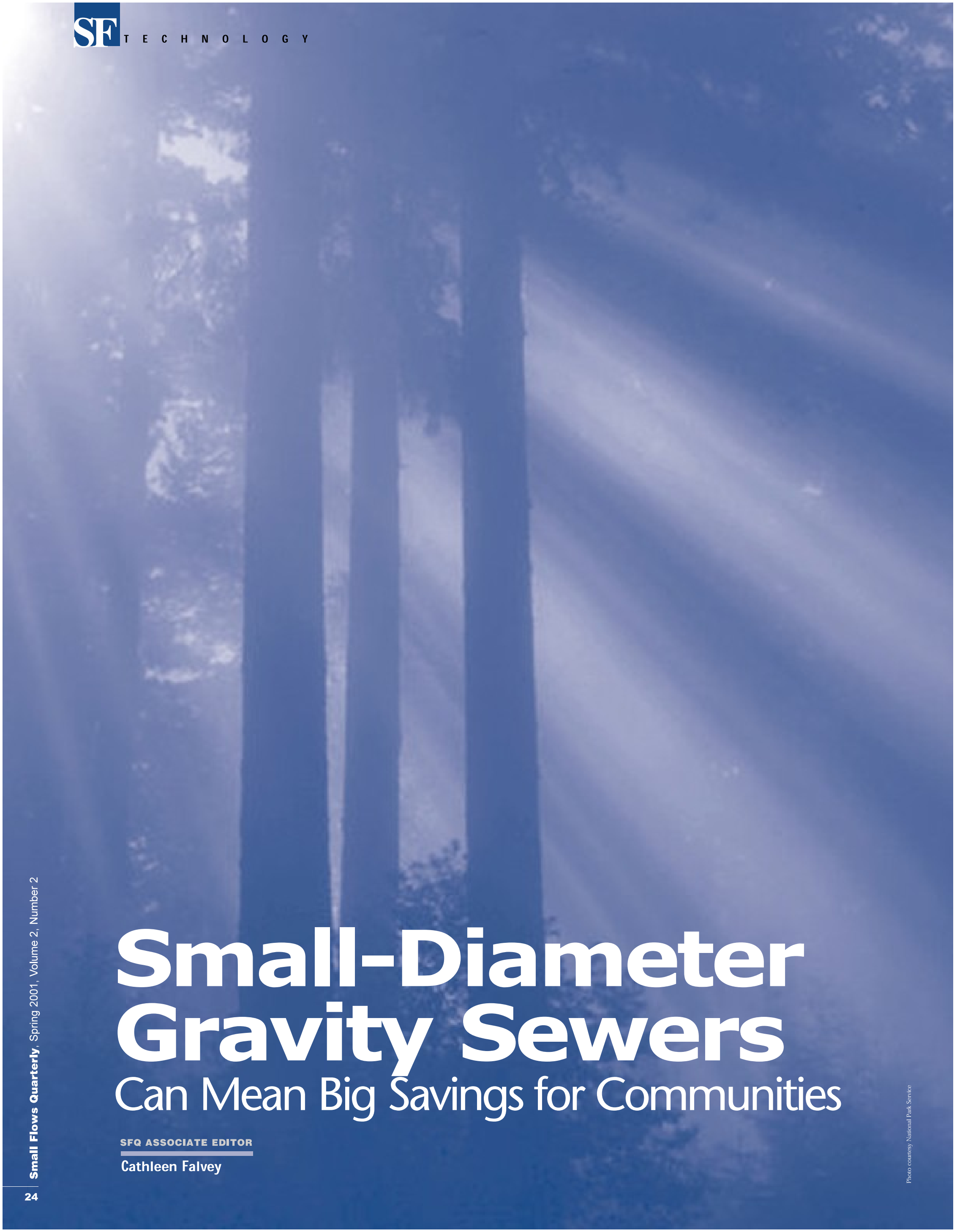

Small-Diameter Gravity Sewers

Can Mean Big Savings for Communities

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Photo courtesy National Park Service

For years, a sign at the edge of the tiny town of Miranda, California, welcomed visitors to "The Land of Enchantment." Located on the famous "Avenue of the Giants," Miranda's residents live among one of Earth's true wonders—the giant redwoods.

However, by the 1970s, failing septic systems were leaving many in the town feeling less than enchanted. A former logging community, Miranda has only 350 permanent residents, many of whom are retired; yet more than 500 students from surrounding areas attend the local schools. The town needed an economical solution to its wastewater treatment problems, so residents obtained a grant from the U.S. Environmental Protection Agency and the state of California to study the problem and investigate wastewater collection and treatment alternatives (Campos, 1984).

After evaluating different technologies, Miranda chose to install a small-diameter gravity sewer system to collect effluent from individual septic tanks. The system serves 125 residential, commercial, and institutional connections in the town, including the high school, a junior high, two rest homes, and three churches. Septic tank effluent is transported by gravity to two lagoons, which precede an intermittently-dosed recirculating sand filter for final treatment.

Miranda completed its system in 1982, and according to volunteer operator Bert Stevens, it has been operating successfully ever since. "We've had people from all over the world come to visit our little system, " said Stevens. "It has worked so well over the years."

At the time it was installed, Miranda's system was one of the first small-diameter gravity collection systems built in the U.S. Since then, many more communities around the country have chosen this alternative to conventional gravity sewers because of its low installation and operation costs, and because it is well-suited to their particular site characteristics.

How Small-Diameter Gravity Sewers Work

Small-diameter gravity sewer (SDGS) systems are known by a variety of names, including variable grade sewers, septic tank effluent gravity (STEG) systems, and effluent drains. The technology was pioneered in the 1960s in Australia where much of the terrain is extremely flat. SDGS systems can work well in very flat terrain, because settleable solids are not conveyed through the collection lines. Therefore, SDGS systems require less hydraulic gradient and velocity to transport the wastewater through the lines than is necessary with conventional sewers. The lines also can be laid at shallower depths, which saves on system installation costs. In addition, SDGS systems do not employ manholes and require fewer lift stations, reducing system maintenance costs.

In a SDGS system, grease and solid materials in the wastewater are separated out at each connection in a septic tank, which system designers sometimes refer to as the interceptor tank. The septic tank is connected to the house or business by a standard 4-inch building sewer. A small-diameter (approximately 2-inch) service lateral on the homeowner's property conveys the septic tank effluent to the SDGS main.

The size of SDGS mains are calculated based on the peak hydraulic flow rate and the hydraulic velocity needed to transport the wastewater through the entire system. The mains typically range from 2 to 8 inches in diameter. Design professionals calculate the pipe diameter necessary by using the Hazen-Williams formula, Manning's equation, or the Darcy-Weisbach equation (EPA, 1986; Crites and Tchobanoglous, 1998).

Unlike conventional gravity sewers lines, which often are constructed of concrete or clay, SDGS pipes are similar to pressure sewer lines and are made of polyvinyl chloride (PVC) or high-density polyethylhlene. The joints are solvent weld or rubber gasket, and the system usually employs cleanouts or pigging ports instead of manholes, reducing the possibility of inflow and infiltration of stormwater and groundwater.

Air release or combination air release/vacuum valves may be installed for air venting at high points in the system layout. Check valves may be present at each connection with the main to prevent backflow during periods of high flow (EPA, 1991).

SDGS Systems Can Be Adapted to a Variety of Terrains

Similar to pressure and vacuum sewers, SDGS lines are laid at a relatively constant, shallow depth, following the natural contour of the land. So in communities with hills, the wastewater will flow downhill in some areas and uphill in others (hence the name variable grade sewers). These up and down flow patterns are possible as long as the beginning of the SDGS system is higher overall than its final destination—the outlet to the treatment facility. Also, the system should be low enough to receive flows from the majority of service connections by gravity.

Photo courtesy of the Humboldt County Convention & Visitors Bureau

Ideally, the SDGS system outlet should be lower than any individual building connected to the sewer. However, if homes or businesses are located below the system, they often can connect by installing a septic tank effluent pump (STEP) system. Most SDGS systems are actually combination STEP/SDGS systems. Such hybrid designs can minimize or eliminate the need for costly lift stations. (STEP systems are described in detail in the articles "Pressure Sewers Overcome Tough Terrain and Reduce Installation Costs" on page 24, and "STEP System Clears the Air in Illinois Village" on page 28 of the Winter 2001 *Small Flows Quarterly*. The issue can be accessed online at *www.nsfc.wvu.edu*.)

System design engineers typically make use of spreadsheets and design software to plan the overall layout and design of SDGS systems.

Which Communities Should Consider SDGS Systems?

Dick Otis, P.E., Ph.D., of Ayres Associates in Madison, Wisconsin, has been involved in the design of several SDGS systems, including some of the first in the U.S. He states that although they have many advantages, SDGSs are not necessarily the best option for every community.

Photos courtesy of Jan Adams Photography

Above, redwoods are logged near Miranda in Humboldt County, California. Both Miranda and Conrath, Wisconsin, are former logging towns. Both chose small-diameter gravity sewer systems in lieu of conventional sewers.

"It's never the case that one system fits all communities," says Otis. "You have to look at each situation individually. What we try to do with SDGS systems is to reduce excavation costs. If a community has simple slopes all going in the same direction, then SDGS systems may be the best option. But if the treatment plant is uphill, or if the town has undulating topography, then pressure sewers may be a better option."

Any small community that is considering building a conventional sewer system should give small-diameter sewers a look. Systems such as SDGS, vacuum, and pressure sewers can save communities money in a variety of ways.

For example, in addition to lower excavation costs, SDGS systems also can help communities save on final wastewater treatment costs, because the solids and grease in wastewater are separated and treated in septic tanks. Therefore, the need for headworks is reduced in the final treatment facility, because screening and grit removal is not necessary. As a result, inexpensive systems, such as sand filters or lagoons, can be used to provide final treatment.

Also with SDGS, systems communities do not have the burden of removing, treating, and disposing of sludge after final treatment. Instead septage can be removed less expensively from septic tanks at regularly scheduled intervals. Before deciding on conventional gravity sewers, communities should compare the life cycle costs of these low-tech wastewater treatment systems with the costs of constructing a traditional mechanical treatment facility and staffing and maintaining it over the years.

More SDGS Pros and Cons

SDGS system mains usually are run down the side of streets rather than down the middle and below the pavement like those of most conventional sewers. In densely populated areas, collector mains may be located on both sides of the street to minimize pavement crossings, or, less commonly, they may run along backlots to be closer to preexisting septic tanks. Therefore, extensive pavement excavation and restoration isn't usually necessary with SDGS systems, which translate to additional savings on installation costs and less disruption to the environment and everyday life.

Communities also save when installing SDGS systems because only shallow, narrow trenches are required. SDGS mains also are simpler to install than conventional gravity mains, which must be strictly aligned vertically and horizontally. The plastic SDGS mains can be laid at varying grades and can be easily routed around obstacles discovered during construction, such as large boulders.

However, many communities that choose SDGS systems must replace all their old septic tanks with new ones to ensure system performance. Sometimes, new septic tanks are relocated to front yards to be closer to the SDGS mains. This additional excavation should be factored into overall installation costs.

Because SDGS systems include onsite components, the community or management entity may need to go through the time-consuming and sometimes difficult process of obtaining easements and the cooperation of individual property owners to successfully complete the project.

Odors from hydrogen sulfide in the wastewater can sometimes be a nuisance with SDGS systems. Engineers often can prevent odor problems, for example, by carefully designing how ventilation is provided in the system and by avoiding turbulence in the mains. Other odor control measures include the use of carbon filters with air release valves, aerating the lines, chlorinating the final effluent, or adding hydrogen peroxide to the system.

Operation and Maintenance Requirements

Steve McHaney, assistant region manager for Winzler & Kelly, the firm that designed Miranda's system, believes that while SDGSs don't have particularly rigorous operation and maintenance requirements, taking proper care of them is of critical importance.

"We will consider SDGS systems only in situations where we know we can get good quality maintenance for the septic tanks—communities with a septic tank maintenance district, for example," says McHaney. "If you don't have good clean effluent going into the lines, then you'll have solids carryover that can clog the service lines and the mains."

Miranda has a formal maintenance district. Bert Stevens performs or supervises all maintenance to Miranda's system on a part-time, volunteer basis. He estimates that he spends an average of about two hours per day, mostly in maintaining the final treatment system rather than the SDGS system.

"Mostly we check the meters at the sand filter to make sure that the system is running," Stevens said. "We monitor water quality leaving the system, fill out our monthly reports, and do things such as check and change valves and pull weeds out of the ponds. All septic tanks are pumped every five years, unless there is a problem with them sooner. The septic tanks at the rest homes and commercial establishments have different requirements and are pumped more often."

Stevens says that the small-diameter collection system itself has required little maintenance over the years. "We have it on our agenda to flush the lines every four years or so," said Stevens. "We have manholes with our system as well as cleanouts, so occasionally groundwater and stormwater get into the system."

Miranda residents pay a $25 per month base fee for water and sewer, plus additional fees for individual water use. The fee includes any service calls for septic tanks and all costs for periodic pumping.

Conrath, Wisconsin

Although they live on opposite sides of the country, Bert Stevens and Louie Konieczny have been living parallel lives. Konieczny is the wastewater treatment plant operator for the village of Conrath, Wisconsin. Like Stevens, a retired logging truck owner, Konieczny is a retired auto shop owner who was originally enlisted by his community to operate the local wastewater system because "there was no one else to do it."

Conrath also is a former logging community like Miranda. It was incorporated more than 90 years ago. According to Konieczny, the town has always had about 100 residents.

"I've been here for about 50 years," he says. "We're just a little town that never grew. We have about 38 homes, a church, a school with only about 30 students, three commercial establishments and farmland all around. One business is a convenience store, one is a feedmill with a bathroom, and one is a garage with two bathrooms. But all of our wastewater is septage—no chemicals. None of their commercial waste goes into our system. "

Like Stevens, Konieczny oversees the operation and maintenance of the SDGS system; the subsurface, intermittently-dosed sand filter; and the septic tanks. The SDGS lines require little maintenance. Yet he performs all the paperwork and sees that all the septic tanks are pumped every three years. "We pump one-third of the septic tanks every fall to pace ourselves," he says.

The town hires a local contractor to do the septic tank pumping. The septage is mixed with lime and is land applied and buried nearby on fields volunteered by two local farmers. The town alternates the use of the fields.

About six homes in Conrath are located below the system and are connected via STEP systems. Konieczny also helps maintain the STEP system pumps and the pumps at a lift station, which precedes the sand filter. Two 1,000-gallon holding tanks also precede the sand filter and act as additional septic tanks. These final tanks are pumped and cleaned every year. Konieczny says that the sand filter requires little maintenance, but that he sometimes must clean the bulbs of an ultraviolet (UV) disinfection unit that follows the sand filter. He says that the UV filter is only required seasonally, and that the entire system has done an excellent job throughout its 11 years of operation.

Most SDGS systems are actually combination STEP/SDGS systems. Such hybrid designs can minimize or eliminate the need for costly lift stations.

"The wastewater system discharges to Main Creek," says Konieczny. "The creek has been polluted over the years by farming, but the effluent we discharge is at least 50 times cleaner than the water in the creek, even in the winter without UV disinfection."

Above: Miranda High School, circa 1940. Today the school looks much the same and continues to be fully enrolled by serving students from surrounding communities.

Konieczny says that fecal coliform values usually range from 0 to 9 or 10 most probable number (MPN)/100 milliliters (mL) in the summer, when they are allowed 400 MPN/100 mL. Testing for fecal coliforms is not required in the winter.

The firm of Morgan & Parmley Limited in nearby Ladysmith, Wisconsin, designed the system for Conrath and confirms that the SDGS/sand filter system has served the community well.

"Effluent from Conrath's system averages only 2 milligrams per liter (mg/L) biochemical oxygen demand (BOD), and total suspended solids from the system is in the single digits when the design requirement is 30," says Bob Parmley, president of Morgan & Parmley. "To my knowledge, the collection system hasn't had any problems and hasn't needed to be flushed out or unclogged in the past 11 years."

Parmley says that he first began working with Conrath in the 1980s during the facility planning process, and that his firm proposed several possible systems to residents.

"The soils in the community are very tight, so all the septic systems were failing," says Parmley. "Conrath decided on the SDGS/sand filter system because it was the least expensive and also the most environmentally sound option. As it turned out, the system was classified as being innovative, which qualified it for additional funding. But that wasn't at all part of the town's original motivation."

According to Parmley, Conrath installed all new septic tanks with their SDGS system. Konieczny says the septic tanks are all owned by the town, "so residents don't have to worry about maintenance; the town does all the maintenance." Sewage fees are $20 per month per household.

For More Information

If you would like to know more about Miranda, California's SDGS system, contact Neal Carnam or Steve McHaney at (707) 443-8326, or by e-mail to *nealcarnam@w-and-k.com.*

Bob Parmley can answer questions about Conrath, Wisconsin's SDGS system. He can be reached at (715) 532-3721.

References

Campos, Marilyn Miller. 1985. Innovative wastewater collection and treatment—Miranda, California. *Proceedings 1985 International Symposium on Urban Hydrology, Hydraulic Infrastructures and Water Quality Control.* University of Kentucky, Lexington.

Crites, R., and G. Tchobanoglous. 1998. *Small and decentralized wastewater management systems.* New York: WCB/McGraw Hill, Inc.

U.S. Environmental Protection Agency (EPA). 1986. *Small-diameter gravity sewers: an alternative for unsewered communities.* Cincinnati: Water Engineering Research Laboratory. EPA 600/S2-86/022.

———. 1991. *Alternative wastewater collection systems.* Washington D.C.: U.S. EPA Office of Research and Development. Office of Water. EPA 625/1-91/024. NSFC Item #WWBKDM53.