Water Research Foundation– Past, Present, and Future Support for One Water

Water Research Foundation defines One Water that all water sources must be managed holistically and collaboratively to meet the public, environmental, and economic needs for these sources. WRF's water utility subscribers, representing 80% of municipal drinking water supplied in the U.S., are actively pursuing sustainable approaches to water supply development including the protection of raw water supplies, utilization of impaired sources of supply, water conservation, development of more energy efficient approaches, and the minimization of environmental impacts. New research programs at WRF, Emerging Opportunities and Facilitated Research Services, coupled with a new research Focus Area on water supply planning, have been designed to foster collaborations to allow advancement of research in integrated water resources management.

In January of 2014 the WRF Board approved a new research focus area titled Integrated Water Management: Planning for Future Water Supplies. WRF has assembled an advisory committee, and has developed objectives and a research agenda for this new focus area. The objectives for the new focus area include:

1. Evaluate water supply diversification efforts through an integrated water management approach with a focus on institutional issues and economics.
2. Identify elements of an integrated, resilient and reliable supply to improve water supply planning.
3. Evaluate how new water supplies from nontraditional sources, including reuse strategies beyond wastewater effluent, such as graywater and stormwater, can be protective of public and environmental health while diversifying water supplies.

This paper frames WRF's One Water long term initiatives for the water community under two main topic areas, water supply planning, and potable reuse. Throughout each section, projects that support a One Water approach to water management are highlighted.

Support for One Water Beginning with Water Supply Planning

As utilities plan for how they will provide customers with safe and sustainable water supplies, they must consider many factors. Current supplies may become stressed from under the following conditions that utilities can use source water management planning and other management strategies to address and prioritize.

1. Increased water demand from multiple industries both private and public: energy; agriculture; petrochemical, textile and manufacturing industries; and even municipal consumption.
2. Climate change or weather related challenges.
3. Lower groundwater levels.
4. Water quality challenges.
5. Instream flow requirements.
6. Reduced reservoir capacity.

Florida utilities need to find the right balance in assessing these factors in order to provide a resilient, reliable, and affordable water supply to customers. Numerous approaches are taken by water utilities to conduct their water supply planning. Increasingly an integrated approach to water management is being implemented, which may influence water supply planning decisions by opening up new supplies or new strategies for protecting existing supplies. This overview will help connect key relationships between demand management, watershed management, water footprinting, and integrated water management.

One of the most referenced and used documents to support water supply planning in the water industry is AWWA's *Water Resources Planning: Manual of Water Supply Practices M50* (M50). (AWWA, 2007) The Water Research Foundation has conducted research on many aspects of the water supply planning process identified in M50 starting with identifying and evaluating new water sources. New sources may include:

1. Expanded groundwater and surface water supplies
2. Ocean desalination
3. Reclaimed/recycled/reuse water
    a. Reuse will be the primary emphasis of this paper.
    b. Non-potable reuse is currently available in Florida
    c. What does the Florida water community need to consider to expand potable reuse considerations?
4. Increased conservation
5. Water transfers or purchases

When evaluating potable reuse as a new source, several relevant issues should be considered including water quality, regulations, yield, impacts on other sources as well as environmental impacts, financial considerations, and future reliability. Ideally, use of new water sources will balance cost-effectiveness, financial feasibility, public acceptability, and environmental issues.

Past Challenges with Potable Reuse Water Supply Development

Water supply planning decisions may be based on a variety of constraints, including technical, financial, legal, institutional, and policy. The WRF report "Managing Constraints to Water Source Development," identified the legal, institutional, and policy constraints. (Graham, Hathhorn, Wubbena, Lampe, & Grigg, 1999) Eighteen kinds of regulatory programs and institutional factors were identified as the key constraints many of which apply across the state of Florida. Examples include threatened and endangered species protection, Tribal and Federal Reserve rights, continuity between surface and groundwaters, wetland protection and growth management programs. Graham et al include several case studies that provide additional information on where these issues were experienced, and how those utilities worked to overcome these issues.

To overcome these challenges, Graham, et al recommend a variety of strategies. These approaches include considering public values, emphasizing all stewardship initiatives, being responsive, balance urban and rural common ground for supply planning, coordinate support, plan farther ahead, extend internal capacity from engineering roles to other skill sets.

1. Consider public values when making water supply decisions. In order to address emerging public concerns such as environmental issues, tribal rights, economic justice, growth management, coordinate among water use communities.
2. Emphasize potable reuse as water resource stewardship in addition to communicating how other activities such as conservation, leak repair, water loss control, and watershed management are being leveraged. Stewardship of available water supply while minimizing environmental impacts can develop public and agency bodies perceive current supplies are being wasted.
3. Use adaptive management strategies to maintain flexibility and respond to issues with supply development activities.
4. Find common ground between urban and rural communities to ensure support for water supply development activities that may extend beyond a utilities urban boundaries.
5. Consider water supply projects with multiple benefits to gain support of other groups such as agriculture, industry, environmental or other interest groups.
6. Coordinate planning among multiple utilities to take advantage of regional supply solutions. This information was further validated in 2006 by the WRF research team for "Regional Solutions to Water Supply Provision." (Raucher, et al., 2006, 2007, 2008)
7. Consider a 50-year time horizon in order to lengthen the planning horizon for potential future needs, and reduce the number of times new sources need to be developed. The Water Corporation, which serves Western Australia and Perth has taken this approach as detailed in their planning document in "Water Forever: Towards Climate Resilience." (Water Corporation, 2009)
8. Build internal capacity to handle negotiation, organization analysis, and political strategy to deal with the issues that go beyond the traditional utility skill sets of engineering, administration, and operations. In addition to Graham, et al there are many guidance resources available in workforce development and resiliency through the WRF resources.

Past Lessons Informing Potable Reuse Water Supply Implementation in the Context of Integrated Water Management

Many of the solutions identified by Graham, et al to overcome the challenges with water supply development are an important part of integrated water management (IWM). Integrated water management considers all aspects of the water cycle across the whole watershed, going beyond individual jurisdiction boundaries. IWM cannot be implemented by a single entity. Successful integration requires coordination and collaboration among drinking water, wastewater, and stormwater entities. Other partners from land management and industry play an important role in IWM as well. The public, government agencies, funding organizations, and other water users and managers must also be a part of the process of implementing IWM, which is a key element emphasized by “Managing Constraints to Water Source Development.” (Graham, Hathhorn, Wubbena, Lampe, & Grigg, 1999)

One of WRF’s earliest efforts to support IWM began with the project “Guidelines for Implementing an Effective Integrated Resources Planning Process.” (Albani, 1997) Albani identifies 20 steps required for implementing an Integrated Resources Planning (IRP) process. Examples from eleven key steps include: identification of stakeholders, review of stakeholder issues, identification of supply limitations and issues, assessment of current and future water quality and quantity issues, development of alternatives, analysis of alternatives, comparison of alternatives, ranking of alternatives, selection of preferred alternative, implementation, and, if necessary, modification of alternatives to address emerging issues. Six case studies from Denver Water, Edmonton Water, Las Virgenes Municipal Water District, Massachusetts Water Resources Authority, Philadelphia Suburban Water Company and Seattle Water Department highlight how the IRP process has been applied at several utilities. Nearly twenty years later these several utilities still conduct their planning through an IRP process.

Expanding on IRP involved international coordination. Another Water Research Foundation project addressed the objective to create a generic process for cities and towns to follow to help them through the challenges of transitioning to an urban water management process that is truly integrated. This generic structure for cities was referred to as Integrated Urban Water Management Planning. Canadian, US and British utilities helped create a manual that describes the process. It considers all parts of the water cycle, the full range of demands for water (anthropogenic and ecological), and the impact of the water cycle on city planning and management. (Maheepala, et al., 2010) As part of this project, case studies from six participating utilities were completed to compare current practices with the transition to an integrated water management planning process.

From these three historic WRF projects and the work of Graham et al, Albani and Maheepala, et al, key lessons for the water community indicate ensuring IWM success requires a project champion to steer a stakeholder group through the process. In addition, IWM is not a stagnant process, once a desired goal is met then it is a good idea to evaluate the goal and adjust activities in an adaptive way in order to continually achieve sustainable operations. One of the key institutional challenges recognized in the Maheepala, et al report is that one agency rarely manages all aspects of water in a watershed. Even when this does occur, integrated water management needs to be incorporated into the utilities’ operations, which may present unique challenges.

Because of the many complexities of institutional challenges for IWM, WRF project “Institutional Issues for One Water Management,” through case study analysis, will identify and evaluate institutional issues and governance structures for established water, wastewater, and storm water management. (Mukheibir, Howe, & Gallet, 2014) (WRF, 2015) The project will also explore stakeholder-driven solution-sets for a utility to adopt a One Water Paradigm. Approaches that encourage a One Water Paradigm will be identified along through examples. The project will also provide information to overcome potential barriers.

Present Support for One Water through Answering Questions about Potable Reuse

Water utilities globally face increased water supply pressures. Pressure on water utilities arise simultaneously from many factors. These factors primarily result from:

- Population growth
- Increased uncertainty from hydrologic and climate variability indicators
- Decreasing availability of high quality water sources
- Decreasing quality of existing sources
- Increasing water demands from other sectors like energy and agriculture

The challenge to existing water supplies from population growth has been managed successfully in many locations through water conservation and demand management. Other challenges are leading to a tipping point of action where new, cost-effective supplies will need to be developed.

Potable reuse is one component of a more integrated approach to water management that many utilities are interested in implementing.

As part of WRF's support for One Water, we are working on a variety of efforts by utilities to support a more sustainable and integrated approach to water management. There are many questions that need to be addressed and they are outlined with the most recent information for each question in the subsequent sections.

What is driving utilities towards potable reuse?

Sources of potable water are very geographically and locally dependent. Whereas some utilities have the luxury of switching between sources when they have quality or quantity issues with one of their sources, many utilities do not have a diversified portfolio of water supply options. This challenges utilities to look beyond traditional surface and groundwater sources. Increasing interest is focused on several non-traditional water supply options to help water utilities diversify their water supplies. In addition to options such as desalination and managed underground storage (injecting water underground for future use), potable water reuse is becoming an increasingly popular option for utilities to explore. Local control of water supply is an important political consideration in some communities. In such situations, potable reuse can be an attractive alternative to importing water from elsewhere.

What are the different types of potable reuse?

Non-potable Reuse - To conserve potable supplies, some utilities provide non-potable recycled water to customers for non-potable uses. Non-potable reuse refers to water that is not treated or intended to be a part of the potable supply, so there is no human consumption. Non-potable water may be treated to a specific quality depending on its purpose, such as irrigation or industrial use. While non-potable reuse systems reduce demand on potable water supplies and require less treatment than potable reuse operations, these systems can be cost prohibitive to develop and maintain due to the need for a separate distribution system.

Non-potable distribution systems are assessed in WRF project Dual Water Systems: Characterization and Performance for Distribution of Reclaimed Water. (Grigg, Rogers, & Edmiston, 2013) The report includes short descriptions of dual water systems from 37 utilities in the United States. The report was heavily focused on Florida with 12 participating utilities from Cape Coral Utility Division, City of Dunedin, City of Eustis Public Utilities Department, City of

Largo, City of Orlando Wastewater Department, City of Oviedo, Pinellas County Utilities, St. Pete Beach Public Services Department, City of St. Petersburg, Tallahassee Underground Utilities, Tampa Water Department, and the City of Winter Springs Public Works/Utility. Reviewing the performance of the systems presented a challenge because no standard classification system had been developed and the systems varied widely in scale, type, and stage of development. Initial groundwork towards developing a classification system is presented. Qualitative performance results are discussed in the areas of water safety and public health, effectiveness in meeting system goals, risk and reliability, total cost, and implementation and operations.

Indirect potable reuse - To date, most water reuse in the United States has been indirect potable or non-potable. Indirect potable reuse means that after extensive treatment the water spends time in an environmental buffer. This environmental buffer may be a surface reservoir or subsurface storage. The reclaimed water typically undergoes additional treatment before entering the potable distribution system. Often, the reclaimed water is blended with the utility's traditional approach.

Direct potable reuse - Direct potable reuse eliminates the environmental buffer, relying on more robust and redundant treatment that eliminates the time delay of the environmental buffer. While regulations for direct potable reuse do not currently exist on the national level, there are some states, such as California, that are actively working to develop direct potable reuse regulations. In absence of a consistent regulatory framework, different direct potable reuse systems are being explored, often driven by the individual utility circumstances. The most direct approach is to blend the reclaimed water directly into the distribution system. A more conservative approach is to introduce the treated wastewater just upstream or within the drinking water treatment process.

De-facto reuse - Often overlooked in the conversation about reuse is that water is already being used many times over in many places. Referred to as de-facto or unintentional reuse, this type of reuse occurs when a community downstream from another community utilizes a surface water supply downstream of treated wastewater discharges. There has not been a comprehensive study of the contribution of wastewater to downstream water treatment plants in the United States; however, one study was recently conducted to review and update a 1980 EPA study that focused on 25 cities. (Swayne, Boone, Bauer, & Lee, 1980) (Rice, Wutich, & Westerhoff, 2013) The results of this updated study showed an increase in the amount of sewage discharged from these 25 cities, as well as an increased contribution of wastewater to downstream drinking water facilities in most cities. In most de-facto reuse scenarios, the distance between the wastewater discharge point and the drinking water intake, creates an environmental buffer that may result in some natural attenuation of contaminants; however, some United States drinking water sources are dominated by the effluent from the upstream community, particularly at times of the year with less volume of natural flow. The following three figures from "Exploring Potable Reuse to Diversify Water Supplies," illustrate each scenario. (Whitler, 2014)

Figure 1 Scenario depicting indirect potable reuse.

Figure 2 Scenario depicting direct potable reuse.

Figure Scenario depicting de-facto potable reuse.

What are the sources of water for reuse?

There are many sources of water that utilities may look to reuse as part of their water supply portfolio. Municipal wastewater effluent is the most common source for potable reuse schemes. Some utilities are able to capture and reuse stormwater as part of their water supply. Stormwater reuse may serve a dual purpose of reducing water quality impacts in receiving streams due to stormwater runoff. Reuse of graywater (water from laundry and non-kitchen sinks) from domestic or commercial buildings, may offer utilities another supply option at a local or community scale. The Water Research Foundation is a funding partner to a National Research Council study on graywater and stormwater, entitled, Beneficial Use of Graywater and Stormwater: An Assessment of Risks, Costs, and Benefits. (National Academy of Sciences, 2014).

Where is potable reuse currently occurring?

In order to provide more context and a better understanding of how reuse has been implanted across the United States, a few examples provide an interesting perspective.

The Montebello Forebay Spreading Grounds in Los Angeles is one of the oldest reuse projects in the United States. Since the late 1930s, they have been recharging the groundwater basins with stormwater runoff. Imported water was added in the 1950s and recycled water in the 1960s to supplement this natural source, because storm water amounts are insufficient for the total replenishment needs. (Johnson, 2008)

Potable reuse projects are not just limited to California or the southwest. The Upper Occoquan Service Authority discharges highly treatment wastewater into the Occoquan Reservoir, Fairfax County Water uses that reservoir as part of their water supply. (National Research Council, 2012) (Rice, Wutich, & Westerhoff, 2013) Another example of potable reuse in the eastern part of the United States occurs in Gwinnett County, Georgia. Gwinnett County returns highly treated wastewater back into Lake Lanier, which is also their water supply source. (National Research Council, 2012) (Gwinnett County & Citizens Advisory Panel with AECOM)

One of the most recent potable reuse projects was just completed in Big Springs, TX. About 2.5MGD of reused water is utilized in this system where highly treated wastewater is blended with a raw surface water supply before going to a drinking water treatment plant. Many are hopeful this new project will address potable water reuse terminology and public perception issues. The other potable reuse project in Texas that is currently operating is in Wichita Falls. (National Research Council, 2012)

Additional case studies can be found in EPA's 2012 Water Reuse Guidelines. (US EPA, 2012)

Future Support for One Water Management and Addressing Utilities Key Issues Pursuing Potable Reuse

Key Issues – Regulations

The first and perhaps most important issue to consider is the regulatory context for the type of reuse the utility wishes to pursue. While the Clean Water Act and Safe Drinking Water Act provide a foundation for reuse schemes that protect public health, there are no U.S. federal regulations that specifically address reuse. Utilities therefore rely on state regulations in order to implement reuse. This patchwork system of state-specific regulations has left differences in what types of reuse can be done in different states. The state with perhaps the most robust regulatory framework is California as part of SB 918 and SB 322. (California Environmental Protection Agency, State Water Resources Control Board, 2014) EPA's 2012 Water Reuse Guidelines document provides detailed information on different state reuse regulations. (US EPA, 2012)

Key Issues – Public Perception

Using treated wastewater effluent directly as a drinking water source may not always be a popular idea with customers. This can present a challenging hurdle for utilities to overcome in their efforts to implement potable reuse. Fortunately, there are several successful example of public outreach that have improved public perception of potable reuse. The Groundwater Replenishment System in Orange County, CA, provides information in a variety of formats, including an extensive website, tours of the facility, fact sheets, videos, and email newsletter. Pure Water San Diego is another effort that has been successful in increasing public support for potable reuse.

Key Issues – Advanced Treatment Challenges

Treating wastewater effluent to drinking water quality requires advanced treatment. Challenges in the system design, configuration, operation, and maintenance need to be overcome. The treatment technologies used must be robust to treat a wide variety of contaminants. They need to be redundant in case one part of the system fails. They need to be resilient so that they can recover quickly from disruptions. Reliability is key so that the system provides a steady supply of pure water. WRF has sponsored several projects relating to advanced treatment, and is developing a knowledge portal to synthesize this information.

Key Issues – Residuals Management

Many advanced treatment process used for potable reuse result in concentrated residuals that the utility must dispose of properly. Many of these residual management challenges are similar to those for desalination. Please reference the desalination topic overview, concentrate management section, for additional information on residuals management.

Key Issues – Blending

Water utilities with multiple sources of supply may have experience in blending different supplies to maintain water quality and distribution system integrity. Due to the highly treated nature of potable reuse water, it may be a more aggressive water source than current supplies. Utilities therefor need to consider blending and water conditioning as part of their potable reuse distribution planning.

Although not focused specifically on blending recycled water, WRF produced a case study with Tampa Bay Water that addresses challenges from blending several sources including desalinated water, treated surface water, and treated groundwater. (Owen, 2003) Additional guidance on managing recycled water quality in the distribution system can be found in WRF project

“Characterizing Microbial Water Quality in Reclaimed Water Distribution Systems.” (Narasimhan, et al., 2005) This project characterizes the extent and nature of problems of water quality deterioration as it relates to microbial fouling and regrowth in reclaimed distribution systems. Also determines the operational procedures to best meet the needs of utilities for operation of reclaimed water storage/distribution systems and provides guidelines for the operation and maintenance of these systems.

Key Issues – Contaminants of Emerging Concern

While there are many different classes of contaminants of emerging concern (CECs), certain types of CECs that are prevalent in wastewater may raise concerns for reuse schemes that reclaim wastewater effluent. These CECs may not be removed by the wastewater treatment process and have potential, but unknown health effects. Utilities may also be challenged by communicating effectively about CECs because of their complexity. WRF has funded several studies relating to CECs and has developed a knowledge portal on the topic which provides detailed, state-of-the-science information on CECs. (WRF, 2015)

WRF Coordination Driving Solutions for Utilities Pursue Potable Reuse

WRF has a long history of research that supports utilities that are implementing or considering potable reuse. Past projects at WRF have focused on aquifer storage and recovery of reclaimed water, membrane treatment, concentrate management, public perception, and a variety of other key technical and institutional challenges associated with potable reuse.

Most recently, WRF has undertaken two direct potable reuse projects “Blending Requirements for Water from Direct Potable Reuse Treatment Facilities,” and “Assessment of Techniques to Evaluate and Demonstrate the Safety of Water from Direct Potable Reuse Treatment Facilities.” (WRF, Carollo Engineers, 2014) (WRF, Arizona State University, 2014) Miami-Dade is a participating utility for the ongoing research in the blending requirements project.

Potable reuse is not a one size fits all approach. It must be tailored to the specific location where it is being implemented. Additional research questions may arise as reuse is attempted in new places with new circumstances.

Numerous United States and international organizations are working to advance the science of potable reuse. WRF is actively coordinating with many of these organizations to ensure our subscribers have access to the most up to date and relevant information, and is working to help compile and summarize the outcomes of the many ongoing efforts at the local, state, and federal level.

As utilities plan for future water supplies, an integrated approach is needed to ensure they have resilient, reliable, and sustainable water supplies. This approach may require utilities to do things a little differently than they have in the past, partner with new agencies, and explore supply alternatives that were previously not considered. The Water Research Foundation has resources to help this new approach, and will continue to research topics to support an integrated water management approach by utilities.

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