



Decentralized Systems Technology Fact Sheet

Septic Tank Systems for Large Flow Applications

DESCRIPTION

A septic tank system is a traditional wastewater treatment technology utilizing treatment in a tank system followed by soil absorption. The system operates on gravity and has been used in residential areas for decades. A modification to the traditional system is an enlargement to accommodate many homes and/or commercial discharges. This is accomplished with individual septic tanks followed by a community collection and subsurface disposal system, or a community collection system followed by a single treatment system. Commercial establishments, such as restaurants, nursing homes, hospitals and other public use areas do not generally use septic tank systems due to oil & grease, odor, and flow issues.

The primary device in treatment is a septic tank enclosed in a watertight container that collects and provides primary treatment of wastewater by separating solids from the wastewater. The tank removes solids by holding wastewater in the tank and allowing settleable solids to settle to the bottom of the tank while floatable solids (oil and grease) rise to the top. In large commercial systems, a separate oil/grease removal system is applied to the commercial waste before introduction to the septic tank. The tank should hold the wastewater for at least 24 hours to allow enough time for the solids to settle.

Some solids are removed from the water and stored in the tank while some are digested. Up to 50 percent of solids retained in the tank decompose while the remainder accumulate as sludge at the tank bottom and must be removed periodically by pumping the tank.

Three main types of septic tanks are used for wastewater treatment:

- Concrete.
- Fiberglass.
- Polyethylene/plastic.

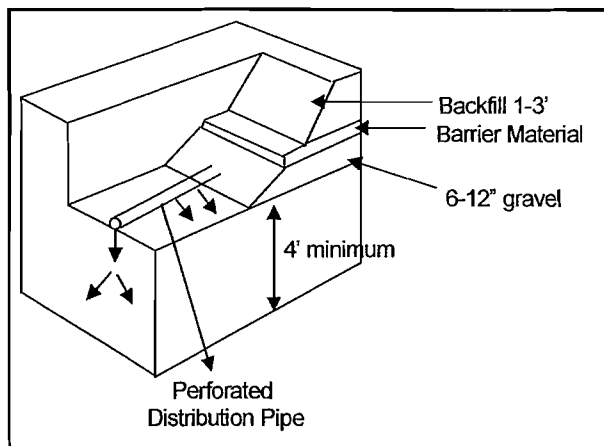
All tanks must be watertight because groundwater entering the system can saturate the soil absorption field, resulting in a failed system. Furthermore, in instances where septic tanks precede a secondary treatment process, excess groundwater may inundate the downstream process, causing it to perform poorly.

From the septic tank, the clarified wastewater passes through the tank outlet and enters the soil absorption field. The most common outlet is a tee fitting connected to the pipe leading to the soil absorption field. The top of the tee retains floatable solids (scum, oil, and grease) that might otherwise clog the absorption field. An effluent filter can be placed in the outlet tee for additional filtering of wastewater. The effluent filter removes additional solids, keeping them from clogging the absorption field and causing premature failure. Effluent filters must be cleaned regularly.

Soil Absorption Field

The soil absorption field provides final treatment and distribution of the wastewater. A conventional system consists of perforated pipes surrounded by media such as gravel, chipped tires, or other material, covered with geotextile fabric and loamy soil. This system relies heavily on the soil to treat wastewater, where microorganisms help remove organic matter, solids, and nutrients from the water.

As effluent continually flows into the soil, the microbes eating the components of the wastewater form a biological mat. The mat slows the movement of the water through the soil and helps keep the area below the mat from becoming saturated. The water must travel into unsaturated soil so microbes there and in the mat can feed on the waste and nutrients in the effluent. The grass covering the soil absorption system also uses the nutrients and water to grow.



Source: Robillard and Martin, 2000

FIGURE 1 SECTION OF TRENCH SOIL ABSORPTION SYSTEM

Treatment

Used properly, the septic tank and soil absorption system works well, reducing two parameters commonly used to measure pollution: (1) biochemical oxygen demand, which is lowered by more than 65 percent; and (2) total suspended solids, which are cut by more than 70 percent. Oil and grease are typically reduced by 70 to 80 percent (EPA 1980).

Using a septic tank to pretreat sewage from commercial sources also makes other secondary treatment systems more effective. The effluent from the septic tank is consistent, easy to convey, and easily treated by either aerobic (with free oxygen) or anaerobic (without free oxygen) processes.

Common Modifications

Septic tanks for large flow systems may be followed by traditional soil absorption systems or by one of several alternate technologies such as constructed wetlands or slow sand filtration. Pressure sewers and small diameter gravity sewers may also be used as alternate collection systems for transport of effluent to central treatment facilities. These systems are discussed in other fact sheets (see Reference section). This fact sheet focuses on the traditional septic tank system applied to commercial waste and multiple sources, using subsurface infiltration for wastewater disposal.

Subsurface Infiltration

Subsurface wastewater infiltration systems (SWISs) are subgrade land application systems most commonly applied in unsewered areas by individual residences, commercial establishments, mobile home parks, and campgrounds (EPA, 1992). The soil infiltration surfaces are exposed in buried excavations that are generally filled with porous media. The media maintain the structure of the excavation, allows the free flow of pretreated wastewater to the infiltrative surfaces, and provides storage of wastewater during times of higher flows. The wastewater enters the soil where treatment is provided by filtration, adsorption, and biologically mediated reactions which consume or transform various pollutants. Ultimately, the wastewater treated in the SWIS enters and flows with the local groundwater.

Various SWIS designs have been developed for various site and soil conditions encountered. The designs differ primarily in where the filter surface is placed. The surface may be exposed within the natural soil profile (conventional or alternative technology) or at or above the surface of the natural soil (at-grade or mound systems) (see related Fact Sheets). The elevation of the filter surface is critical to provide an adequate depth of unsaturated soil between the filter surface and a limiting condition (e.g. bedrock or groundwater) to treat wastewater applied.

The geometry of the filter surface also varies, with long, narrow filter surfaces (trenches) much

preferred. Wide filter surfaces (beds) and deep filter surfaces (pits and deep trenches) do not perform as well, although they require less area.

Subsurface infiltration systems are capable of high levels of treatment for most domestic wastewater pollutants. Under suitable site conditions, they provide nearly total removal of biodegradable organics, suspended solids, phosphorus, heavy metals, and virus and fecal indicators.

The fate of toxic organics and metals is not as well documented, but limited studies suggest that many of these constituents do not travel far from the system. Nitrogen is the most significant wastewater parameter not readily removed by the soil. Nitrate concentrations above the drinking water standard of 10 mg-N/L are commonly found in groundwater immediately below SWISs (EPA 1992), but these concentrations fall with distance down-gradient of the SWIS.

APPLICABILITY

Community Establishments

Septic tanks are usually the first component of an on-site system and are the most widely used on-site wastewater treatment option in the United States. Currently, about 25 percent of new homes in the United States use septic tanks for treatment prior to disposal of home wastewater.

Septic tanks for single family homes are generally purchased as “off the shelf” items, which means that they are ready for installation and based on a standard flow. The wastewater characteristics used to design septic tanks are generally those for a typical residence.

Commercial Establishments

For many commercial establishments, the wastewater-generating sources are sufficiently similar to the wastewater-generating sources in a residential dwelling. For other establishments, however, the wastewater characteristics may be considerably different from those of typical residential wastewater.

Commercial establishments can take advantage of a centralized system if the flows and capacities are sufficient and adequate pretreatment is available. Wastewater must be pretreated prior to being discharged to a soil absorption system. Wastewater is most commonly pretreated by an on-site septic tank when a soil absorption system is used for treatment/disposal. In areas where soil and groundwater conditions are favorable for wastewater disposal and land costs are low, a community soil absorption system is usually the most cost effective wastewater treatment/disposal option for flows below 35,000 gallons per day. Careful application of the effluent to the soil absorption system ensures uniform application of effluent over the filtration surface. Distribution laterals should be provided with cleanouts for access and flushing. Ponding monitors should be installed in trench areas to allow observation of liquid level in trenches.

Subsurface Infiltration

In some instances, it is desirable to bury the absorption system. Buried systems, known as subsurface wastewater infiltration systems (SWISs), are advantageous because the land above a SWIS may be used as green space or park land, and because they provide groundwater recharge. Subsurface infiltration systems are well suited for treatment of small wastewater flows. Small SWISs, commonly called *septic tank systems*, are traditionally used in unsewered areas by individual residences, commercial establishments, mobile home parks, and campgrounds. Since the late 1970s, larger SWISs have been increasingly used by clusters of homes and small communities where wastewater flows are less than 25,000 gpd. They are a proven technology, but require specific site conditions to be successfully implemented. SWISs are often preferred over on-site mechanical treatment facilities because of their consistent performance with few operation and maintenance requirements, lower life cycle costs, and less visual impact on the community.

DESIGN CRITERIA

Pretreatment of Wastewater for Commercial Septic Tank Systems

The most serious operational problem encountered with commercial septic tank systems has been the carry-over of solids, oil and grease due to poor design and lack of proper maintenance. The carryover of suspended material is most serious where a disposal field is to be used to dispose of septic tank effluent without further treatment. Recognizing that poor septic tank maintenance is common, some regulatory agencies require the addition of a large septic or other solids separation unit before collected septic tank effluent can be disposed of in subsurface disposal fields. The use of oil and grease traps reduces the discharge of TSS and oil and grease significantly. The presence of oil and grease in effluents from septic tanks servicing restaurants has led to the failure of downstream treatment processes such as intermittent and recirculating sand filters. As a consequence of these problems, pretreatment is recommended.

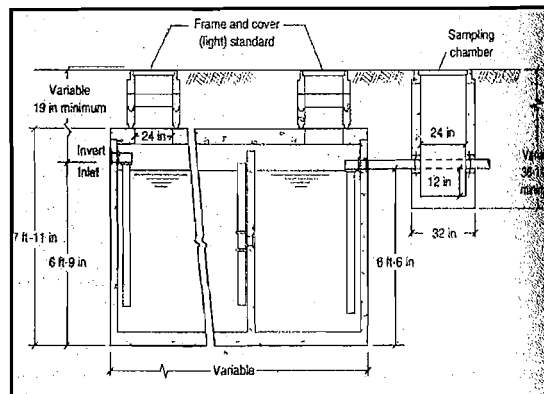
Pretreatment in centralized treatment systems involves coarse screening, comminution, grit removal, oil and grease removal, flow equalization, and TSS removal.

Pretreatment for Oil and Grease Removal

Wastewater from restaurants, laundromats, and other commercial establishments may contain significant amounts of oils and grease which may be discharged to the soil absorption system when they enter a septic tank. Oils and greases tend to accumulate on the surface of the soil absorption system, reducing the infiltration capacity. Oils and greases are especially troublesome because of their persistence and low rate of biodegradation. To avoid problems in decentralized wastewater treatment and disposal systems, the effluent oil and grease concentration should be reduced to less than about 30 mg/L before it is introduced to the soil absorption system (Crites and Tchobanoglous 1998).

The problems associated with the removal of oils and greases become more complex with the

increase in different types of oils and greases available for cooking. The problem is further complicated because many of these oils are soluble at relatively low temperatures, making their removal more difficult. Typically, skimming or interceptor tanks (grease traps) are used to trap greases and oils. Figure 2 shows a schematic of an oil and grease trap with an external sampling chamber.



Note: 1 in = 2.54 cm

Source: Crites and Tchobanoglous, 1998

FIGURE 2 SCHEMATIC OF OIL AND GREASE TRAP WITH EXTERNAL SAMPLING CHAMBER

Several commercial oil and grease traps are available. Most commercial units are rated by average flow rather than instantaneous peak flows observed in the field from restaurants and laundries. The use of conventional septic tanks as interceptor tanks has also proven to be effective in removing oil and grease. Depending on the tank configuration, some replumbing may be necessary when septic tanks are used to trap grease. Typically, the inlet is located below the water surface while the outlet is placed closer to the tank's bottom. The larger volume provided by the septic tank helps achieve the maximum possible separation of oils and greasy wastes. For restaurants, the use of a series of three interceptor tanks is effective to separate oil and grease. High concentrations of oil and grease associated with restaurants make the use of three interceptor tanks in series necessary to reduce this concentration to acceptable levels.

Volumes for grease interceptor tanks typically vary from one to three times the average daily flowrate. For example, if a restaurant serves 100 customers/day at an average flow of 38 liters/day/customer (10 gallons/day/customer), the size of the grease interceptor tank should be between 3,800 and 11,400 liters (1,000 and 3,000 gallons). Depending on the activities at a given facility, accumulated sludge and scum should be removed every three to six months (Crites and Tchobanoglous 1998).

Septic Tanks

A septic tank must be the proper size and construction and have a watertight design and stable structure to perform successfully.

- Tank size. The required size of a septic tank for a commercial establishment depends on anticipated flows from the facility, coupled with additional flow from residences or other inputs, if on a community system.
- Tank construction. A key factor in septic tank design is the relationship between the amount of surface area, its sewage storage capacity, and the amount and speed of wastewater discharge. These factors affect the tank's efficiency and the amount of sludge retention. Tank construction must also assure a watertight structure.

A key to maintaining a septic tank is placing risers on the tank openings. If a septic tank is buried below the soil surface, a riser must be used on the openings to bring the lid to the soil surface. These risers make it easier to locate and maintain the tank.

Septic tank effluent may be applied to the soil absorption field by intermittent gravity flow or via a pump or dosing siphon. Periodic application using a dosing siphon maintains an aerobic environment in the disposal field, allowing biological treatment of the effluent to occur more rapidly. Dosing siphons are particularly desirable for fields composed of highly permeable soils because they help maintain the unsaturated flow

conditions necessary to achieve effective biological treatment of effluent.

Subsurface Infiltration

Important considerations in designing subsurface infiltration systems include:

- Soil texture. There are three sizes of soil particles: sand, silt and clay. Texture reflects the relative percentage of each of these soil particles at a particular site. Soil texture affects the rate at which wastewater infiltrates into and percolates through the soil (called hydraulic conductivity). These factors determine how large an absorption field is needed. Sand transmits water faster than silt, which is faster than clay.
- Hydraulic loading. This is the amount of effluent applied per square foot of trench surface or field, an important factor in septic tank design. Because water filters through clay soils more slowly than through sand or silt, the hydraulic loading rate is lower for clay than for silt, and lower for silt than for sand. Because clay soils have a very low conductivity, they may easily smear and compact during construction, reducing their infiltration rate to half the expected rate.

Site Selection

Selection criteria for a site on which wastewater treatment and renovation is to occur must consider two fundamental design factors. These are the ability of a site to assimilate the desired hydraulic load and the ability of the site to assimilate the process load. The process load consists of the organic matter, nutrients, and other solids contained in the wastewater. The hydraulic assimilative capacity of a site is often determined by the texture of the soil material on a site. Sites with sandy textured soils generally are assigned high hydraulic loadings while sites with fine textured clay are often assigned low hydraulic assimilative capacities. This typical hydraulic loading scenario often results in excessive loadings of the process constituents on a sandy site.

Sandy textured soils generally exhibit rapid permeability. This suggests that these soils will drain rapidly and reaerate quickly. These characteristics allow moderately high organic loadings onto these soils, but limit the potential for these soils to attenuate soluble pollutants such as nitrogen and phosphorus. The fine textured soils - those that contain clays - exhibit high potential to attenuate soluble pollutants, but exhibit very limited capacity to transmit liquid; consequently the hydraulic loadings applied to these soils must be very conservative. No soil provides the optimum characteristics to assimilate all constituents applied and the challenge to the onsite wastewater professional is to balance the loadings applied with the total assimilative capacity of the designed receiver site. Treatment objectives must be utilized to optimize system design.

When large volumes of wastewater are designated for application onto a site, then a groundwater mounding analysis may be required. This analysis is required to assure that the separation distance between the bottom of the trench and the shallow groundwater is adequate to provide necessary treatment. Large systems should be designed so that the longest dimension of the trench is along site contour lines and the shortest dimension crosses field contours. This generally results in systems designed with hydraulic gradients that facilitate treatment.

Soil and site conditions on which wastewater will be treated will vary from location to location. Sites selected as receivers for wastewater must exhibit characteristics that facilitate treatment and renovation of wastewater. Sites for wastewater treatment and renovation must be selected based on criteria established by local regulatory agencies as acceptable

Trench bottom application rates range from 0.2 to 1.2 gpd/ft² depending on soil conditions. Table 1 contains suggested rates of wastewater applications for trench and bed bottom areas.

TABLE 1 SUGGESTED RATES OF WASTEWATER APPLICATION

Soil Texture	Percolation Rate (min/in/ min/cm)	Application Rate (gpd/ft ² / Lpd/m ²)
Gravel, coarse sand	<1/ <0.4	not suitable
Coarse to medium sand	1 - 5/ 0.4 - 2.0	1.2/ 0.049
Fine to loamy sand	6 - 15/ 2.4 - 5.9	0.8/ 0.033
Sandy loam to loam	16 - 30/ 6.3 - 11.8	0.6/ 0.024
Loam, porous silt	31 - 60/ 12.2 - 23.6	0.45/ 0.018
Silty clay loam, clay loam	61 - 120/ 24.0 - 47.2	0.2/ 0.008
Clay, colloidal clay	>120 / >47.2	not suitable

Notes: 1) min/in x 0.4 = min/cm
2) gpd/ft² x 40.8 = Lpd/m²

Source: Crites & Tchobanoglous, 1998.

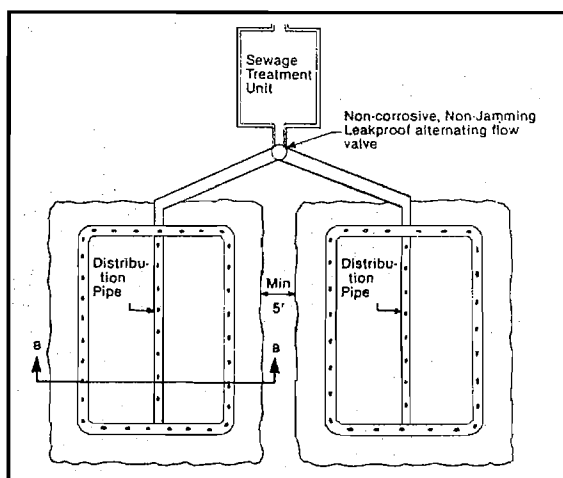
Hydraulic Loading Rate

The design hydraulic loading rate is determined by soil characteristics, groundwater mounding potential, and applied wastewater quality. Clogging of the infiltrative surface will occur in response to prolonged wastewater loading, which will reduce the capacity of the soil to accept the wastewater. However, if loading is controlled, biological activity at the infiltrative surface will maintain waste accumulations in relative equilibrium so reasonable infiltration rates can be sustained.

Selection of the design hydraulic loading rate must consider both soil and system design factors. Typically, design rates for larger SWISs are based on detailed soil analyses and experience, rather than measured hydraulic conductivities.

Wastewater Pretreatment

At a minimum, wastewater treatment in a septic tank is required before application to a SWIS. Figure 3 presents a schematic of a dual soil absorption system. Higher levels of treatment such as achieved with an aerobic treatment unit (ATU) can reduce SWIS size or prolong system life, but this must be weighed against the increased costs of pretreatment and potential damage from poor maintenance of the system.



Source: Barrett and Malina, 1991

FIGURE 3 PLAN VIEW OF DUAL SOIL ABSORPTION BED SYSTEM
ADVANTAGES AND DISADVANTAGES

Advantages

Subsurface infiltration systems are ideally suited for decentralized treatment of wastewater because they are buried. They are often the only method of wastewater treatment available for rural homes and business establishments. Some communities choose subsurface infiltration systems to avoid costly sewer construction. Where individual lots are not suited for their use, remote sites may be used to cluster homes onto a single SWIS, limiting the need for sewers. Alternatively, wastewater from entire communities may be treated by a SWIS. Because the system is buried, the land area can be used as green space or park land. In addition, SWISs provide groundwater recharge.

Disadvantages

Use of SWISs is limited by site and soil conditions. Because the infiltrative surface is buried, it can be managed only by taking it out of service every 6 to 12 months to “rest”, requiring the construction of standby cells with alternating loading cycles. Therefore, larger SWISs are usually restricted to well-drained sandy soils to reduce land area requirements. Because nitrogen is not effectively removed by SWISs, pretreatment may be necessary to prevent nitrate contamination above drinking water standards in underlying groundwater.

Flows from commercial establishments greater than the design capacity of the system may overwhelm the SWIS and produce overflow conditions and objectionable odors.

PERFORMANCE

Septic tanks and other pretreatment units must be properly maintained to keep a SWIS system treating sewage efficiently. As the septic tank or ATU is used, sludge accumulates in the bottom of the treatment unit. As the sludge level increases, wastewater spends less time in the tank and solids may escape into the absorption area. Properly sized septic tanks generally have enough space to accumulate sludge for at least three years. ATUs require aggressive sludge management.

The frequency of tank pumping depends on:

- The capacity.
- The amount of wastewater flowing into the tank (related to size of household).
- The amount of solids in the wastewater (for example, more solids are generated if garbage disposals are used).

The soil absorption field will not immediately fail if the tank is not pumped, but the septic tank will no longer protect the soil absorption field from solids. If the tank or ATU is neglected for long, it may be necessary to replace the soil absorption field.

One example of septic tank/absorption field system failure is found in Missouri. Several statewide surveys have shown that 70 percent (150,000) of systems are not functioning properly, causing nearly 60 million gallons of untreated or semi-treated sewage per day to reach groundwater supplies (Schultheis and Hubble). Based on the general soils map of Missouri, 60 to 99 percent of counties in the Ozarks region show severe limitations in the use of absorption field systems.

Many studies of failing septic tank systems have been conducted. The Lower Colorado River Authority (LCRA) received a grant from the Texas Water Commission (TWC) to identify clustered sites of on-site wastewater treatment and disposal facilities in the Lavaca and Colorado coastal basins that may be failing. Information from this study will identify areas which may qualify for funding under Section 319 of the Clean Water Act.

A study was conducted by the Texas Water Commission (TWC) to gauge whether septic tanks were polluting Lake Granbury in Hood County, Texas (TWRI Spring 1993). Because so many septic tanks were in use near the lake, there was additional concern of fecal coliform contamination. Analysis of samples taken in coves along the lake showed that 10 percent of tested areas had more than 200 colony-forming units per 100 milliliters, indicating that the lake is highly contaminated with fecal coliform bacteria.

Increasingly stringent discharge regulations have led many communities to turn to more effective on-site means to treat waste. One example is Eagle Mountain Lake near Fort Worth, Texas, where the Tarrant County Water Control and Improvement District (WCID) is taking strides to improve the effluent quality of the 2,500 local on-site wastewater systems at Eagle Mountain Lake. Many homes in this area are weekend homes, with septic tanks designed for limited use. WCID is designing the on-site system to be large enough for full time use to improve effluent quality.

In the Texas Panhandle, the Texas Natural Resource Conservation Commission (TNRCC) has used innovative on-site technologies to solve wastewater problems in the region associated with

failing septic tank systems due to rapid growth in the region. In the 1980s, the town of Umbarger installed a 44,000-gallon septic tank and a 30,720-square foot drainfield to serve its 325 residents. This community system replaced the collection of many smaller septic tanks distributed throughout the town, many of which had previously experienced failures.

OPERATION AND MAINTENANCE

Subsurface Infiltration

A well-designed SWIS requires limited operator attention. Management functions primarily involve tracking system status, testing for solids accumulation, evaluating pump performance, monitoring system controls, and monitoring performance of pretreatment units, mechanical components, and wastewater ponding levels above the filtration surface. Operator intervention may be required if a change is noted. Routine servicing of SWIS is generally limited to annual or semiannual alternating of infiltration cells.

Another maintenance task to prevent a system from backing up is to clean the screen on the effluent end of the septic tank. This filter must be cleaned periodically by removing the filter from the outlet and spraying it with a hose directed back into the septic tank.

Soil absorption fields must be protected from solids and rainfall. If a tank is not pumped, solids can enter the field. Rainfall running off roofs or impermeable surfaces such as concrete areas should be diverted around the soil absorption field to prevent it from becoming saturated with rainwater. Fields saturated with rainwater cannot accept wastewater. Planting cool-season grasses over the soil absorption field in winter can help remove water from the soil and keep the system working properly.

COSTS

Subsurface Infiltration

Land and earthwork are the most significant capital costs. Where fill must be used to bed the primary

infiltrative surface, the cost of transporting the material also becomes significant. Other costs include pretreatment and transmission of wastewater to the treatment site.

Other factors that affect septic tank costs include subsurface site conditions, location of and access to the site, and the type of tank used. Costs of tanks, including installation, typically range from \$1.00 to \$4.00 per gallon of tankage. Pumping septic tanks ranges from \$150 to \$200 per 2,000 gallons. If a tank is pumped once every 3 ½ years, the maintenance cost will be about \$50 per year, with a pump and haul cost of \$175.

REFERENCES

Other Related Fact Sheets

Mound Systems
EPA 832-F-99-074
September 1999

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

Small Diameter Gravity Sewers
EPA 832-F-00-038
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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