Rethinking decentralized systems

A new tool for sustainable water management

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Left, Battery Park City, N.Y., is an urban example of the decentralized approach, with some buildings reusing reclaimed wastewater and stormwater. Above, the courtyard at the Chatham County, N.C., Jordan Lake Business Center, where the water reclamation and reuse system is designed to emphasize both design and function.

When visitors to the Jordan Lake Business Center (JLBC) in Chatham County, N.C., look out the window, they see an attractive courtyard and indoor atrium. What Hal House sees is a sustainable, highly effective – and multifunctional – water reclamation and reuse system. House is one of a growing number of practitioners developing new and innovative uses for decentralized wastewater systems. His company, Integrated Water Strategies (Apex, N.C.), uses natural ecosystem functions for inspiration, resulting in systems that are at once attractive, functional, and efficient. "We are designing reclaimed water systems based on natural systems such as tidal wetlands, and integrating them into green buildings in a variety of different areas," House said.

Lower Manhattan in New York City couldn't be any more different from Chatham County, but Ed Clerico, president of Alliance Environmental (Hillsborough, N.J.), also has been implementing decentralized water reclamation systems in new buildings there and in other dense urban landscapes. "The economics are really starting to drive these new approaches," according to Clerico, "and the environmental and social benefits are just icing on the cake."

Recent research by the Water Environment Research Foundation (WERF; Alexandria, Va.) identified a number of emerging applications for decentralized wastewater systems in rural, suburban, and urban areas where traditional sewer options were available. These include systems integrated into green buildings such as the JLBC, as well as a phased system installation for communities striving to support existing residents and new development, and the targeted use of decentralized systems by traditional municipal water and wastewater utilities to improve service and efficiently provide local sources of reclaimed water.

A growing trend

Decentralized systems historically have been used in areas where public sewer service was impractical, unnecessary to meet regulations, or too expensive. Some of these traditional settings include septic systems serving residences on large rural lots, historic villages developed before modern sewer systems, and small towns or developments outside of major urban areas that could be more economically served by cluster systems rather than by extensions of centralized sewer systems. Decentralized systems often were considered a temporary solution until public sewers were available.

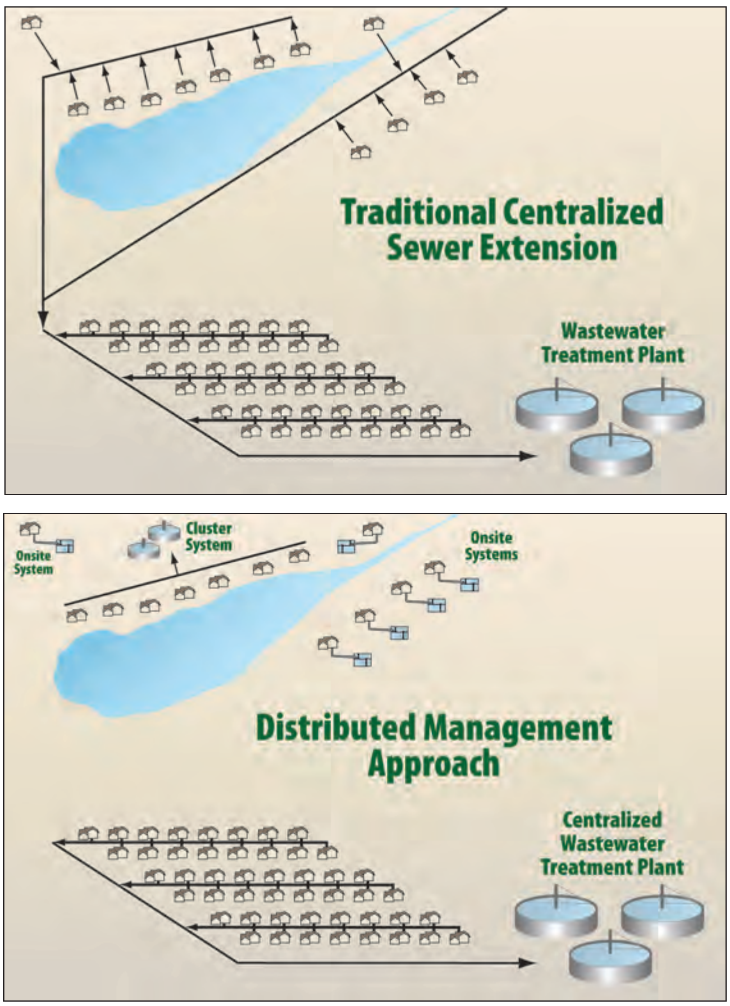
However, just as the economic and environmental demands associated with an aging national water infrastructure system have grown, it has become apparent that decentralized systems also need to be properly managed as critical wastewater assets over the long term. Additionally, a number of leading practitioners have recognized that decentralization will be a critical element of more sustainable, paradigm-shifting urban and suburban water infrastructure systems of the future because of their various "triple-bottom-line" economic, environmental, and social benefits.

Economic advantages

In the early 1990s, Loudoun County, Va., a suburb of Washington, D.C., decided to rely on the integrated management of both centralized and decentralized systems (sometimes called "distributed management"), including professionally managed cluster wastewater systems for new development outside of the utility's centralized service area. According to Todd Danielson, formerly Loudoun Water's manager of community systems, the county's approach to wastewater service is for growth to pay for growth: Developers design and construct cluster wastewater facilities to Loudoun Water standards and then transfer ownership to the utility for continued maintenance. "In addition to these financing benefits, [this] distributed management approach allows each development to proceed on its own without having to wait for other developments 'to bring the line out' and also better addresses sustainability, often by recharging the groundwater that serves as the water system's source water," Danielson said.

Like Loudoun County, Piperton, Tenn., requires developers to pay for their own infrastructure and then turn it over to the city to own and operate, eliminating the tax burden that would have been placed on existing residences if a centralized plant had been constructed, particularly since the current tax base is small compared with the city's future population growth projections. Because of the town's clear ordinances and well-established protocols, permits are easier to obtain in Piperton than in the surrounding area, attracting development to Piperton, which now has more than 1 million L/d (280,000 gal/d) of wastewater treatment capacity serving six subdivisions. These cluster systems include septic tank effluent pump, septic tank effluent gravity, and low-pressure sewer collection systems; trickling filter treatment; and ultraviolet (UV) disinfection with drip irrigation used for effluent dispersal.

This distributed approach to wastewater service gives the city independence with its own infrastructure and ultimately is better for public health and the environment than the other alternatives considered. According to Craig Lindell of AquaPoint Inc. (New Bedford, Mass.), the wastewater system designer and manufacturer, among the system's advantages, "perhaps the biggest benefit of a distributed sewer for Piperton is the ability to build when and where needed, thereby eliminating a huge capital outlay and burden on taxpayers for a central plant and sewer system."



In a distributed approach to wastewater management, a variety of system scales are used to provide treatment that matches the context.

The 20-year plan for the LOTT Alliance, a water utility providing sewer service for the Lacey–Olympia–Tumwater urban area of Washington state, calls for the construction of three satellite reclaimed water treatment plants. As currently planned, each satellite plant would initially be built to treat at least 3.8 million L/d (1 mgd), expandable up to 19 million L/d (5 mgd). Building the satellite plants in smaller, decentralized increments is intended to allow "just-in-time" construction to meet future wastewater treatment needs. This strategy is expected to save the alliance an estimated $87 million over the course of its 20-year capital improvements planning period, while minimizing risk, wisely managing community resources, and taking advantage of the latest advances in technology.

Environmental performance

As illustrated by the LOTT Alliance's 20-year plan, decentralized approaches are being used to treat and reuse wastewater close to its source or reclaimed water reuse area, potentially saving energy, money, and greenhouse gas emissions associated with extensive collection and reclaimed water distribution systems. The Solaire and other buildings in Battery Park City, a mixed-use community of residential, commercial, and institutional properties along the Hudson River on the southern end of Manhattan in New York City, each have building-scale water reuse systems (using reclaimed wastewater and stormwater) that provide nonpotable water for toilet flushing, cooling, laundry, and irrigation. Wastewater is mined from within The Solaire and treated using a membrane bioreactor (MBR) followed by ozonation and UV disinfection – all of which are built into the basement of the building. The building also features a green roof to capture and filter rainwater.

In addition to the efficiencies associated with localized treatment, the use of passive (or less mechanically complex) systems often is more feasible at the smaller scales associated with decentralized treatment. Like the JLBC, water management systems at Sidwell Friends School in urban Washington, D.C., uses natural systems for wastewater treatment and reuse that are exposed and are part of the "working" landscape of the school's entrance courtyard. Wastewater is treated using recirculating sand filters, trickling filters, and a series of terraced constructed wetland cells integrated into the landscape. Reclaimed wastewater is recycled for toilet flushing and cooling towers. An integrated water monitoring system tracks wastewater and recycled water flows and is used as a teaching tool in the school's curriculum. The building has received a Leadership in Energy and Environmental Design platinum rating and has won an American Institute of Architects award as a top green building project.

Prepackaged fixed media filtration units such as this one are commonly used to provide affordable and effective treatment in decentralized systems.

Decentralized wastewater and stormwater systems also are valuable tools for implementing watershed management plans and can be used to complement local climate change adaptation and mitigation efforts. Land application of treated wastewater, whether through reuse or soil dispersal, helps to restore natural hydrology, recharge groundwater resources, and ultimately augment stream baseflows that may have been disrupted by growth and development. In densely settled Wickford Village in North Kingston, R.I., a geographic information system-based watershed analysis showed that nitrogen associated with substandard septic systems was affecting adjacent Narragansett Bay. In lieu of connecting to a nearby state-owned wastewater treatment facility, the town chose to adopt a decentralized approach, creating a wastewater management program that requires all homeowners to regularly inspect and maintain septic systems and report problems to the town. Repairs and upgrades of onsite systems with advanced technologies also were encouraged for homeowners in high-risk areas. Priority areas were established to better match treatment technology and grant funding with watershed sensitivity.

Societal perspectives

Professionally managed decentralized systems can provide important benefits to the broader community. Water and wastewater utilities are better able to properly manage decentralized systems than a homeowner, association, or developer. In addition to minimizing the cost exposure associated with improperly managed, malfunctioning systems, professionally managed decentralized systems are less likely to have negative effects on shared local ground and surface water resources. The Village of Warren, Vt., provides centralized management (town administrator, wastewater board, and contract technicians) for a variety of decentralized systems, ranging in size from individual onsite systems to a 113,000-L/d (30,000-gal/d) cluster system. Following a significant amount of scientific assessment, and homeowner and regulator education and outreach regarding pretreatment technologies and decentralized cluster systems, the community overwhelmingly passed a vote to issue bonds for the local share of funding for implementing the management program, including system construction.

Decentralized systems can be an important tool for accommodating growth and development in a way that doesn't tax community resources. For example, preservation of the town's historic character was a major factor in the decision to better manage onsite systems rather than build a public sewer in Wickford Village. Residents and village officials also were concerned that the secondary impacts of a public sewer, including the stormwater runoff associated with new development, would offset potential water quality benefits. In Loudoun County, Va., exurban growth is managed using cluster wastewater treatment and dispersal systems along with sound land use planning and associated zoning.

As illustrated by the Sidwell Friends School and JLBC examples, decentralized systems can be integrated into buildings and landscapes and designed to provide multiple functions as

The Solaire integrates rainwater harvested from this green roof with reclaimed wastewater treated using a membrane bioreactor to provide reclaimed water for indoor and outdoor reuses.

recreational and educational amenities. At the Dockside Green development in Victoria, British Columbia, treated wastewater is stored and conveyed using a restored stream–pond complex. The stream acts as a reclaimed water conveyance and partial polishing treatment system integrated into the landscape as a site amenity, which enhances residential unit values, more than offsetting associated costs. An additional revenue source results from a colocated energy plant, which gasifies wastewater treatment residuals.

At the Pennant Hills Golf Club in Sydney, Australia, wastewater is mined from a passing sewer main and treated onsite to provide a local source of reclaimed water for irrigating the championship-caliber course during periods of drought and associated potable water use restrictions. As Kurt Dahl, managing director of Permeate Partners (Sydney) that operates the Pennant Hills plant, explained, "For many potential reclaimed water customers, it is technically and/or economically infeasible to install traditional centralized reclaimed water systems. However, for certain users, such as Pennant Hills Golf Course, sewer mining and satellite reuse systems provide a cost-effective means for augmenting existing water supplies." The public–private project uses an MBR system to produce 650,000 L/d (172,000 gal/d) of reclaimed water, which is used to irrigate 22 ha (55 ac) of greens, tees, and fairways.

Challenges and opportunities

The University of North Carolina–Chapel Hill is considering developing a nonpotable water supply for a planned satellite campus that will include more than 60 new buildings when complete. The new campus is envisioned to be a model of sustainability, and there is a strong desire throughout the community not to expand the local water supply beyond its current, well-protected supply reservoirs. Patrick Davis, sustainability manager of Orange Water and Sewer Authority (OWASA; Chapel Hill, N.C.), believes there is great promise in the well-managed use of decentralized reclamation and reuse systems at the new campus and in other applications. However, he also has questions about how the management of these systems might affect the operations of traditional water and sewer utilities such as OWASA.

"As research moves forward, public utilities and other stakeholders will need help answering questions, including but not limited to: What are the capital, and operating and maintenance costs for these types of systems? What is the carbon footprint of these systems compared to conventional systems and other alternatives? What impact will these technologies have on our service levels, operating revenues, and business model? And what rate structures will be needed to fully and equitably recover costs and ensure the financial sustainability of these systems?" Davis said. Although the answers are often community and context-specific, research sponsored by the Decentralized Water Resources Collaborative (DWRC) and managed by WERF and others over the past decade have begun to address questions raised by Davis and other utility managers.

DWRC, formally known as the National Decentralized Water Resources Capacity Development Project, is a cooperative effort funded by the U.S. Environmental Protection Agency to support research and development on decentralized wastewater and stormwater systems. DWRC was established to improve the capacity of electric utilities, water and wastewater utilities, municipalities, engineers, contractors, regulators, and other public and private entities to respond to the increasing complexities of and expanding need for decentralized wastewater and stormwater systems. DWRC has sponsored more than 70 projects since 2000 in three broad topical areas: environmental science and engineering; management, economics, and policy; and training and education. Although federally sponsored research and development efforts began in the 1940s and continued for decades, the more focused and sustained efforts of DWRC have helped clarify the role of decentralized systems as essential elements of a sustainable wastewater infrastructure portfolio for the United States.

A series of new tools has been developed to help stakeholders navigate various research products developed by DWRC, including a frequently-asked-questions guide, project matrix, informational video, and brochures targeted to different audiences. These tools can be accessed at www.werf.org/decentralizedoutreach. Case studies for many of the projects featured in this article can be found at www.werf.org/distributedwater.

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