path Forward*. As a result of this partnership, in 2012 the DPR Initiative was launched—a four-year joint effort resulting in 34 cutting-edge projects to advance DPR as a water supply alternative, including a key demonstration project in San Diego. This information fundamentally helped shape WRF's research over the next decade. Results from this effort are synthesized in the 2016 report, *Potable Reuse Research Compilation* (Reuse-15-01).



Potable reuse is the process of taking treated effluent from a typical wastewater treatment plant and purifying it further with advanced technologies.

Criteria and Guidelines

Although safety and reliability are critical to all water systems, when it comes to potable reuse these issues are of increased importance. However, without established national regulations for potable reuse, the development of water quality criteria for this purpose is in the hands of each state. And because every state is faced with different geographic conditions and approaches, there is no one-size-fits-all solution. WRF is at the forefront of this issue—pioneering tools and guidance to help states determine the best path forward for safe, effective potable reuse and providing research to ensure that current and future guidelines are backed by the best science. WRF research has played a prominent part in helping several states begin the process of establishing guidance for potable reuse, including California, Arizona, New Mexico, Florida, Texas, Oregon, and Virginia.

In 2011, many utilities that had been exclusively using IPR options began exploring DPR. Implementing DPR, and eliminating the environmental buffer, offers potential operational advantages as well as benefits to a utility's bottom line; but many utilities had questions about the most effective treatment options. To provide solutions, WRF launched a multi-phased research project to explore the benefits and tradeoffs of various treatment process trains. The resulting series of reports, *Examining the Criteria for Direct Potable Reuse* (Reuse-11-02), released between 2012 and 2016, contains criteria for assessing the effectiveness of different advanced treatment trains, taking some of the top microbial and chemical concerns into consideration and introduces a model to weigh the options. The research funded the first U.S.-based pilot of an advanced treatment train for DPR under realistic operating conditions, showcasing the potential for DPR use. The water quality criteria developed in this project informed several states, including California, that have either developed or are looking to develop water quality criteria for potable reuse.

Anticipating that the newfound acceptance for DPR could lead to more projects statewide, in 2013, the Texas Water Development Board (TWDB) commissioned a study on the quality of water being produced in the United States' first DPR project, located in Big Spring, Texas. WRF provided additional funding to expand the sampling campaign, which was launched in an effort to increase confidence in the safety and effectiveness of these applications. The results were published by TWDB in a comprehensive report, *Direct Potable Reuse Monitoring: Testing Water Quality in a Municipal Wastewater Effluent Treated to Drinking Water Standards* (Reuse-14-10), laying out valuable guidance for long-term monitoring at DPR facilities, including indicators and surrogates to determine treatment effectiveness. This document is being used for permit planning in Texas.

More recently, WRF has stepped up efforts to help utilities, municipalities, and agencies implement potable reuse programs with much-needed resources to assist in the development of DPR guidance or regulations. In conjunction with the Water Environment Federation and the American Water Works Association, WRF released the 2015 document *Framework for Direct Potable Reuse* (Reuse-14-20), providing guidance to implement DPR programs, including regulatory and technical considerations, and assisting decision makers in understanding the role DPR can play in an overall water portfolio. *Assessment of Techniques for Evaluating and Demonstrating Safety of Water from Direct Potable Reuse Treatment Facilities* (4508), published in 2019, provides guidance for utilities and regulators to evaluate the safety of DPR systems, laying the groundwork for a proactive DPR-monitoring process that protects public health, including the selection of monitoring and control tools.

Treatment and Best Practices

Because the bar for potable reuse treatment practices is often higher than that of other water sources, WRF helps utilities keep up with a stricter set of demands. WRF research drives leading-edge advances in treatment and technology, including membrane- and non-membrane-based treatment options, helping to improve treatment and ensure contaminants are properly managed.

In 2016, WRF took instrumental steps in establishing best practices for DPR by demonstrating the reliability of multiple treatment processes to meet the highest water quality standards. *Critical Control Point Assessment to Quantify Robustness and Reliability of Multiple Treatment Barriers of DPR Scheme* (Reuse-13-03) pinpoints the elements in a treatment train that are most important to ensuring water safety, and uses full-scale operating data to evaluate the ability of those points to remove chemical and biological contaminants in potable reuse. Findings suggest that both membrane- and non-membrane-based potable reuse systems are capable of effectively managing microbial and chemical contaminants with proper monitoring and operational practices.

Beyond practices for initially purifying DPR water, WRF research also explores best practices for incorporating these sources into our drinking water supply—including guidance on how to blend purified water with traditional water sources. The 2018 report *Blending Requirements for Water from Direct Potable Reuse Treatment Facilities* (4536), examines variables such as the proportion of recycled water to raw water, quality of recycled water (based on treatment processes), and different introduction points. Short-term studies offer promising results, indicating that DPR blends of up to 50 percent do not present added risk in terms of enhanced regrowth of pathogens or antibiotic-resistant bacteria compared to conventional drinking water sources.

Fostering Integration

Even with effective guidelines and practices, the successful integration of potable reuse into a utility's water portfolio relies heavily on an organization's ability to support these changes. WRF research helps ease the integration, providing tools and resources to address gaps in operations planning, training, and certification, as well as methods to secure funding to get DPR programs off the ground.

Because potable reuse systems are not commonly implemented and use technologies not widespread in traditional treatment systems, these operations, and the teams that support them, are under greater scrutiny—requiring different operations strategies, as well as training and certification not fully covered under current wastewater and drinking water programs. WRF research helps fill this void. The 2017 project *Development of an Operation and Maintenance Plan and Training and Certification for Direct Potable Reuse Systems* (Reuse-13-13) illustrates a standard process for DPR operations and upkeep, highlighting risk management procedures. The research also takes the first steps in identifying the employee skills and training needed to sustain these activities.

SOLUTIONS IN THE FIELD:
Potable Reuse in California

Driven by a California state mandate to study the feasibility of developing uniform criteria for direct potable reuse (DPR), WRF launched the DPR Initiative in 2011. Raising $6M from utilities, consulting firms, and manufacturers—which grew to $24M with in-kind contributions—the four-year effort produced 34 research projects. The research explores everything from regulatory concerns to economic feasibility to public perception.

An expert panel, working on behalf of the California State Water Resources Control Board to document health, scientific, and technical issues related to DPR, credits WRF's research as being instrumental in their findings. The studies helped provide the scientific underpinning the State Water Board needed to determine that it is feasible to set standard DPR regulations and to green light their development by 2023. Thanks to a $4.5M grant awarded by the State Water Board in 2018, WRF will be able to conduct additional research on potable and non-potable as the process moves forward.

Building on this research, the 2018 project *Curriculum and Content for Potable Reuse Operator Training* (Reuse-15-05) features some of the first tools designed to help utility personnel understand specific treatment processes and other unique issues that are fundamental to the safe operation of potable reuse facilities. Based on a facility's treatment processes and other specific needs, utilities can tap into a series of eight modules designed to educate operators on technologies and topic areas not typically found in water treatment systems. This information is helping to form the basis for standard training programs, including an operator certification program for advanced water treatment developed by the California-Nevada section of AWWA and the California Water Environment Association that can be applied to potable reuse systems.

Because funding is often one of the biggest organizational hurdles in implementing DPR, WRF helps utilities better understand all of the costs—as well as potential benefits—of adopting these projects. In 2014, WRF released *The Opportunities and Economics of Direct Potable Reuse* (Reuse-14-08), which measures the cost of DPR versus other alternative sources, taking into account factors such as carbon footprint and the amount of new water a utility stands to gain. This research helps utilities make informed, cost-effective decisions and build better business cases for project upstarts.

Communication and Outreach

While community interest in potable reuse projects has grown substantially in the last decade, particularly in water-scarce regions, public acceptance still remains an obstacle. Understanding and addressing community concerns—and involving the public in the process—is a critical piece of every successful potable reuse project. WRF has helped the water sector make strides in this area, increasing the understanding of long-held perceptions of recycled water use, identifying primary concerns, and developing educational and communication tools to provide greater assurance.

The 2015 report, *Model Communication Plans for Increasing Awareness and Fostering Acceptance of Direct Potable Reuse* (Reuse-13-02), features a catalog of community-tested methods and messages for those involved with or planning potable reuse projects. Offering outreach plans at local and state levels, this how-to guide contains strategies and public outreach tools designed to be adapted for specific community needs. Whether pursuing IPR or DPR options, the research helps utilities understand common concerns and how to summarize the critical need to expand water supply sources. Communication plans walk users through the information they can provide to help communities understand how the process works and the steps to build support and awareness of existing and planned potable reuse programs.

INNOVATION

The WRF Innovation Program embraces innovation to support healthy, sustainable communities, with efforts focused on moving water technology to the field quickly and efficiently. Because innovative technologies and processes will play a critical role in making potable reuse a sustainable water source, WRF chose reuse as a priority innovation topic for potential pilot projects. These pilot projects will evaluate promising reuse technologies and processes beyond the bench scale. These projects will be supported by a consortium of utilities, researchers, consultancies, and agencies to create a seamless pipeline between reuse research and innovation at WRF.

WHAT'S NEXT?

As the need for alternative water supplies continues to grow, WRF is moving forward with several new research efforts that will further carve out a lane for DPR as a sustainable option, inlcuding additional work supported by the California State Water Resources Control Board. Because safety is a top concern, research will focus on better methods and guidance for pathogen risk assessment and monitoring. Recently launched projects are already headed in this direction—looking to develop a better understanding of pathogen concentrations in wastewater as well as tools for quantitative microbial risk assessment. This work will help improve pathogen monitoring in raw wastewater to gather better data on concentration and variability, and develop methods to better understand the necessary levels of removal for viruses and waterborne parasites for potable reuse—which can then be used to benchmark the effectiveness of DPR treatment trains. Another project is studying the feasibility of outbreak reporting, and the potential for collecting pathogen concentration data from raw wastewater at the site of community disease outbreaks.

WRF will also explore the use of next-generation technologies and methods, such as the use of metagenomics to study microbial communities, as well as previously unexplored contaminants. Current research is working to develop methods to identify unknown contaminants, particularly smaller compounds that can potentially be found in wastewater, which might not be removed by advanced treatment and are not detectable by current monitoring approaches. And because all of these new methods will produce a lot of data that must be processed and interpreted, data management strategies will also play a key role.

Non-Potable Reuse

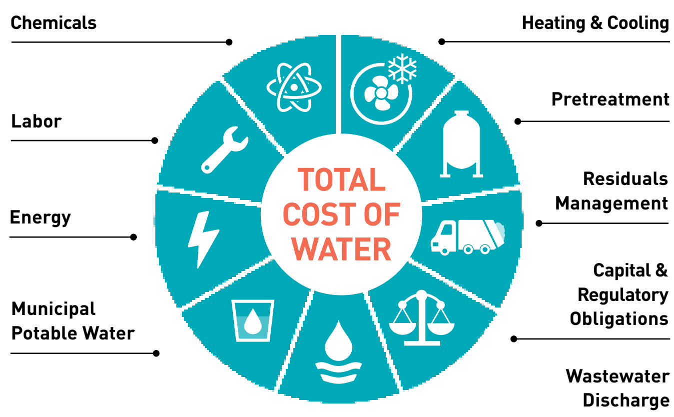
THE CHALLENGE

One of the biggest challenges today's communities face is the ability to provide safe, sustainable sources of water—not only for drinking, but for an assortment of other everyday uses that don't require water treated to drinking water standards. With a growing number of pressures straining our water sources, many utilities are relying on non-potable water reuse to keep up with demand—recycling municipal wastewater and water from impaired sources for activities that don't involve human consumption, such as landscape and crop irrigation, industrial processes, and other uses. Depending on the purpose and the risk of human exposure, different types of wastewater can be treated to meet specific quality standards. By treating water to match its intended use, utilities can avoid the high costs associated with over treatment—producing a product that relieves the demand on drinking water resources and offers a host of environmental benefits, including lower energy consumption, decreased diversion of water from sensitive ecosystems, and decreased discharges of nutrients and other pollutants.

While non-potable reuse systems have the potential to extend drinking water supplies and may require less treatment than potable reuse operations, these systems can be difficult to develop and maintain due to regulatory uncertainty. Challenges like the cost of maintaining separate "purple-pipe" distribution systems and long-held public perceptions on water reuse also increase this challenge.

THE RESEARCH

Starting in the mid-1990s, WRF was among the first organizations to explore the long-term viability of water reuse, charting its path as a sustainable resource. As the need for alternative water sources continued to grow, WRF stepped up these efforts, making this area a critical focus in the early 2000s. Since that time, WRF has launched more than 150 projects, leveraging over $100M in applied research to advance the science of water reuse, including roughly $1M each year in non-potable reuse. This research works



As industries weigh the cost of using reclaimed water against traditional water sources, they must factor in all of the expenses that go into treating and transporting water.

to help develop the most cost-effective processes and technologies to support water quality standards, protect public health, and preserve the environment—as well to more effectively integrate these systems into current operations.

Through strategic partnerships with state, federal, and international agencies, WRF has explored a range of community, utility, and regulatory issues to help develop sustainable water reuse systems. Key collaborations include efforts with the California State Water Resources Control Board, the Pentair Foundation, and the Metropolitan Water District of Southern California, as well as a nearly two-decades long collaboration with the Bureau of Reclamation to advance water reuse and accelerate the adoption of transformative technologies. This joint effort resulted in 124 research projects valued at $53M.

In 2018, the California State Water Board expanded their work with WRF, providing a $4.5M grant to identify and execute key research needed to bolster the production and use of recycled water in California. A substantial amount of this funding will go directly toward non-potable studies, which will drill into issues such as agricultural reuse, industrial reuse, and the energy-water nexus.

Agricultural Reuse

Because agriculture accounts for 80% of total water use in the United States, increasing water reuse practices in this area has the potential to have a big impact—making it a top priority for WRF. Agricultural reuse for food crops is currently practiced in many states, including California, Florida, and Colorado. To help supplement these efforts, in 2012, WRF began to strategically partner with agricultural organizations to better understand cross-sector issues, such as sources and impacts of nutrients, as well as to aid in moving agricultural reuse forward.

The 2019 WRF project *Agricultural Use of Recycled Water: Impediments and Incentives* (Reuse-15-08/4775) takes stock of some of the top challenges involved with switching from traditional water sources to recycled water for agricultural irrigation—looking at causes of setbacks and potential challenges and offering strategic solutions. Through interviews with both utilities and growers, a spatial assessment of irrigated farmlands, case studies of successful projects around the world, and a collaborative workshop, the findings highlight the largely untapped potential for agricultural reuse and serve as a springboard for other research efforts—including a follow-up study that is weighing the environmental, economic, and social costs and benefits of this agricultural water source.

This research also helped launch a number of WRF workshops and cross-sector events focused on finding collective solutions for overcoming the challenges associated with agricultural reuse. The 2018 Agricultural Water Reuse Workshop took an important collaborative step, bringing together the agricultural community, water utilities, regulatory agencies, and consultants to work toward the common goal of making water reuse more feasible for growers and utilities. The workshop, which attracted over 100 attendees, included expert presentations by WRF agricultural reuse researchers and an expert panel session to identify areas of potential collaboration across sectors and future research gaps.

Another 2019 study also made strides in the area of reuse on agricultural land, this time with a focus on groundwater recharge—which has the potential to restore more than 300,000 acre-feet of sustainable groundwater each year in California alone. *Groundwater Replenishment with Recycled Water on Agricultural Land* (Reuse-16-03) documents how agricultural areas with a need for reliable water supplies, due to a lack of access to surface water or reduced availability of groundwater, could benefit from combining agricultural reuse with groundwater recharge, resulting in substantial cost savings. The research also covers top concerns, including pathogens, nutrients, salinity, crop risks, and regulations, and offers potential approaches to address these issues.

Industrial Reuse

Because industrial facilities rely on water for a variety of uses beyond drinking, there is a significant opportunity to use recycled water. And because these facilities can also generate a large amount of wastewater, they also have the option of capturing, treating, and reusing their own wastewater for industrial processes or other uses such as landscape irrigation. This means less reliance on outside water sources, which can translate into cost savings and improve community relations. But, because reuse in industrial settings is different than in municipal settings, there are often questions about how to design, construct, and operate these systems. WRF research is targeting these issues, offering guidance and resources to effectively implement industrial reuse projects—with a focus on the unique organizational, regulatory, and motivational issues involved with industrial reuse to help ensure projects align with business strategies.

The 2016 study, *Drivers, Successes, Challenges, and Opportunities for Onsite Industrial Reuse* (Reuse-13-04), highlights industrial water reuse practices, homing in on the best opportunities based on various industrial sectors, including the food and beverage, oil and gas, and manufacturing sectors, and explains how water reuse can help improve their bottom line. This work was expanded on in the WRF research project *Framework for the Successful Implementation of Onsite Industrial Water Reuse* (Reuse-14-04). Released in 2017, this research identifies the elements necessary for developing a successful onsite industrial water reuse program as well as how to achieve a favorable return on investment—an instrumental piece in the project approval process.

More recently, WRF research has also explored how industrial reuse can prove mutually beneficial to both the power industry and wastewater treatment facilities. Particularly in the United States, where up to 80% of power plants are within 10 miles of a wastewater treatment facility, there is a large opportunity to collaborate. Findings from WRF's 2019 report, *Multipurpose Reuse of Reclaimed Water at an Electric Utility and for Wetlands Rehydration in Florida* (Reuse-15-12), provides an overview of tangible benefits to both wastewater and power utilities, barriers that limit joint efforts, and potential risks to both operations. The report evaluates the ability of current treatment technologies to meet water quality requirements for applications, such as cooling towers and boilers, and includes cost estimates for individual treatment process trains.

Onsite Non-Potable Systems

Although there is an increased interest in onsite non-potable reuse, the lack of water-quality or monitoring standards for these systems can make implementing these projects difficult. To help expand the use of onsite non-potable systems, WRF joined forces with the U.S. Water Alliance to establish the National Blue Ribbon Commission for Onsite Non-Potable Water Systems. The commission, which works to advance best practices for non-potable reuse within individual buildings or on local scales, has already released more than a dozen resources.

To further help fill the void, in 2017 WRF released the guidebook, *Risk-Based Framework for the Development of Public Health Guidance for Decentralized Non-Potable Water Systems* (SIWM10C15), which lays out a flexible process for developing systems that are reliable, efficient, affordable, and protective of public health. The framework, which was a result of collaborative efforts between public health and utility leaders, offers a fit-for-purpose approach, looking at site-specific conditions and targeting human health-based goals, which could help inform future state or national regulatory conversations.

Potential potable water offset by using non-potable water for toilet and urinal flushing:

25% Residential Buildings | 75% Commercial Buildings

WRF and the U.S. Water Alliance are also moving forward on another newly launched collaborative project, *Development of a Design, Operations, and Regulations Guidance Manual and Training Materials for Onsite Non-Potable Water Systems* (4909). This project is in the process of developing a guidance manual and training program for engineers and operators for design, operations, and monitoring of onsite non-potable water systems. The manual will also be of use to regulators permitting these systems and utilities working with communities to implement them.

Water Reuse Diversification

As water demands shift, many communities are turning to water reuse as an alternate source to keep pace with growing and moving populations. Although water reuse has already found a place in many industries—including agriculture, landscaping, energy production, and industrial and manufacturing processing—WRF research is helping to open up new opportunities and uses. Research is laying the foundation for water reuse to become a bigger piece in a balanced water portfolio through non-traditional applications.

Recycled Water Use in Zoo and Wildlife Facility Settings (Reuse-07-06), released in 2013, chronicles water reuse practices at two-dozen zoos and wildlife facilities in the United States and abroad. The research offers the water sector its first glimpse at the current state of recycled water use in these settings, which typically operate using large amounts of water. It looks at water quality, treatment technology, current regulations and guidelines, and possible animal health effects. The study outlines potential water quality criteria to support long-term animal health, and helps assess the suitability of recycled water for potential uses at zoos—a first step toward the development of a standard sustainability program that encourages the use of recycled water at these facilities.

Assessing and Communicating Risk

As the use of the recycled water continues to gain momentum, receiving more recognition as a viable and beneficial practice, risk to public health remains a top priority. WRF research has been leading the way in accurately measuring potential risks, as well as helping to communicate the results to the public—which is key to expanding these efforts.

To investigate the presence of residual chemicals in recycled water, in 2012 WRF undertook an effort to understand the actual health effects of these substances, considering factors like exposure pathways and concentrations. *Risk Assessment Study of PPCPs in Non-Potable Recycled Water to Support Public Review* (Reuse-09-07), measures the risk of common pharmaceuticals and personal care products (PPCPs)—starting with a small group of substances like ibuprofen, caffeine, and DEET, as well as some of the top exposure scenarios, such as a golfer playing on a course that uses recycled water. Results showed that risks from PPCPs in water reuse are comparable to the risks from the same substances in drinking water, and much less than the levels of these chemicals most people experience through daily exposure. These findings were broken down in a series of easily understandable communications pieces, including a short video, talking points, and answers to frequently asked questions, which could aid in overcoming negative public perceptions and generating support for potential reuse projects.

Along the same lines of research, *Attenuation of PPCPs through Golf Courses Using Recycled Water* (Reuse-08-02/WERF1C08) explores the fate and transport of PPCPs once they are in the environment, looking at how these substances behave when applied to turf grass. The multi-year, collaborative project assessed the presence of 15 PPCPs, demonstrating the ability of turf grass to remove up to 98% of PPCPs under most conditions and underscoring the viability of recycled water for irrigation purposes. It also called out key factors that impact how much reclaimed water should be applied, including soil type, turf type, and evapotranspiration rate, providing guidance for turf managers going forward.

INNOVATION

The WRF Innovation Program embraces innovation to support healthy, sustainable communities, with efforts focused on moving water technology to the field quickly and efficiently. Because innovative technologies and processes will play a critical role in making reuse a sustainable water source, WRF chose reuse as a priority innovation topic for potential pilot projects. These pilot projects will evaluate promising reuse technologies and processes beyond the bench scale. These projects will be supported by a consortium of utilities, researchers, consultancies, and agencies to create a seamless pipeline between reuse research and innovation at WRF.

WHAT'S NEXT?

As shifting environmental conditions and other changes raise our reliance on alternate water sources, WRF will continue to provide sound science to support the role non-potable reuse will play in a well-balanced water portfolio. Although growers have been increasingly turning toward water reuse to meet their irrigation needs, there is still much to learn about agricultural reuse. WRF is helping to fill these knowledge gaps with newly launched research like, *SAR-Soil Structure Interactions to Provide Management Options for Recycled Water Use in Agriculture* (4963), which hopes to shed light on specific plant-soil interactions after irrigation with recycled water. Another new project, *Assessing the State of Knowledge and Impacts of Recycled Water Irrigation on Agricultural Crops* (4964) is working to develop guidance on growing crops for farmers using recycled water.

As it becomes more important for industries to improve their water management practices, the use of municipal reclaimed water and onsite reuse of industrial wastewater will likely play a larger part. WRF research will remain focused on this critical area, as well as explore the viability—and ensure the safety—of new industrial uses. One ongoing project is studying the emerging area of reusing oil-field produced wastewater for applications such as irrigation. WRF will also look to extend work on onsite reuse in buildings and other applications, continuing to invest in other ways this valuable resource can be used.

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