Does water reuse make economic sense in water-rich environments?

Recycling water is a strategically smart move for many water-challenged communities, but communities with plentiful supplies may also find consideration of non-potable water reuse for agricultural and industrial applications worthwhile. Authors **Gary Hunter**, **James Schlaman**, and **Jeff Henson** at Black & Veatch; **Charles G. Stevens** at KC Water; and **Andy Clements** at the City of St. Joseph's Public Works Department in Missouri explore various reasons why reuse may benefit communities in water-rich areas.

Recycling water makes perfect sense in regions where demand regularly outpaces supply, and recycled water has long been part of many utilities' water-supply portfolios. It typically makes less economic sense for water-rich areas of the United States (US), but that is changing as more utilities consider evolving markets and revenue options for non-potable water reuse.

Non-potable applications for recycled water may include agriculture, landscape, public parks, and golf course irrigation; cooling water for power plants and oil refineries; commercial; and industrial process water. Agricultural, industrial, and commercial interest in reuse water is rising as businesses seek non-potable water supplies that are more economical, fit-for-purpose, and in line with sustainability initiatives. Significantly, while the use of non-potable water may be attractive for the value of raw water itself, the thermal value and benefits from the same could be more significant. Education efforts are paying off as investors, rate payers, and customers become savvier about the benefits and use of recycled water and are more apt to support, if not press, utility and community leaders where reuse can be leveraged to better protect potable supplies and drive greater sustainability.

Although interest in direct reuse has grown significantly in popularity in the desert southwest and other water-stressed regions of the US (e.g., California, Texas, Arizona, Florida), large-scale implementation of direct reuse is not common in water-rich regions. This is true, in part, because providing recycled water hasn't historically made financial sense where other sources of water are plentiful, and costs are relatively low. As water reuse grows in popularity, innovations in treatment technologies and alternative approaches to financing are helping drive down the cost for utilities to provide reuse water – especially in the central US.

Along with the evolving market conditions, utility leadership in traditionally water-rich areas today are beginning to recognize that variables such as regional growth, changing regulations, and aging infrastructure also play a key role in the reuse conversation. The timing and scale of water and wastewater treatment facility rehabilitations and expansions are driven by these variables, and wastewater reuse can be one strategy that extends the useful life of existing assets and drives greater cost efficiency.

Location, location, location – and other considerations

Just as location is key to real estate and business sales, location is key to favorable economics for implementing water reuse where water is

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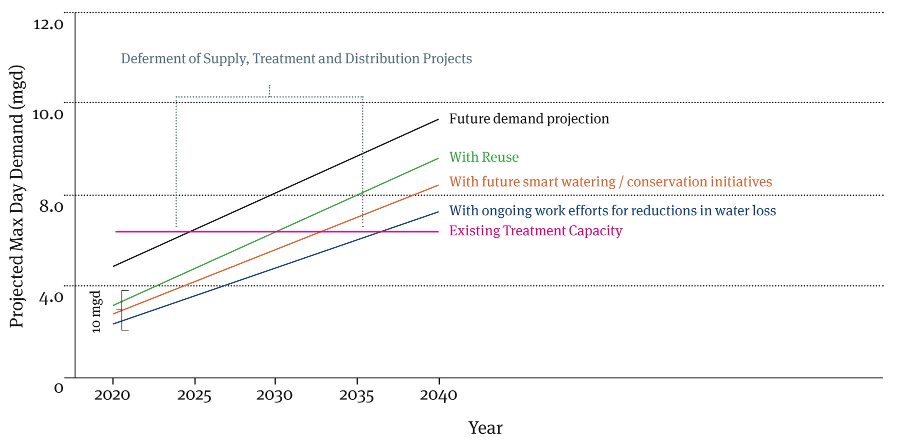
Figure 1: Impact of Water Reuse on Drinking Water Plant Capacity



Cooling Tower Water Quality Requirements

PARAMETER	PPM
Silica	11.4
Calcium	67.7
Magnesium	11.8
Iron (Total)	0.72
Chloride	149
M-Alk (CaCO3)	235
Nitrogen, ammonia	18.9
Phosphorous	4.8

Table 1 exemplifies the graywater quality needs in parts per million (ppm) of an industrial facility with cooling towers that use 5 cycles of concentration.

Opposite: Figure 4. A third approach, referred to as scalping, would position reuse facilities close to reuse customers.

plentiful. The proximity of reuse customers to utilities' water resource recovery facilities (WRRFs) is an important consideration. In general, the closer the potential reuse customers to WRRFs, the more economical the solution. Distribution costs to deliver the flow to reuse customers can become a substantial part of the reuse system cost. Studies indicate that the reuse customer needs to be within 8 kilometers (5 miles) to be cost effective.

Identifying users can be easier for utilities that provide both water and wastewater services. Utilities that provide water services can use data from water meters to identify the largest water users throughout the service area. The resulting list can serve as the starting point to screen locations, clusters, and potential reuse customers with proximity to WRRFs in mind. This type of screening process focuses on the viability of using reuse water to meet the potential customers' non-potable demands. It can be more difficult to obtain water-use information where potable water and wastewater responsibilities are divided. Additionally, industrial facilities may have their own water wells that would need to be considered during the evaluation. The overall key is to work with the industrial users to understand their water demands.

Factors to consider in addition to location include the capacity of potable drinking water and wastewater treatment facilities, the water quality and quantity needs of potential customers, the layout of potential reuse distribution networks, irrigation demands and opportunities, and potential credits for state nutrient reduction programs.

As customer needs and desires are identified, it's important to fully examine the economics of providing reuse water and how the cost charged by the utility for the reuse water impacts the potential reuse customers' actual operating costs. For instance, if a utility provides water treated by reverse osmosis, the reuse customer may be able to reduce operating costs for additional treatment of potable water to be used in cooling towers or production processes.

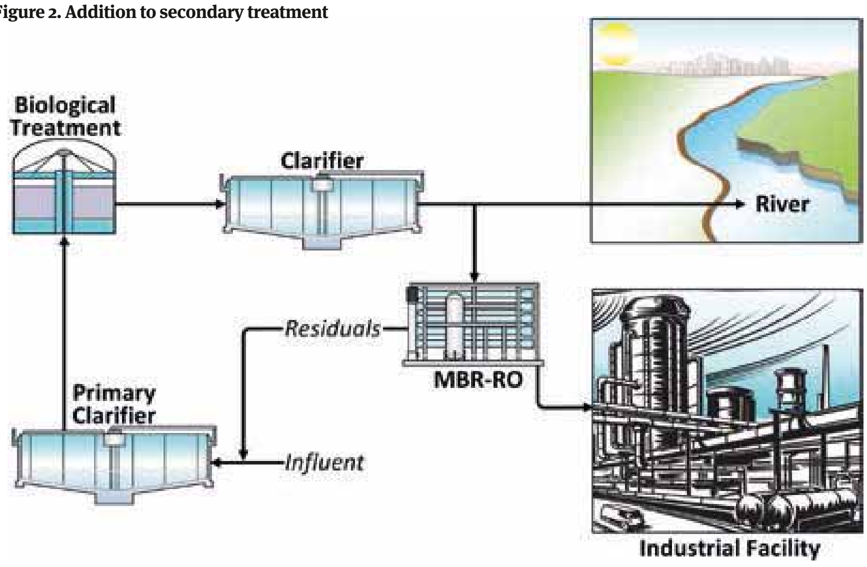
Factors considered in greater detail below include the impact on drinking water production, customer needs, treatment approach, nutrient trading, energy recovery, and the potential for direct potable reuse.

Impact on drinking water production: A plentiful water supply does not necessarily mean that potable drinking water treatment capacity will be sufficient in the future. Typically, potable water treatment plants are sized to meet peak water demand to ensure that communities always have the water they need during drought conditions.

As part of a broader water reuse study, the city of Kansas City, Missouri, US, recently examined the impacts of implementing water reuse. As Figure 1 indicates, if 37.9 million liters (10 million gallons) per day of reuse water could be provided at a viable cost to potential users, the reduction in flow would extend the life of the city's potable water treatment plant by 10 years. In effect, the costs to expand water treatment facilities could be delayed. In some cases, this approach could represent several million dollars in savings. Utilities that do not provide drinking water to their potential reuse customers may need to identify the source of supply during discussions with potential customers. Where industrial source water relies on wells that are under capacity or in need of repair – or where the water quality of the well does not meet the desired requirements – industrial customers may be more interested in reuse opportunities.

Customer needs: In water-rich areas, large industrial users such as power generation stations are strong candidates for water reuse. Industry acceptance of reuse water requires a working relationship between utilities and these water users, including an understanding of industrial water quality needs. Table 1 exemplifies the water quality needs of one type of industrial user. Gathering information about potential industrial customers' distribution pipe routing can help utilities gain a better idea of costs while helping them plan for the most direct and economical routing. Development of a closer relationship with industrial users early in the consideration and planning of a reuse program facilitates better evaluation of economics and successful deployment of reuse water.

Figure 2. Addition to secondary treatment



Wastewater reuse can be one strategy that extends the useful life of existing assets and drives greater cost efficiency.

Figure 3. Addition to primary treatment

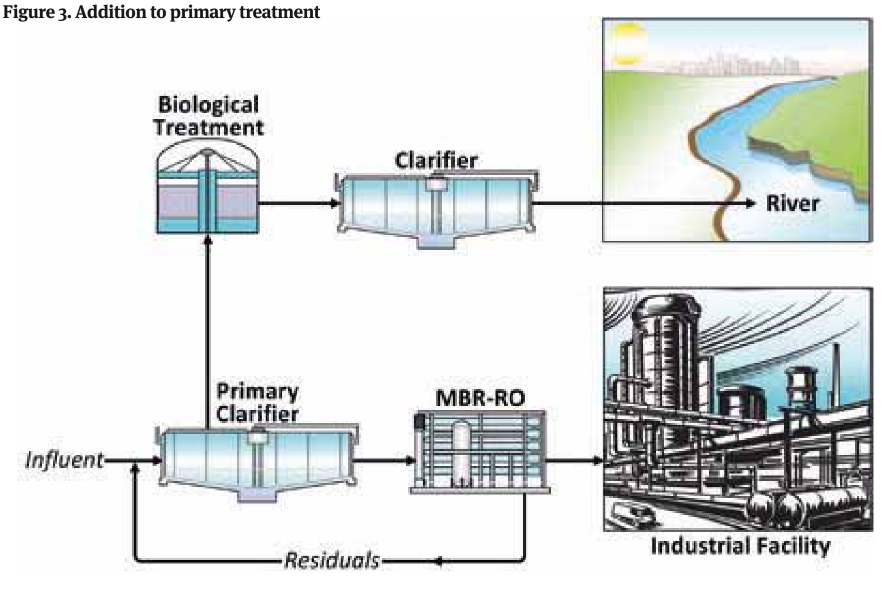


Figure 4

In addition to industrial and commercial use, irrigation – especially agricultural, golf courses, and large parks irrigation – is a possible application for recycled water. For irrigation to be a cost-effective alternative in a water-rich environment, it needs to be located near the WRRF. Furthermore, agricultural interest would typically be higher in times of drought. For applications that count precipitation as another supply option, erratic need makes water reuse a less cost-effective option.

Another potential use for reuse water in water-rich environments would be to supplement a utility's water-supply lakes and reservoirs. In some cases, this application merits consideration to increase reliability of water supply for the community. This application is worth examination as part of a reuse economic analysis, but, like agricultural irrigation, it may not make economic sense where precipitation is generally sufficient to meet demand.

Treatment approach: The optimal treatment approach will vary with the quality of reuse water requested by potential customers and the location of those customers relative to the location of the utility's existing WRRF. It is important to minimize the cost of reuse distribution systems as well as reuse treatment facilities.

Treatment may range from filtration and high-level disinfection (less than 2.2 MPN/100 (Most probable number [MPN]/ milliliters [mL] total coliform) to microfiltration (MF) and reverse osmosis (RO). Membrane bioreactors (MBRs), which combine membrane filtration with the activated sludge process, are widely used to treat water for reuse.

Figure 2 presents the most common approach. Locating reuse facilities after the secondary treatment processes enables utilities and their reuse customer to take full advantage of the treatment processes already in place. All the process schematics provided are examples of using MBRs with reverse osmosis. Utilities would need to confirm the final water quality requirements of the end users to determine actual treatment requirements.

A second approach (Figure 3), is to connect the reuse treatment facilities to the primary facilities at the treatment plant. This may be done if the reuse customers are closer to the primary part of utilities' treatment facilities. In this case, MBRs or other means of providing biological treatment and advanced filtration will likely be required to meet water quality needs required by the reuse customer.

A third approach (Figure 4), often referred to as scalping, requires installation of reuse facilities as near as possible to reuse customers. This approach may be required in large municipal communities where providing construction of a reuse distribution lines may be cost-prohibitive. In this case, additional biological treatment and MF/RO facilities may also be required to meet reuse water quality requirements.

Nutrient trading: Implementation of a reuse program would reduce the amount of water being discharged to the receiving stream, therefore providing loading capacity that may be available to allow for the implementation of nutrient trading. Nutrient trading may provide an option to offset the increased treatment requirements for biological nutrient removal (BNR) facilities. Water quality and nutrient trading programs have existed in the US as early as 1981. However, they currently have only been implemented in a limited number of states and are not widely accepted by regulatory agencies. Water Quality Trading (WQT) was introduced primarily because in many locations non-point sources are the primary nutrient loads to receiving streams. WQT incentivizes municipalities and farmers to mitigate the nutrients/sediment from nonpoint sources (NPS) and offsets the need for downstream WRRFs to provide more stringent nutrient controls.

Energy Recovery: For some reuse customers, the thermal value of the water could impact the decision to use recycled water. Industrial users who must heat the existing water supplies may require less energy to heat reuse water, which results in a net energy saving for the customers.

Direct potable reuse as a future possibility: If a utility provides the high quality needed to improve the water quality needs (using MF and RO) for a cooling tower, the water quality from the reuse facility may be at or better than that of the current community water supply. As part of a reuse analysis, the economics of both indirect potable reuse through water reservoir augmentation and direct potable reuse may be investigated for future planning purposes.

Economics 101: Supply and demand

In a water-rich environment, many community-specific factors affect the economic viability of water reuse. Location, water quality needs, treatment requirements, industrial interest, availability of nutrient credits, irrigation, and other applications for recycled water – along with the possibility of direct potable reuse – all figure into such analysis.

To assist its potential reuse customers, the city of St. Joseph, Missouri, developed a model to help its potential reuse customers understand the economics of water reuse. This model allowed potential customers to examine costs for treatment using filtration, MBR, or MBR plus RO, as well as costs for delivering reuse water (pumping and distribution). Potential customers could then model various conditions to determine their potential rates for reuse water. The model helps the customers clearly understand treatment, distribution, and financing costs while also enabling potential customers to compare the predicted rate for recycled water with current water costs that they obtain from the local water supplier. The city is using this tool to help potential reuse customers individually assess the economics of reuse based on their internal business economic requirements.

Water reuse in water-rich environments can be economically viable, but the decision to determine that viability and implement water reuse may hinge on other drivers as well. Communities that don't have a pressing need for recycled water as part of a water-supply portfolio may especially find investigation worthwhile where sustainability goals, changing climates, or other non-economic factors impact reuse decisions.

Authors' Note

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