The Place of Nonpotable Reuse in Water Management

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Nonpotable water reuse has become a viable option for supplementing public water supplies in semi-arid and humid regions of the U.S. and elsewhere in the world. The attractiveness of water reclamation for nonpotable purposes stems from the following attributes:

- Resourceful—Nonpotable reuse is often the only feasible way of supplementing water resources in a community where additional freshwater resources are not available;
- Economical—Nonpotable reuse is often the least expensive option for increasing water resources in a community;
- Serviceable—Nonpotable reuse often offers an expedient approach to pollution abatement, and treatment for nonpotable water reuse may be less costly than treatment for discharge to a receiving body of water;
- Feasible and convenient—The technology for nonpotable reuse is relatively well established, and experimental investigations are not required to establish the design criteria, except to improve or optimize the practice;
- Suitable—The public health problems associated with nonpotable reuse are more easily addressed than for potable reuse and do not require research in each instance;
- Dependable—Customers are pleased with the availability of reclaimed water because it is generally available at a significantly lower cost than freshwater and the supply may be more reliable in periods of water shortage; and
- Acceptable—Where nonpotable reuse is practiced with proper guidelines for reliability and monitoring, and such practice is now widespread, the public has been enthusiastic in its endorsement.

Experience has defined these nonpotable reuse attributes. A study done in Denver described the uncertainties that beset potable reuse.[1] For example, health issues associated with the synthetic organic compounds that are in most urban wastewaters are difficult to resolve. Even if they are resolved in Denver, the type and concentration of synthetic organics will likely be considerably different in the wastewater of other urban areas. The extensive research that has been found necesary in Denver will need to be reproduced in every instance where potable reuse is considered. Only very large suppliers can undertake such studies.

A reuse program in Tucson, on the other hand, has demonstrated that nonpotable reuse can move ahead with no need for health effects research, providing additional water resources where freshwater resources are limited and at a lower cost than other alternatives.[2] In Midland, Tex., nonpotable reuse provided an economical alternative for wastewater disposal.[3] A California municipality's experience demonstrated that special investigations are needed to enhance nonpotable reuse and technical evaluations will reduce cost and improve effectiveness.

Nonpotable reuse projects were, until recently initiated locally, without much stimulation from regulatory or water management authorities. Many projects were located in areas close to the treatment plants so additional treatment and extensive transmission pipelines were unnecessary. Thus, reuse was more of an opportunistic nature than the result of a well-planned program to supplement or replace the use of potable water for nonpotable purposes. This began to change as water demands increased and wastewater was perceived as a valuable resource. In some cases, treated wastewater was the only affordable source available of additional water and, therefore, reclaiming wastewater became more of a necessity than a means of effluent disposal. Treatment plants were built with the objective of reclaiming wastewater and not for wastewater treatment and disposal.

An example of the attractiveness of reclaimed water to meet water demands occurred during the 1976-77 drought in California, when the water shortage prompted an affected and concerned community to submit proposals for using reclaimed water and highlighted the potential of using treated wastewater for a wide variety of nonpotable purposes. Proposals included using reclaimed water at laundromats, car washes, San Francisco International

Airport to clean airplanes, and at a navy base for use during fire-fighter training. When potable water use was restricted to essential uses in Marin County, (Calif.) and extensive wastewater hauling progam was implemented in which treated wastewater was trucked to individual residences to irrigate lawns, shrubs, plants, and trees.

There are no federal regulations pertaining to wastewater reclamation, and few states have comprehensive standards or guidelines. Also, economic incentives for reclamation projects are quite limited at both state and federal levels. These factors inhibit the development and implementation of potential projects for two reasons. First, the absence of standards is viewed by some as prohibiting reuse or allowing regulatory agencies to make *ad hoc* and, perhaps, inappropriate decisions on specific projects. Secondly, without discrete regulations, requirements could change in time, become significantly more stringent in the future, and affect financial estimates; thus, the specter of having to meet a subjective "moving target" undoubtedly affects the decision-making process.

California has long recognized the benefits associated with wastewater reuse. The state legislature declared that "a substantial portion of future water requirements can be met economically by beneficial use of reclaimed water," and that "it is the intention of the legislature that the state undertake all possible steps to encourage development of water reclamation facilities so that reclaimed water may be made available to help meet the growing water requirements of the state."[5] Statutes added to the Porter-Cologne Water Quality Control Act[5] in 1977 prohibit the use of water from any suitable potable use source for the irrigation of greenbelt areas, including golf courses, cemeteries, parks, and highway landscaped areas, when suitable reclaimed water is available. Reclaimed water is considered suitable under the following conditions: the reclaimed water source is of adequate quality for such use and is available; the reclaimed water may be furnished to such greenbelt areas at a reasonable cost; reclaimed water use will not be detrimental to public health; and reclaimed water use will not affect downstream water rights, will not degrade water quality, and is not determined to be injurious to plant life.

California provided the earliest criteria encouraging engineers and communities to undertake nonpotable reuse. Title 22 of the California Administrative Code includes the "Wastewater Reclamation Criteria"[6] promulgated by the California Department of Health Services, which include water quality standards, treatment process requirements, sampling and analysis requirements, operational requirements, and treatment reliability requirements.

During the last 10 years, wastewater reclamation has been encouraged further by the Office of Water Recycling (OWR), a division of the California State Water Resources Control Board. OWR promoted wastewater reuse, identified potential projects, and provided financial assistance. Large-scale reclamation studies, such as the Orange and Los Angeles Counties (OLAC) Water Reuse Study,[7] indicated that the potential for reuse is great in the southern California area.

The impact of these and other associated activities in California increased reclaimed water use for nonpotable purposes. Wastewater reuse has increased by approximately 20% in the last eight years. While agricultural irrigation accounts for more than one-half of the use of reclaimed water in the state, the trend in recent years has been toward urban irrigation uses. At the present time, there are approximately 115 such irrigation operations, 9 industrial reuse applications, 13 landscape or recreational impoundments, and 2 salt water intrusion barriers that use reclaimed water. These do not include agricultural irrigation.

Because nonpotable reuse can be expected to be attractive in semiarid regions such as southern California, the most significant advances in reuse are state initiatives in Florida, where rainfall averages approximately 1.3 m (50 inches) per year, however water resources are limited. The Florida Department of Environmental Regulation has declared as policy the ". . . use and reuse of the lowest acceptable quality for the purpose intended."[8] This has been expressed in the rules of the Southwest Florida Water Management District which state, "Before a consumptive use permit (for water abstraction) is issued, consideration will be given to the lowest quality water which the applicant has the ability to use. If it is determined that the applicant can use lower quality water, (and) such water is available, . . . the consumptive use permit will be issued only for the use of the lower quality water."[9]

The Florida Department of Environmental Regulation[10] has reported that there are approximately 400 landscape irrigation projects in the state, including irrigation of many golf courses, and 6 industrial reuse applications—all of them for power plant cooling water. There is one large urban irrigation dual water system, however four are in the design stage and two are in the planning stage. In addition, one salt water intrusion control barrier via shallow well injection of reclaimed water is being planned.

Such practices have been identified as "source substitution," where industry, power plant, golf course, and municipal officials have found that they can substitute reclaimed water for a wide range of uses that were formerly met by scarce freshwaters. Reclamation of water for agricultural irrigation, the oldest and most extensive nonpotable reuse adopted in the U.S. and worldwide, is not the subject of this paper.

Industrial reuse

Water reclamation for industrial reuse is also not new. The oldest, and largest, application is the use of secondary effluent from the Back Bay Wastewater Treatment Plant in Baltimore for process and cooling water by the Bethlehem Steel Corporation. The most widespread application is for reuse in cooling towers. Fourteen such installations, located in seven states in the west, midwest, and east, are listed in *"Guidelines for Water Reuse,"* published by EPA in 1980.[11]

A notorious example of the attractiveness of reclaimed water for cooling towers is the contract negotiated by the city of Phoenix for the sale of its wastewater to the new Palo Verde nuclear power installation for cooling. An interesting facet of this contract is that Phoenix and several owners of the power plant were sued by a Phoenix developer who claimed that the reclaimed water should not have been allowed to be sold outside the Phoenix area; it is allegedly more valuable as a nonpotable water for Phoenix. In any event, cooling is already widely perceived as an attractive beneficial use for reclaimed water. Some facilities use a filtered secondary effluent directly, providing on-site pH and slime control. Others use secondary effluents and provide their own supplementary treatment, generally lime treatment for phosphorus removal.

Public health concerns related to wastewater use for cooling water are minimal, except where cooling towers produce plumes that may come in contact with either workers or the public. In such cases, it is prudent to provide a high quality of effluent that is essentially pathogen-free, so that incidental contact does not present undue risks of disease transmission. In California, there are no specific standards that address the use of reclaimed water for cooling, and proposals are evaluated on a case-by-case basis, taking into account the design and location of the cooling towers. The need for slime control in cooling towers, generally by chlorination, helps assure the bacteriological quality of escaping aerosols and larger water droplets.

Not yet so widely perceived as being economically attractive is the use of reclaimed water for process water in industry. Nine classes of industrial processes that can be served by reclaimed water were listed by the federal Office of Water Research and Technology in 1979, with their quality requirements.[12] These are listed in increasing order of water quality required: primary metal production, petroleum and coal products, tanning, lumber, textiles, chemicals, pulp and paper, food canning, and soft drinks.

Within each industry, and within each plant, water quality requirements may vary substantially. Pulp manufacture requires lower quality than most paper manufacture, while certain papers, such as food packaging and high-class printing, require very high quality. The latter, along with food and pharmaceutical processing may require higher than nonpotable systems provide, so that supplemental treatment is provided regardless of the source. Process water for some applications in the electronics industry requires extremely pure water, and on-site water treatment, including reverse osmosis, is often practiced.

Examples of less common industrial applications include:

Stack gas scrubbing. The McIntosh Power Plant in Lakeland, Fla., uses reclaimed water for cooling towers, and uses the blowdown from the cooling towers for scrubbing solution make-up water. This plant is subject to zero discharge limitation so that final blowdown is discharged to an artificial marsh system. Initially, trickling filter plant effluent was used directly, but bio-fouling presented problems which were solved by providing a higher degree of treatment.

The TECO Big Bend Plant near Tampa, Fla., uses reclaimed wastewater, with lime added, for scrubbing sulfur dioxide from stack gases. In addition reclaimed water is used for water seals, mist eliminator sprays, and ash pond make-up.

Phosphate mining. The international Minerals and Chemical Corporation uses secondary effluent from Bartow, Fla., for their mining operations, while eliminating effluent discharge to the Peace River. The Estech General Chemicals Corporation takes secondary effluent from the Ft. Meade, Fla., wastewater treatment plant for mining wash water.

Paper manufacturing. Two paper mills use tertiary treated effluent from the Los Angeles County Sanitation Districts' Pomona Water Reclamation Plant as process water. The Garden State Paper Company uses 11 000 m^3/d (3 mgd) of reclaimed water during newsprint reprocessing, and the Simpson Paper Company uses 4000 m^3/d (1 mgd) during the manufacture of high quality paper for stationery and wrappings. The tertiary treatment includes carbon adsorption to remove color from the wastewater.

Construction purposes. Several wastewater treatment plants in California provide secondary or tertiary effluent for soil compaction or dust control at construction projects. The effluent is tank-trucked from the treatment plants to the construction sites.

Rocket pad cooling. Rockwell International Corporation uses secondary effluent to cool rocket engine deflector pads at its Canoga Park, Calif., test facility.

Municipal nonpotable reuse

Nonpotable reuse in communities is not new. Among the landmark and better known comprehensive systems in the U.S., where the predominant use of the reclaimed water is for urban irrigation, are:[11] Grand Canyon Village, Ariz., begun in

1926, where reclaimed water is also used for toilet flushing; Colorado Springs, Colo., begun in 1960, where reclaimed water is also used for power plant cooling; Irvine Ranch Water District, Calif., begun in 1975, perhaps the best managed of such systems in the U.S.; and St. Petersburg, Fla., begun in 1977, the first major reuse project in a humid area.

All these may properly be characterized as dual distribution systems, the reclaimed water being distributed widely for diverse nonpotable uses, often including fire protection, while water of potable quality is distributed conventionally through a separate system. The adoption of dual distribution systems is growing to the extent that the American Water Works Association (AWWA) published a manual in 1983, "Dual Water System,"[13] which is now being updated.

Neither state nor federal standards for nonpotable water distribution have been developed. Pipe materials, color coding, chlorine residuals, pressures, and related features of such systems are now the responsibilty of each community, but may be subjected to approval by the reglatory agencies, some of which have developed guidelines addressing certain facets of nonpotable systems.

In California, the need for adequate design and operation of nonpotable systems has been recognized both by regulatory and operating agencies. The California Department of Health Services has developed use area guidelines pertaining to reclaimed water use. These guidelines include recommendations for cross-connection control, identification of reclaimed water lines and appurtenances, public notification, worker protection, and so on. Use area guidelines can be, and in many cases are, included in discharge requirements by the Regional Water Quality Control Boards. In 1984, the California-Nevada Section of AWWA developed a manual, "Guidelines for Distribution of Nonpotable Water,"[14] which has been endorsed by the California Department of Health Services. The manual establishes guidelines necessary for the implementation of a nonpotable water system and addresses such subjects as transmission lines, storage, pumping, onsite applications, and system management. Perhaps the Water Pollution Control Federation (WPCF) and AWWA together can evolve similar standards of practice for dual distribution systems nationwide.

Other issues relate to responsibilities for the production and distribution of reclaimed water nonpotable purposes, its regulation, and its financing:

- Where separate agencies of local government provide water supply and wastewater collection and disposal services, which agency should design, build, and operate the nonpotable distribution system?
- Separate agencies in state government are generally responsible for regulating water supply and wastewater disposal. Which agency should be responsible for regulating the production and quality of reclaimed water used for nonpotable purposes? (In California, the Department of Health Services establishes the standards, but the regulatory enforcement responsibility rests with the Regional Water Quality Control Boards.)
- Water supplies are financed generally by users of the water. Sewerage and wastewater treatment and disposal enjoy a federal subsidy. Are federal and state subsidies as available for water reclamation as they are for meeting National Pollutant Discharge Eliminaation Permits? Is the withholding of such subsidies a disincentive for water reclamation for reuse?
- Should nonpotable waters be metered; and, if so, how should prices be established?
- Where should liability rest for damage from failure to maintain service and/or quality?
- Where do technical papers on water reclamation and distribution for nonpotable reuse belong—at WPCF meetings and in its journal or at AWWA meetings and in its journal, or both? Perhaps the need for managing reclaimed water for nonpotable reuse will stimulate more common enterprise between WPCF and AWWA.

Water reclamation for urban irrigation, which includes landscape and recreational area irrigation, such as parks and golf courses, is already so widely accepted and economically and environmentally attractive that its adoption is spreading rapidly even where standards and regulations are not yet adopted. While the potential for nonpotable reuse is obvious in arid regions, in humid regions reuse is becoming increasingly attractive as insurance in dry periods when water resources are limited and as an alternative to discharge to surface waters.

Dual water systems that make reclaimed water available throughout a community for irrigation and other uses where significant portions of the populations will be exposed should be safe from a microbiological standpoint such that inadvertant contact or ingestion does not constitute a health hazard. Therefore, wastewater treatment that reliably produces an effluent free of measurable pathogens and bacteriologically equivalent to potable water is necessary for such systems. On the other hand, trace organic and heavy metal contaminants, which are of concern only when ingested over many years, require little attention. Accordingly, the treatment most widely adopted for nonpotable distribution is biological wastewater treatment followed by coagulation, filtration, and chlorination. The most important quality measure (other than the microbiological quality) is turbidity, which is generally required to be less than 1 to 2 NTUs. Low turbidity is necessary to preserve aesthetic quality as well as to assure disinfection at reasonable dosages. In any event, the issue of trihalomethane formation does not arise.

Distribution of nonpotable water throughout a community makes applications other than urban irrigation attractive. Industrial reuse for process and cooling water was discussed earlier. Still neglected, however, is the use of reclaimed water for toilet flushing which, next to lawn irrigation, is the largest residential use (Grand Canyon Village is a special case.). In Singapore, a 38 000-m^3/d (10-mgd) water reclamation facility, uses secondary wastewater treatment plant effluent, which otherwise would be discharged into the sea, for industrial process water. The nonpotable system was then extended to new 12-story multi-family housing serving some 25 000 people where the reclaimed water is used for toilet flushing.

Use of reclaimed water for toilet flushing will be more economically attractive in large multi-family housing, commercial buildings, and the like, than it will be in single-family houses. Also its regulation in such settings is much easier because of a better degree of overall system control by responsible agencies. Proper design, operation, and management of dual piping systems within buildings are critical to avoid misuse, either intentional or accidental, of the reclaimed water, and it is particularly important to minimize the potenial for cross-connections with the potable water supply.

Summary

Water reclamation for nonpotable reuse in municipalities is being widely adopted throughout the U.S. for urban irrigation and other uses, often to the extent of providing dual distribution systems. Communities and their engineers should consider nonpotable reuse as one of the options for evaluation when additional water resources will be developed. However, several issues need to be addressed if this practice is to continue to receive professional and public acceptance.

- Agencies in local and state government that should have replanning, design, construction, operation, and financing of nonpotable reclaimed water systems must be identified.
- Practices and standards need to be developed and codified to provide guidance and assurance to communities that they can adopt sound water reclamation programs.
- The potential markets for reclaimed water, such as toilet flushing, car and street washing, and construction, need to be identified and developed so as to release additional high quality water for potable purposes; and lastly,
- National and state agencies should, at the very least, eliminate deterrents to nonpotable reuse and preferably provide leadership in its adoption.

Although some states have regulations and guidelines pertaining to various types of nonpotable reuse, comprehensive policies that address economic and management aspects of reuse are lacking. Some states are beginning to develop policies that urge consideration of reuse. These need to be extended if nonpotable reuse is to receive the consideration it deserves as an option for meeting increasing water demands.

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