Beyond Gravity

Lessons from the largest low-pressure sewer project in New England

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The town of Marion, Mass., is a coastal community that suffers from high groundwater and variable terrain. This resort community has many vacation homes turned into year-round residences and still many vacation homes closed up for the winter. Since the homes are built fairly close together, land availability is limited. The town chose low-pressure sewers (LPSs) over gravity sewers as part of its sewer expansion project in 2004. LPSs were chosen as the best alternative methodology for design, installation, and operations and maintenance (O&M). Having gained public acceptance and buy-in for this unconventional system, Marion's 455-home project is the largest single-contract LPS system in the northeastern United States.

Affected Areas

The Marion Sewer Expansion Project was designed and constructed to fulfill the recommendations of the town's Comprehensive Wastewater Management Plan and an administrative consent order between the town and the Massachusetts Department of Environmental Protection that required the town to increase its wastewater treatment capacity. The town's wastewater management plan identified three neighborhoods requiring offsite wastewater treatment due to their soils, groundwater conditions, past onsite system problems, potential to meet state Title 5 regulations, population density, lot sizes, and other factors. These three neighborhoods are known as the Berry, South Converse, and Dexter Beach areas.

Two of the three neighborhoods abut the Atlantic Ocean and thus present problems, including variable terrain that slopes toward the water, small lots associated with vacation cottages, and a high groundwater table, which likely would cause problems during sewer construction. However, prior to implementing the design phase, the town polled the three neighborhoods on their preferred type of sewer extension (LPS versus conventional gravity sewer). Based on the majority vote to utilize LPS, the Town Meeting (the legislative body for towns in Massachusetts) appropriated funding for the sewer design and construction. The town selected Earth Tech (Long Beach, Calif.) for the design, bid, and construction phases of the project. Design began as a routine design in May 2003 with an expected start of construction in June 2004.

Low-Pressure Sewers

LPSs became a true alternative to conventional gravity sewers in the late 1980s. LPSs require a grinder pump and a series of small-diameter pipes to convey wastewater to an existing gravity sewer (see figure, p. 46). The wastewater from each residence flows via gravity to a grinder-

Construction of a service connection to a Marion, Mass., residence.

Low-pressure systems feature small-diameter pipes and grinder pumps.

pump unit, which grinds solids into fine particles before discharging through a check valve and 31.25-mm (1.25-in.) discharge into the main sewer system. LPSs require minimal retention time and friction losses while maintaining adequate scouring velocities.

Each grinder pump is a self-contained unit measuring 600 mm (24 in.) in diameter by 1800 mm (72 in.) deep. The semipositive displacement pump tolerates varied system pressures, which is useful when the number of units operating on the system varies at any particular time. The pump is designed and tested to function at 42 m (138 ft) total dynamic head to produce a flow rate of 34 L/min (9 gal/min). If the system pressure exceeds 42 m (138 feet) total dynamic head, the pump will continue to function normally but at a slightly reduced flow rate. Each unit has a 265-L (70-gal) high-density polyethylene tank that is automatically activated and accommodates 2650 L/d.

Benefits of an LPS include shallow trenches; reduced construction duration (about 43 m/d, or 140 ft/d, versus about 23 m/d, or 75 ft/d, for conventional gravity sewers); elimination of pump stations, which in turn reduces O&M and capital costs; and the use of smaller-diameter pipes, which equates to lower costs during construction and later maintenance, if repairs are needed.

O&M, Cost Considerations

Many communities are reluctant to adopt LPS systems because of the concern that O&M requirements will be excessive. These concerns were legitimate 20 years ago, when pressure sewers and grinder pumps had no track record. Today, however, a large body of well-documented experience shows the long-term reliability and operating costs associated with LPS systems from many parts of the United States.

Two other concerns are poor-quality grinder pumps and poorly designed LPS systems. Some grinder-pump manufacturers do not offer quality equipment, which lowers the life expectancy of the pump and increases maintenance problems and repairs. Furthermore, many engineers are to blame as well for neglect during the design phase, which also causes system failures, increasing O&M costs and damaging the reputation of LPSs.

Many construction and maintenance costs are favorable for such communities as those in the Marion sewer expansion project. Material and trenching costs are significantly lower than those for traditional gravity sewers because of the smaller pipe size and depth requirements. Low-cost cleanouts and valve assemblies are used, rather than manholes, and may be spaced farther apart than manholes. Due to the construction materials, pipe size, flow pressure, and depth, infiltration is greatly reduced. The homeowner pays for the electricity to operate the pump unit, estimated at about $22 per year. However, the slight increase in electric bills is significantly lower than the user fees required for a pumping station.

The project costs were determined to be recovered through a combination of betterments and users fees. Massachusetts general law allows public works project costs to be recovered through the use of betterments, since the project will "better" property values. A betterment becomes a lien on the property if it is not paid in full within 30 days of its assessment. In addition, each homeowner would be responsible for all other costs associated with installation, estimated at approximately $22,000 plus the cost for private property construction.

Final Design

The final design consisted of approximately 14,000 m (45,000 ft) of LPS, including main-line installation and service connections up to the property lines, where an isolation valve and check

valve would be located for future homeowner connection. The town would be responsible for installing the main line and service pipe. The homeowner would be responsible for purchase of materials, with the exception of the grinder pump and associated control panel; installation of the grinder pump; internal and external electrical work, including installation of the control panel and any internal plumbing; service connection from the house and from the pump to the cleanout at the property line; "abandonment" of the existing onsite disposal system, which includes legally disposing of the system's contents; as well as property restoration.

In addition, the town elected to provide the grinder-pump units to each property owner. This approach enables the town to purchase the grinder pumps in mass quantity, benefiting homeowners financially and the town as it ensures standardization, as all units are from one manufacturer. The inventory of spare parts also is kept at a minimum.

The Role of the Homeowner

During the design phase, each homeowner was asked to fill out a service connection form to aid in locating the new service connection, the grinder-pump unit, and the location of the existing onsite system. The form is printed on three sheets of carbonless paper to enable the property owner, the town, and Earth Tech to retain a copy of the information.

Public outreach was an important tool to get buy-in and ensure smooth construction and long-term system operation. It also was important to educate residents and increase communication through numerous neighborhood meetings, both during normal working hours and in the evening. During the design, Earth Tech and the town held public meetings to answer questions and ease concerns, as well as gather data on such items as the location of existing utilities, the presence of onsite systems, and the preferred grinder-pump location. Mailings also went to each resident as part of an information gathering and distributing process prior to survey and subsurface work. This mailing explained the project in detail and asked for information, including the sewer service connection form. Then meetings were held with each neighborhood to again explain the project and offer assistance in filling out the connection form. Residents were encouraged to meet with their plumber if they needed help identifying locations. Residents also had the option to set up a one-on-one meeting with Earth Tech if they did not have a plumber or needed further assistance.

Besides reminding residents through mailings and meetings, other public means were used (newspaper notifications and cable television ads). If the resident did not submit a service connection form, the longest route possible was used for installation. However, the resident would have final say during construction, and Earth Tech's resident engineer would contact each resident prior to installation. The project cost for homeowners at this point was estimated to be approximately $15,500, plus the private property construction cost (see table, p. 49).

Some Residents Say 'No'

A turn of events occurred when some residents in the Dexter Beach neighborhood thought the town approval of the LPS system was unfair. These residents, who lived on the same street, called Ridgewood Lane, claimed LPS is inefficient and causes the homeowner many problems and, therefore, they requested the gravity sewer.

Earth Tech and town officials met with the neighborhood to present what the changes would mean to their betterments and the rest of the project. The preliminary design for a conventional sewer system indicated that 20 pump stations would be required to provide gravity sewer collection for all three neighborhoods, and pipeline construction would be costly, as the poor terrain would mean very deep cuts, some in excess of 6 m (20 ft). In addition, more rock excavation and dewatering would be required, compared to installation of an LPS system. Another downfall to conventional systems was the need to acquire land for the pump stations, especially with the neighborhood's small lots and potential adverse visual impacts. The pump stations also would require personnel, presenting increased operation costs. With 455

Construction costs for low-pressure sewers can be favorable because of their smaller pipe size and depth requirements.

lots being served, this change would result in a betterment increase of approximately $10,700 per lot. The cost increases include both the estimated additional construction and engineering costs associated with the change.

Although all of the Ridgewood Lane residents agreed to pay for the extra cost of a conventional gravity sewer, pump station, and force main for their neighborhood, the board of selectmen voted to continue with LPS installation as approved by the Town Meeting. Displeased with the outcome, Ridgewood Lane residents presented a new article before Town Meeting voters to overturn the previous vote. Since the Ridgewood Lane residents knew the Town Meeting likely would vote against this proposal, they offered a second proposal, that the town purchase, install, and maintain the grinder pumps for all three neighborhoods.

Voters passed the second article, which also held the town responsible for all pump electrical connections, piping to the property line, abandonment of existing onsite disposal systems, and property restoration. This new proposal also included a 5-year manufacturer warranty and a 10-year service contract from the town for all private property installations. However, any work conducted within a private home was the responsibility of the homeowner due to risks involved. This article resulted in the additional design of 12,000 linear m (39,300 linear ft) of sewer, for a total of more than 26,000 linear m (84,000 linear ft) of LPS.

The town and engineer were able to negotiate an attractive warranty and service agreement with the pump manufacturer, Environment One Corp. (Niskayuna, N.Y.) and its local representative, F.R. Mahoney (Rockland, Mass.). To assure the town that the grinder-pump units would not require maintenance, the manufacturer stated in its contract document that it would provide repairs free of charge onsite by an authorized service center within 24 hours of notice by the town or homeowner. In addition, the pump station and associated appurtenances would require

Some of the properties in Marion presented challenges in their variable terrain, slopes toward the water, and high groundwater table.

Estimated Project Costs

Public property	Design	$2000
	Construction	$9500
	Grinder-pump purchase	$4000
Homeowner	Service pipe installation	$1500
	Grinder-pump unit installation	$4000
	Electrical and plumbing changes	$3000
	Abandonment of existing onsite disposal system	$1500
	Total estimated cost per homeowner	**$25,500**

no periodic maintenance. If periodic maintenance were required, it would be performed by the pump supplier at no cost during the warranty period.

Following completion of the redesign, the construction cost was re-estimated at approximately $8 million. Other costs automatically added to the construction costs included legal costs for right of entry on private property, costs for modifications to existing permits, and the costs associated with the increased construction duration. Compared to the initial project, the final version of the project doubled in cost and increased tenfold in complexity and risk.

Project Completed Under Budget

In September 2005, the Sewer System Expansion Project was awarded in the amount of $7,347,452.50. In October 2006, the contractor successfully completed construction with only one change order, resulting in a net decrease in the contract price of $42,766.48. This complex project came in under the contract budget because of careful planning and clear communications among town officials (including the board of selectmen, Department of Public Works, Building Department, and Board of Health), the contractor, the equipment vendor, the resident inspector, design engineering staff, and residents. In addition to the successful construction period, the final project cost resulted in average betterments of approximately $20,000, compared to the estimated betterment of more than $25,000 (nearly a 22% reduction).

Each resident was provided an O&M manual to help the town and residents know who is responsible for what and how to maintain their units. This manual helps prevent the town from becoming frequently involved in the process. The O&M manual includes winterization procedures and what to do in case of long downtimes, as well as town policies for proper maintenance and homeowner responsibilities. The homeowners also received an exterior control panel for high-water alarm conditions and a battery-operated interior alarm panel that will alert the homeowner, even during a power outage.

Whenever private property work is involved, there is always the risk of property damage. A certain level of contingency was needed for residents' claims that the contractor did not leave their property exactly as it was before, which is why the contractor took preconstruction videos to protect himself, the engineer, and the town. Also, it was important that those working for the town, engineer, and contractor realize that each homeowner was important, and they all should be treated as if their property was the only one in the project. With the number of lots involved, this became a daunting task, but that special care should be emphasized upfront at the preconstruction meeting.

To prepare for natural disasters, the town had the contractor buy three emergency generators, one for each neighborhood. In extreme emergencies, these generators will allow Department of Public Works staff to go to each neighborhood and pump down pump units while waiting for power to be restored, as in the case of Hurricane Bob in 1991, when power was lost for more than 3 days in Marion.

Since substantial completion of the project, there have been 16 nonstartup-related service calls (including one homeowner who ran over the top of the grinder-pump unit), and the town has experienced only a few resident complaints, mostly dealing with property restoration during the contractor's warranty period. For a project with more than 450 homes, this definitely has been a successful one.

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