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Decentralized Systems Technology Fact Sheet

Small Diameter Gravity Sewers

DESCRIPTION

Alternative wastewater collection systems are often implemented in situations where conventional wastewater collection systems are not feasible. Typically, it is desirable to use conventional wastewater collection systems based on a proven track record. However, in areas of hilly or flat terrain, the use of conventional wastewater collection systems may require deep excavation, significantly increasing the cost of conventional collection systems.

Conventional Wastewater Collection Systems

Conventional wastewater collection systems are the most popular method to collect and convey wastewater. Pipes are installed on a slope, allowing wastewater to flow by gravity from a house site to the treatment facility. Pipes are sized and designed with straight alignment and uniform gradients to maintain self-cleansing velocities. Manholes are installed between straight runs of pipe to ensure that stoppages can be readily accessed. Pipes are generally eight inches or larger and are typically installed at a minimum depth of three feet and a maximum depth of 25 feet. Manholes are located no more than 400 feet apart or at changes of direction or slope.

Alternative Wastewater Collection Systems

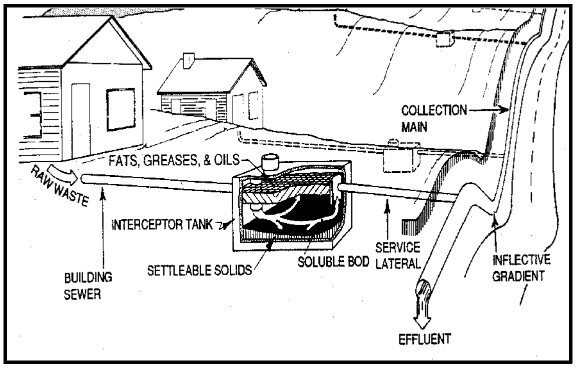
Where deep excavation is a concern, it may be beneficial to use an alternative wastewater collection system. These systems generally use smaller diameter pipes with a slight slope or follow the surface contour of the land, reducing the amount of excavation and construction costs. This is illustrated in Figure 1, which shows a pipe following an inflective gradient (the contours of the ground). As long as the head of the sewer is at a higher invert elevation than the tail of the sewer's invert elevation, flow will continue through the system in the intended direction. Alternative collection systems may be preferred in areas with high groundwater that may seep into the sewer, increasing the amount of wastewater to be treated. Areas where small lot sizes, poor soil conditions, or other site-related limitations make on-site wastewater treatment options inappropriate or expensive may benefit from alternative wastewater collection systems.

This Fact Sheet discusses small diameter gravity sewers.

Small Diameter Gravity Sewers

Small diameter gravity sewers (SDGS) convey effluent by gravity from an interceptor tank (or septic tank) to a centralized treatment location or pump station for transfer to another collection system or treatment facility. A typical SDGS system is depicted in Figure 1.

Most suspended solids are removed from the wastestream by septic tanks, reducing the potential for clogging to occur and allowing for smaller diameter piping both downstream of the septic tank in the lateral and in the sewer main. Cleanouts are used to provide access for flushing; manholes are rarely used. Air release risers are required at or slightly downstream of summits in the sewer profile. Odor control is important at all access points since the SDGS carries odorous septic tank effluent. Because of the small diameters and flexible slope and alignment of the SDGS, excavation depths and volumes are typically much smaller than with conventional sewers. Minimum pipe diameters can be three inches. Plastic pipe is typically used because it is economical in small sizes and resists corrosion.



Source: U.S. EPA, 1991.

FIGURE 1 SDGS SYSTEM

APPLICABILITY

- Approximately 250 SDGS systems have been financed in the United States by the EPA Construction Grants Program. Many more have been financed with private or local funding. These systems were introduced in the United States in the mid-1970s, but have been used in Australia since the 1960s.

- SDGS systems can be most cost-effective where housing density is low, the terrain has undulations of low relief, and the elevation of the system terminus is lower than all or nearly all of the service area. They can also be effective where the terrain is too flat for conventional gravity sewers without deep excavation, where the soil is rocky or unstable, or where the groundwater level is high.

- SDGS systems do not have the large excess capacity typical of conventional gravity sewers and should be designed with an adequate allowance for future growth.

ADVANTAGES AND DISADVANTAGES

Advantages

- Construction is fast, requiring less time to provide service.

- Unskilled personnel can operate and maintain the system.

- Elimination of manholes reduces a source of inflow, further reducing the size of pipes, lift/pumping stations, and final treatment, ultimately reducing cost.

- Reduced excavation costs: Trenches for SDGS pipelines are typically narrower and shallower than for conventional sewers.

- Reduced material costs: SDGS pipelines are smaller than conventional sewers, reducing pipe and trenching costs.

- Final treatment requirements are scaled down in terms of organic loading since partial removal is performed in the septic tank.

- Reduced depth of mains lessens construction costs due to high ground water or rocky conditions.

Disadvantages

Though not necessarily a disadvantage, limited experience with SDGS technology has yielded some situations where systems have performed inadequately. This is usually more a function of poor design and construction than the ability of a properly designed and constructed SDGS system to perform adequately.

While SDGS systems have no major disadvantages specific to temperate climates, some restrictions may limit their application:

- SDGS systems cannot handle commercial wastewater with high grit or settleable solids levels. Restaurants may be hooked up if they are equipped with effective grease traps. Laundromats may be a constraining factor for SDGS systems in small communities. No reports could be found on the use of SDGS systems as a commercial wastewater collection option.

- In addition to corrosion within the pipe from the wastewater, corrosion outside the pipe has been a problem in some SDGS systems in the United States where piping is installed in highly corrosive soil. If the piping will be exposed to a corrosive environment, non-corrosive materials must be incorporated in the design.

- Disposing of collected septage from septic tanks is probably the most complex aspect of the SDGS system and should be carried out by local authorities. However, many tanks are installed on private property requiring easement agreements for local authorities to gain access. Contracting to carry out these functions is an option, as long as the local authorities retain enforceable power for hygiene control.

- Odors are the most common problem. Many early systems used an on-lot balancing tank that promoted stripping of hydrogen sulfide from the interceptor (septic) tank effluent. Other odor problems are caused by inadequate house ventilation systems and mainline manholes or venting structures. Appropriate engineering can control odor problems.

- SDGS systems must be buried deep enough so that they will not freeze. Excavation may be substantial in areas where there is a deep frostline.

DESIGN CRITERIA

Peak flows are based on the formula Q=20 + 0.5D, where Q is flow (gallons per minute) and D is the number of dwelling units served by the system (EPA 1992). Whenever possible, it is desirable to use actual flow data for design purposes. However, if this is not available, peak flows are calculated. Each segment of the sewer is analyzed by the Hazen-Williams or Manning equations to determine if the pipe is of adequate size and slope to handle the peak design flow. No minimum velocity is required and PVC pipe (SDR 35) is commonly used for gravity segments. Stronger pipe (e.g., SDR 21) may be dictated where septic tank effluent pump (STEP) units feed the system. Check valves may also be used in flooded sections or where backup (surcharging) from the main may occur. These valves are installed downstream of mainline cleanouts.

Typical pipe diameters for SDGS are 80 millimeters (three inches) or more, but the minimum recommended pipe size is 101.6 mm (4 mm) because 80 mm (3 inch) pipes are not readily available and need to be special ordered. The slope of the pipe should be adequate to carry peak hourly flows. SDGS systems do not need to meet a minimum velocity because solids settling is not a design parameter in them. The depth of the piping should be the minimum necessary to prevent damage from anticipated earth and truck loadings and freezing. If no heavy earth or truck loadings are anticipated, a depth of 600 to 750 millimeters (24 to 30 inches) is typical.

All components must be corrosion-resistant and all discharges (e.g., to a conventional gravity interception or treatment facility) should be made through drop inlets below the liquid level to minimize odors. The system is ventilated through service-connection house vent stacks. Other atmospheric openings should be directed to soil beds for odor control, unless they are located away from the populace.

Septic tanks are generally sized based on local plumbing codes. STEP units used for below-grade services are covered in a Fact Sheet on pressure sewers. It is essential to ensure that on-lot infiltration and inflow (l/l) is eliminated through proper testing and repair, if required, of building sewers, as well as pre-installation testing of septic tanks.

Mainline cleanouts are generally spaced 120 to 300 meters (400 to 1,000 feet) apart. Treatment is normally by stabilization pond or subsurface infiltration. Effluent may also be directed to a pump station or treatment facility.

A well operated and maintained septic tank will typically remove up to 50 percent of BOD_5, 75 percent of SS, virtually all grit, and about 90 percent of grease. Clogging is not normally a problem. Also, wastewater reaching the treatment plant will typically be more dilute than raw sewage. Typical average values of BOD and TSS are 110 mg/l and 50 mg/l, respectively.

Primary sedimentation is not required to treat septic tank effluent. Sand filters are effective in treatment. Effluent responds well to aerobic treatment, but odor control at the headworks of the treatment plant should receive extra attention.

PERFORMANCE

Point Royal Estates, Texas

Point Royal Estates is an 80-home subdivision developed in the early 1970s near Lake Ray Hubbard in the northwest part of Rockwall County, Texas. For many years, septic tank and drainfield failures were a great inconvenience to the residents of Point Royal Estates, ultimately causing property values to decrease.

Originally, each home was served by two 250-gallon septic tanks, and gravity absorption field lines were placed in the back yards. The systems began to fail regularly, largely due to infiltration problems since soils in the area are mostly extremely tight clays. Many residents pumped their tanks twice a year but still reported system failures. Some residents resorted to renting “port-a-potties”.

In 1990, the City of Rowlett formed a Public Improvement District to install a conventional sewer system in Point Royal Estates. The final cost estimate for this project was nearly $10,000 per residence. These high costs prompted the city to explore other alternatives.

In 1993, the Point Royal Water and Sewage Supply Corporation (PRWSSC) was formed to evaluate alternatives for sewage collection. After a series of public meetings, it became obvious that a small diameter sewer might be the best option for the subdivision. The final cost estimate for a SDGS system was about $3,500 per residence.

The system consisted of interceptor tanks ranging in size from 1,000-1,200 gallons installed at each residence. These tanks were installed with baffles and Clemson design tubes to prevent solids buildup and reduce the amount of sludge sent through the downstream sewer piping. Homes were connected to the interceptor tanks with four-inch PVC pipes installed at a 2 percent slope. Effluent was transported from the interceptor tanks to the SDGS collection line by a two-inch PVC gravity sewer. Valves and cleanout ports that could be easily accessed and serviced were installed at most homes. Existing septic tanks were abandoned and crushed, when practical.

Oxytec, Inc. was the general contractor for the installation, which began in April 1994. Final inspections were performed in July 1995 and no operational problems have yet been reported.

OPERATION AND MAINTENANCE

O&M requirements for SDGS systems are usually low, especially if there are no STEP units or lift stations. Periodic flushing of low-velocity segments of the collector mains may be required. The septic tanks must be pumped periodically to prevent solids from entering the collector mains. It is generally recommended that pumping be performed every three to five years. However, the actual operating experience of SDGS systems indicates that once every seven to ten years is adequate. Where lift stations are used, such as in low lying areas where waste is collected from multiple sources, they should be checked on a daily or weekly basis. A daily log should be kept on all operating checks, maintenance performed, and service calls. Regular flow monitoring is useful to evaluate whether inflow and infiltration problems are developing.

The municipality or sewer utility should be responsible for O&M of all of the SDGS system components to ensure a high degree of system reliability. General easement agreements are needed to permit access to components such as septic tanks or STEP units on private property.

COSTS

The installed costs of the collector mains and laterals and the interceptor tanks constitute more than 50 percent of total construction cost (see Table 1 for more detailed listing of component costs). Average unit costs for twelve projects (adjusted to January 1991) were: 10 cm (4 in.) mainline, \$3.71/m (\$12.19/ft); cleanouts, \$290 each; and service connections, \$2.76/m (\$9.08/ft). A more detailed listing of this information may be found in Table 1. Average unit costs for 440 L (1,000 gal) septic tanks were \$1,315, but are not included in Table 1. The average cost per connection was \$5,353 (adjusted to January 1991) and the major O&M requirement for SDGS systems is the pumping of the tanks. Other O&M activities include gravity line repairs from excavation damage, supervision of new connections, and inspection and repair of mechanical components and lift stations. Most SDGS system users pay \$10 to 20/month for management, including O&M and administrative costs.

TABLE 1 SMALL DIAMETER GRAVITY SEWER COMPONENT COSTS

Community (Cost Index)	In-Place Pipe	Man-holes	Clean outs	Lift Stations	Force Main	Bldg. Sewer	Service Conn.	Site Restoration	Total
Westboro, WI	5.27	0.60	-	1.65	0.55	0.76	a	0.75	13.03
Badger, SD	2.67	1.93	-	3.23	0.39	0.03	2.59	b	15.61
Avery, ID	8.57	0.60	0.25	5.11	1.64	-	0.69	b	43.39
Maplewood, WI	17.30	0.44	0.62	10.72	2.92	-	2.79	1.29	45.85
S. Corning, NY #1	13.36	0.44	0.48	-	-	1.62	7.72	3.08	43.63
S. Corning, NY #2	15.11	0.72	0.32	-	-	2.51	11.87	2.11	50.87
New Castle, VA	9.89	2.40	0.78	2.88	2.60	-	b	b	30.58
Miranda, CA	24.36	1.61	1.60	-	0.17	4.94	7.44	0.53	69.33
Gardiner, NY	15.07	1.47	0.37	0.78	0.50	0.72	2.50	0.77	30.84
Lafayette, TN	6.90	0.64	0.14	1.26	0.37	0.11	4.19	b	16.29
West Point, CA	7.26	-	0.35	2.22	1.56	-	6.00	-	38.64
Zanesville, OH	8.09	0.18	1.05	-	-	9.46	8.71	1.12	46.65
Adjusted Average	15.10	1.42	0.79	4.95	1.66	3.22	7.13	2.12	57.89

a Included in septic tank costs.
b Included in pipe costs. Costs are in \$/ft pipe installed.

Source: U.S.EPA, 1991.

REFERENCES

Other Related Fact Sheets

Sewers, Pressure
EPA 832-F-00-070
September 2000

Sewers, Lift Stations
EPA 832-F-00-073
September 2000

Other EPA Fact Sheets can be found at the following web address:
http://www.epa.gov/owmitnet/mtbfact.htm

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11. Small Community Wastewater Collection Systems, Publication Number 448-405, July 1996, Virginia Cooperative Extension.

ADDITIONAL INFORMATION

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