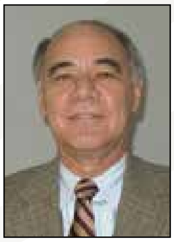
G. WADE MILLER


Wade Miller

Direct Potable Reuse: Its Time Has Come

A rational conversation about direct potable reuse (DPR) would not have been possible six years ago. Even the appearance of advocating DPR, as this author did in a speech several years ago, was typically received with skepticism and even ridicule by some long-time water professionals and the academic community.

DPR has come a long way since then. Several events occurred that have served as a catalyst for the practice and acceptance of DPR. The first event was a resolution by the board of trustees of WateReuse California, the California affiliate of the WateReuse Association. In August 2009, the board of trustees concluded that WateReuse California should form an ad hoc committee to explore how it should develop potable reuse in California. This conclusion was based on several factors:

- Legislative (California) activity related to potable reuse
- Willingness of key environmental organizations and regulators to consider potable reuse
- The fact that construction of purple pipe systems is too costly for utilities to implement on a large enough scale to achieve the State of California's water recycling goals
- The fact that compliance with indirect potable reuse regulations is infeasible for many agencies because of local geological and other conditions
- Drought
- Availability of proven treatment technology

From this single board resolution, the California DPR Initiative has grown into a significant and important program and has achieved many noteworthy accomplishments in the ensuing six years, some of which are highlighted later in this article.

The second event was the severe drought in Texas, which began in 2011. According to the Texas Commission on Environmental Quality (2012), "The year 2011 will go down in the records book as the most severe one-year drought in Texas history." Because of the severe nature of the drought, especially in historically semi-arid West Texas, surface water reservoirs in some communities dropped to less than 10% of capacity—and continued that way for many months as the drought persisted. With some reservoir levels dropping to less than 5% capacity, the Colorado River Municipal Water District (CRMWD) responded by initiating the design and construction of the Big Spring Reclamation Project in 2010.

The facility, which initiated its raw water blending on Apr. 26, 2013, takes tertiary treated wastewater from the Big Spring wastewater treatment plant, treats it in the CRMWD raw water production plant to "near distilled" water quality using microfiltration (MF), reverse osmosis (RO), and advanced oxidation processes, and then blends this highly treated water with water from one of three reservoirs. This blended water is then piped to the Big Spring water treatment plant, where it is treated to Safe Drinking Water Act standards. The blending of the water from the CRMWD raw water production plant with water from the surface water reservoir has caused knowledgeable observers to classify this facility as DPR. Other municipalities in Texas (e.g., Brownwood) have followed the lead of the CRMWD and are in the process of developing similar facilities.

The third event that has been a driver of DPR was the publication of a report by the National Research Council's Water Science and Technology Board titled *Water Reuse: Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater* (NRC 2012). This is a seminal work, an excellent report on the potential for all types of water reuse. In addition to documenting the substantial potential for water reuse, the report removed a stigma from potable reuse that had persisted since the publication of an NRC report titled *Issues in Potable Reuse* (NRC 1998). In the 1998 report, indirect potable reuse was referred to as "an option of last resort." Opponents of indirect potable reuse projects, especially in San Diego, Calif., used this phrase in their efforts to stop reuse projects.

The 2012 report removed the stigma by stating the following: "Recycled water should no longer be considered a water of 'last resort.' In the U.S., up to one-third of the water used nationally each day can be recycled back into water supplies." The blue-ribbon committee that prepared the report also conducted an analysis called a "risk exemplar" in which the committee compared risks from de facto (i.e., unplanned) reuse with those from potable reuse scenarios. The committee's analysis suggests that the risk from 24 selected contaminants in two potable reuse scenarios does not exceed the risk in common existing water supplies.

These three major driving forces have led to a significant escalation in interest and activities related to DPR. Three states are leading the way: (1) California, with its DPR Initiative; (2) Texas, which is sponsoring a project whose ultimate goal is to develop a resource document for DPR that can be used by utilities, agencies, and consultants to ensure technically sound, safe, and practical implementation of DPR in Texas; and (3) Arizona, which has an active committee called the Steering Committee on Arizona Potable Reuse, whose goal is to develop a road map to potable reuse in Arizona. In addition to these three, a growing number of states have expressed interest in DPR, including New Mexico, Florida, and Ohio.

DEFINITIONS AND CONTEXT

Before delving into specifics on current happenings and future prospects for DPR, it might be helpful to provide some definitions and context. There are three basic categories of water reuse, the most common of which is nonpotable reuse. In nonpotable reuse, wastewater is treated to fit-for-purpose use and conveyed to the user through purple pipes. Applications vary from irrigation of highway median strips and golf courses to irrigation of edible crops, urinal flushing in high-rise buildings, and use in the cooling cycle in power plants.

The second category is indirect potable reuse (IPR), which involves treating previously treated wastewater to highly treated water, typically using MF, RO, and ultraviolet irradiation (UV). Examples are the groundwater replenishment system at the Orange County Water District (Calif.), West Basin Municipal Water District (Calif.), and the NEWater facility at the Singapore Public Utilities Board. IPR features an "environmental buffer" or "environmental barrier." The buffer or barrier typically consists of groundwater injection or surface water augmentation. In DPR, the environmental buffer or barrier is eliminated. Examples of DPR are Windhoek in Namibia, Africa, and the aforementioned US facility in Big Spring.

Definitions for DPR can vary. The classic definition is the introduction of reclaimed water directly into a drinking water distribution system (pipe-to-pipe). This is perhaps the ultimate goal toward which the water industry can strive. Another definition, one that more correctly characterizes the current state of the science, is the planned introduction of recycled water either directly into a public water system or into a raw water supply immediately upstream of a water treatment plant for the purpose of augmenting the potable water supply.

WHY DPR?

Now that we know the differences between nonpotable, IPR, and DPR, we should pose a most logical question: Why do we need DPR? There are three basic reasons. The first is impending water shortages. Both Texas and California have experienced terrible and extended droughts over the past four years, and efforts to mitigate the impacts of such droughts are being ramped up, both nationally and at the state level. Second, states cannot achieve their water reuse goals with nonpotable reuse. For example, California recycles approximately 650,000 acre-ft/year. The state has established goals of 1.5 MAF/year by 2020 and 2.5 MAF/year by 2030. The 2030 goal represents more than a fourfold increase over current levels and is unachievable with just nonpotable reuse and IPR. Third, the installation of purple pipe is extremely expensive. Moreover, it is disruptive because it involves digging up city streets. For these reasons and others, DPR is needed.

According to anecdotal evidence, more than 1 bgd of treated wastewater in California is discharged into the ocean between Santa Monica Bay on the north and San Diego to the south. With DPR, a substantial proportion of this wasted resource could be reclaimed and beneficially reused. According to a recent report published by the WateReuse Research Foundation (Raucher & Tchobanoglous 2014),

> It is estimated, using available data and information that more than 2,300 [mgd]—which amounts to 2.6 MAF/year—may be available in California for new water recycling projects in 2020. This source water, after receiving complete advanced treatment, could yield more than 1,000 [mgd] (or more than 1.1 MAF/year) of potable supplies. To place this into context, 1.1 MAF/year is sufficient potable water to supply all municipal needs (including commercial and industrial uses) for more than eight million Californians, or roughly one-fifth of the state's projected population for 2020.

This is both an astounding and positive finding, demonstrating that potable reuse can provide a substantial portion of the future additional water supplies needed to satisfy California's growing demands.

As alluded to earlier, great strides are being made in DPR, especially in California as a result of the launching of WateReuse's DPR Initiative in 2009. It is useful to trace the dramatic and impressive progress in the six years since the WateReuse California board adopted its resolution. Significant progress has been achieved legislatively, in conducting applied research, and in education and outreach.

In 2010 WateReuse California advocated for the enactment of SB 918, which, among other provisions, directed the California Department of Public Health (CDPH) to issue a report to the legislature on the feasibility of DPR by Dec. 31, 2016. This bill was enacted by the legislature and signed into law on Sep. 30, 2010. Pursuant to the provisions of this law, CDPH established an expert panel to advise on the feasibility of DPR and to identify and recommend research. WateReuse has worked closely with this panel and has launched a number of research projects identified by the panel.

A substantial amount of research will be needed to ensure that DPR can be practiced without endangering public health. Research is needed to study treatment train equivalency, to develop sensors and online monitoring systems, to study engineered storage requirements, and to develop a model public acceptance program. These are four of the most important areas, but there are many others. Since 2012, the WateReuse Research Foundation has launched 26 applied research projects. With leveraging of existing funding from organizations as far away as the Water Corp. of Western Australia and the Australian Water Recycling Centre of Excellence, the WateReuse Research Foundation's current portfolio of DPR projects consists of an investment of more than $12 million.

To pay for this massive research effort, the WateReuse Research Foundation and WateReuse California initiated a fundraising effort in June 2012. The fundraising campaign has met with huge success. To date, approximately 50 water and wastewater agencies in California have made donations ranging from $10,000 to $500,000. At least 15 consulting engineering firms and a handful of equipment suppliers have also made generous donations. To date, more than $6 million has been raised for this essential effort (WaterReuse Association 2015).

Given the three driving forces described earlier, to which climate change and growing water scarcity around the globe could be added, the future prospects for direct potable reuse are bright indeed. The benefits are numerous. All types of reuse will be enhanced. If DPR can be achieved successfully, this will result in greater acceptance of nonpotable and IPR projects. Recovering even a fraction of the billions of gallons of water discharged into the ocean each day in California would be a boon to the state's water supplies, economy, and communities. Similar benefits would accrue to other states bordering an ocean or other large body of water (e.g., Gulf of Mexico).

One of the first cities to benefit from DPR could be San Diego, whose IPR facility has been in the planning and permit-approval stages for several years. The current plan is to take the water from the water reclamation facility, which will feature an MF/RO/UV/advanced oxidation treatment train, and pipe the water to the San Vicente surface water reservoir, more than 20 mi from the treatment facility. If San Diego eliminated this surface water augmentation step, a much shorter transmission pipeline (approximately 7–8 mi) would be required to pipe the recycled water to the drinking water treatment plant. Experts have speculated that piping the highly treated recycled water directly to the water treatment facility as opposed to the reservoir could save the city an estimated $175 million to $200 million. That is quite an attractive benefit.

As bright as DPR's future appears, it is still years away from reality in most states and globally. California, as it does in many areas, will likely lead the way. Assuming the expert panel mandated by SB 918 delivers a positive report to the legislature in December 2016, regulations would then have to be developed and promulgated by the State Water Resources Control Board. This could take an additional two to five years. Thus the reality is that we may not see a permitted DPR facility in California before the year 2020 at the earliest. Since Texas already has an operational facility that can be classified as DPR in the Big Spring plant, others (e.g., Brownwood, Wichita Falls) are likely to follow. These facilities would be permitted on a case-by-case basis in the absence of regulations.

CONCERNS

Although all signs point to the increased practice and acceptance of DPR by 2025 at the latest, this article must end with two cautionary notes. The first is that, even with all the research being conducted by the WateReuse Research Foundation, Water Research Foundation, and other organizations such as the Australian Water Recycling Centre of Excellence, several barriers and concerns regarding DPR still exist.

In a presentation at WateReuse's DPR conference in 2013, Rhodes Trussell, who served as chair of the blue-ribbon committee that produced the 2012 NRC report, offered the following thoughts on what still needs to be achieved to practice DPR successfully. Trussell noted, "We are nearly ready to put full advanced treatment water in our raw water supplies today." To do so, we need (1) formal standards, (2) formal operator training and certification, and (3) comprehensive standard operating procedure protocols.

Several additional issues need to be resolved before we as a society are prepared to treat used water and put it directly in potable water distribution systems. We need to understand what it means to build and maintain failsafe protection against waterborne pathogens. The key issue is the acute risks posed by pathogens. We also need a way to wrestle with the rest of the chemical universe (i.e., the chemical compounds of emerging concern). Moreover, we need industrial pretreatment programs that are regularly updated with potable reuse in mind. Trussell went on in his 2013 conference presentation to say that we need comprehensive programs to minimize toxic chemicals from households and to deepen our understanding of pathogens in used water.

Of all these needs, most experts agree that maintaining failsafe protection against waterborne pathogens is the most critical. Most chemicals pose chronic as opposed to acute risks and require a certain level of ingestion to be toxic. This is not true with pathogens; the risks are acute and a person can be infected by a single virus. According to the NRC report on water reuse (2012), "Failures may cause a short-term risk to those exposed, particularly to acute contaminants where even a *single exposure* can lead to an adverse effect." Thus this is a research area that will command attention and resources over the next few years.

Finally, the operation of a DPR facility is extremely important. Two examples will suffice to paint a vivid picture. Many water professionals, including this author, have consumed the water produced at the Orange County Water District's groundwater replenishment system. This recycled water was consumed with confidence because of the familiarity with the treatment technologies being employed and also because of confidence in the knowledge and capabilities of the water district's management and personnel who operate the facility.

By contrast, earlier this year Bill Gates appeared on an episode of *The Tonight Show* and drank water from a recycled water facility in Africa, whose technology development has been sponsored by the Gates Foundation. In reading articles about Gates and the treatment system that produced the recycled water from what was apparently raw wastewater, it would be extremely difficult to reach a comfort level about consuming the water produced. Most water professionals probably would not drink water from this recycled water facility for two reasons: (1) lack of knowledge about and confidence in the technologies contained in the "black box" and (2) lack of knowledge about the plant operators or their qualifications. The bottom line is that both the efficacy of the technologies employed and the effective operation of the treatment facility are crucial to production of potable water that is safe and acceptable to the consuming public.

CONCLUSION

There is little doubt that DPR is going to be a part of our future and will certainly be a critical component of the water supply equation of the 21st century. Much work remains to be done, however, to address the remaining barriers and to eliminate any concerns regarding the protection of public health.

*—**G. Wade Miller** served as executive director of the WateReuse Association and the WateReuse Research Foundation for almost 14 years until March 2014. He has more than 40 years of experience in the water industry as a nonprofit executive and consultant. He currently serves as a water strategies consultant to public and private sector organizations. Miller may be contacted at wmiller483@gmail.com.*

http://dx.doi.org/10.5942/jawwa.2015.107.0075

REFERENCES

NRC (National Research Council), 2012. *Water Reuse: Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater.* The National Academies Press, Washington.

NRC, 1998. *Issues in Potable Reuse.* The National Academies Press, Washington.

Raucher, R.S. & Tchobanoglous, G., 2014. *The Opportunities and Economics of Potable Reuse.* WRFF-14-08. WateReuse Research Foundation, Alexandria, Va.

Texas Commission on Environmental Quality, 2012. *News You Can Use,* June. www.tceq.texas.gov/assets/public/comm_exec/pubs/pd/025/12-06.pdf (accessed January 2015).

Trussell, R., 2013. Public Health Goals for DPR. Proc. WateReuse Association 2013 Direct Potable Reuse Specialty Conference, Newport Beach, Calif.

WaterReuse Association, 2015. Personal communication.