NATIONAL SMALL FLOWS CLEARINGHOUSE

Technical Overview

SOIL ABSORPTION SYSTEMS

Item Number SFBLTO03

NATIONAL SMALL FLOWS CLEARINGHOUSE
a division of the
National Environmental Services Center at West Virginia University.

PO Box 6064, Morgantown, WV 26506-6064
304-293-4191
http://www.nesc.wvu.edu

Project Staff

Edward Winant – Author
Jennifer Hause – Technical Review
Andrew Lake – Technical Review
Tim Suhrer – Editorial Review
John Fekete – Senior Graphics Designer
Jeanne Allen – Project Coordinator

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Cover photo: Installing a drain field Monongalia County, West Virginia. Photo by Ed Winant.

INTRODUCTION

Soil absorption systems (SAS) are the conventional and long-accepted solution to many onsite wastewater treatment needs. Using the soil as part of an onsite wastewater system provides both wastewater treatment and ultimate dispersal of the water into the ground. This makes soil systems an excellent, environmentally sound practice. Soil systems can also be very cost-effective.

The drawback to soil absorption systems is that they can not be used everywhere, relying as they do on the natural soil. There are many sites that lack adequate amounts of soil or have the wrong types. To adequately treat and disperse wastewater, the soil must have enough permeability (a measure of how quickly water moves through the soil) but not so much that the effluent flows through without treatment. Further, there must be enough soil vertically to fully remove the contaminants. Research has shown that 24 inches is sufficient, but many states require 36 inches or even 48 inches of good soil as a factor of safety.

As soil systems are used, a clogging layer or biomat will grow on the interface between the gravel and the soil. Naturally occurring soil bacteria use the contaminants in the effluent as food and use the soil particles to hold themselves in place. As they eat the contaminants, the bacteria grow in size, forming the biomat and closing off the pore spaces in the soil. As living organisms, however, they will die and slough off, to be replaced by younger generations of bacteria.

The best way to control the growth of the biomat is to spread the effluent out over as wide an area as possible. Spreading out the effluent over a large area of soil does two things. First, it applies an amount of water that can easily permeate the soil and be treated. Secondly, spreading out the effluent spreads out the food supply for the biomat and controls the growth. As the biomat grows, the soil permeability will decrease. If new bacteria grow unchecked, they will quickly clog up all available pore spaces, and the soil absorption system will fail as water ponds to the surface of the ground. However, with slower growth, the rate at which bacteria die off will match new growth, and a stable situation will develop. This is called the long-term acceptance rate (LTAR) of the soil.

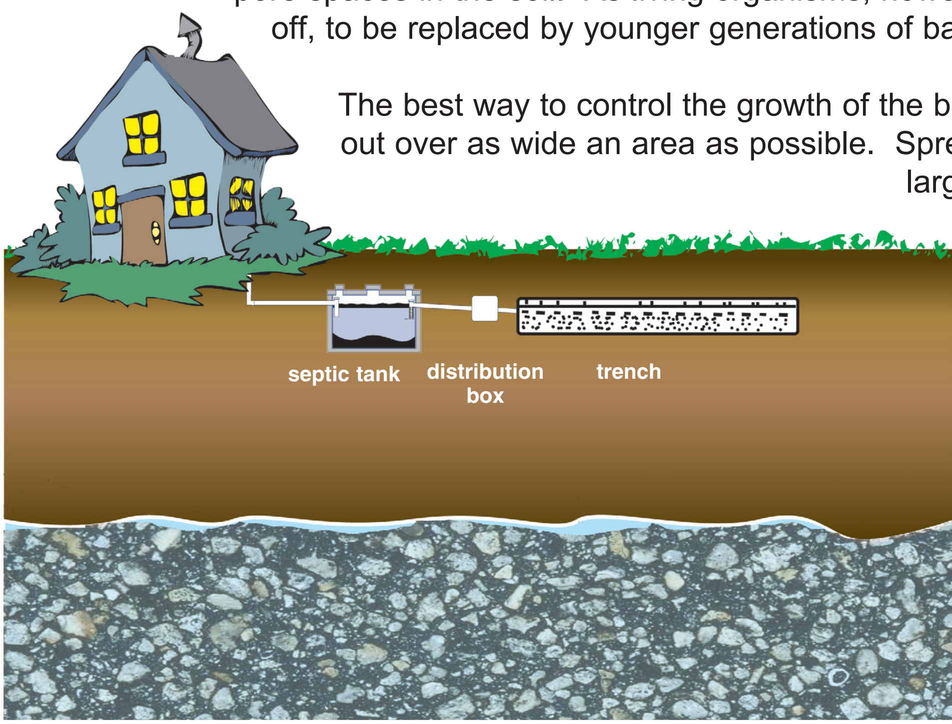


Figure 1: Typical septic tank soil absorption layout

DESIGN

There are many different configurations for soil absorption systems. They include: trenches, beds, pressure trenches, low pressure pipes, serial trenches, and contour trenches. In all these configurations, the goal is to spread the effluent out as widely as possible to let it soak into the ground. Soil treatment is designed to remove contaminants and disperse the effluent into the soil.

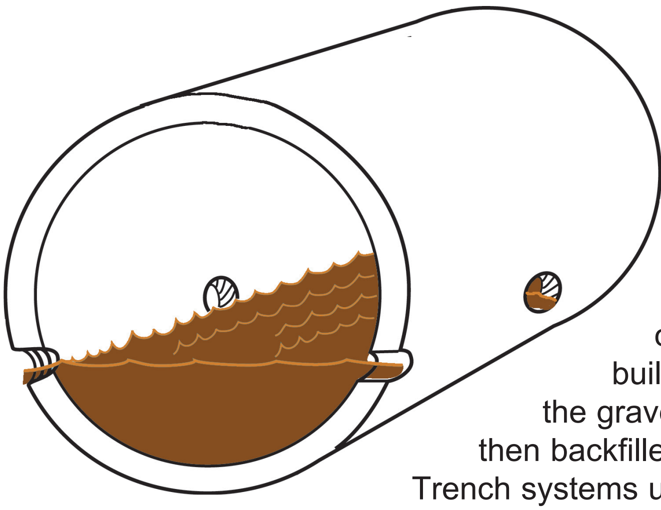


Figure 2: Perforated drainfield pipe

The conventional design is to place a layer of gravel in an excavation, install a perforated pipe (typically a 4-inch PVC pipe) with holes pointing down and cover this with gravel. The depth is typically 2 to 2 1/2 feet. Most designs call for 6 inches of gravel, then the 4-inch pipe and 2 more inches of gravel on top of the pipe. Over the gravel is a layer of building paper or geotextile to keep soil out of the gravel pore spaces. About one foot of soil is then backfilled over the fabric and gravel.

Trench systems use long, narrow excavations, typically 1 to 5 feet wide and up to 100 feet long, with one pipe in each trench. Bed systems excavate the whole field, with a large gravel bed and a system of three or four pipes laid in a rectangular, closed-loop pattern. Some states are no longer permitting beds, since there is evidence that undisturbed soil between pipes is beneficial in allowing air to circulate under the pipes. Research has shown that diffusion of air through the soil is important in controlling the biomat; thus trenches are more efficient than beds, and narrow trenches

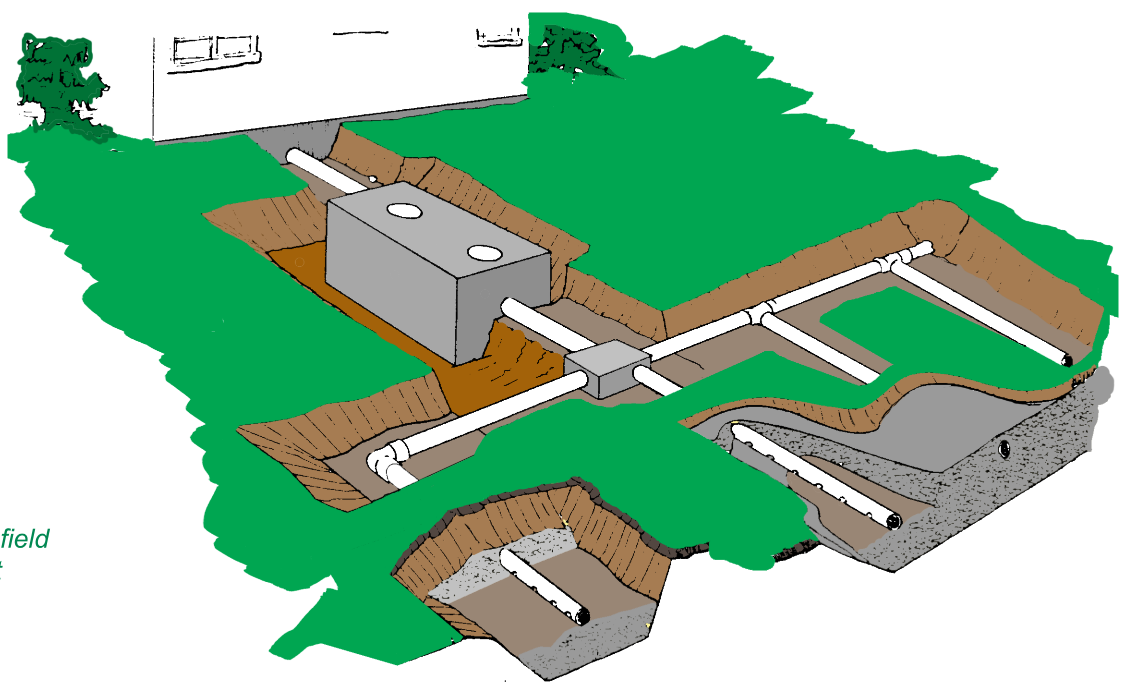


Figure 3: Typical drainfield trench layout

are better than wide trenches.

Both trench and bed systems distribute the effluent by gravity. The pipe between the septic tank and the drainfield is sloped to carry the effluent to the drainfield, but the drainfield pipes are kept level to even out the flow. In many cases, this means that effluent flows out the nearest holes, overloading the front of the drainfield and leaving the rest dry. The biomat will grow more quickly here, potentially clogging part of the drainfield.

Pressure trenches are similar to normal drainfield trenches, but the effluent is pumped to the trench under pressure and flows through the trench by gravity. This is mainly done when the drainfield is higher than the septic tank. On the other hand, low pressure pipe (LPP) systems use smaller pipes (typically 2-inch pipes) and maintain pressure throughout the pipe to ensure a more even distribution. LPP systems can be placed uphill of the tank, using pumps, or downhill using dosing siphons and gravity to pressurize the flow. Additionally, LPP systems can be placed in more shallow trenches, only one foot deep, and thus fit in sites with less vertical separation.

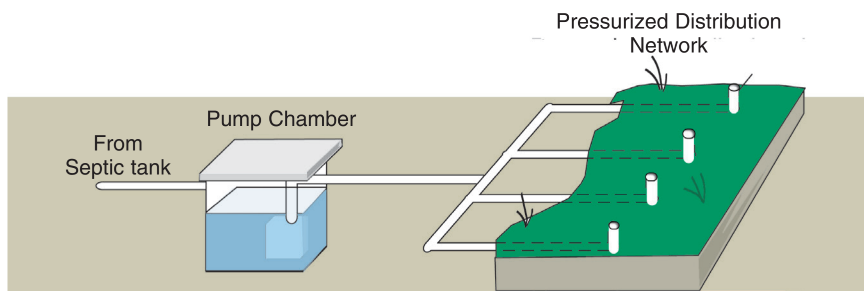


Figure 4: Possible pressure system layout

Serial trenches are a method of gravity distribution to drainfields down slope of the tank. Effluent flows to the first trench, and when that trench is full, passes on to the next trench through an overflow pipe. Contour trenches are also used for hillside distribution, taking account of the fact that effluent will flow along the slope on top of a limiting layer, rather than straight down.

The design of any soil absorption system begins with a site evaluation and soil test. Some states stipulate a percolation test, others a soil evaluation by a certified soil scientist, and some allow other tests to determine the permeability and depth of the soil in the area selected for the soil absorption system. Once this permeability is known, state or local codes will provide an application rate (amount of effluent that can be applied to the soil per square foot).

The size of the house is also important, as this will determine the design flow, or estimated daily water use. Most commonly, the design flow is based on the number of bedrooms for houses. To calculate the required size of the drainfield, simply divide the design flow by the application rate.

$$A \quad \frac{Q}{d}$$

(where A is the drainfield area, Q is the design flow and d is the application rate).

DESIGN: Trenches and Beds

Once the field size is determined, the absorption field can be laid out. In a trench system, the length of each trench times the trench width yields the total area. For example, if a three-bedroom house requires 900 square feet of absorption area based on soil testing, the field could be installed as three trenches, each 100 feet long and 3 feet wide. In a bed situation, the pipes would be installed about 5 or 6 feet apart, and the bed would measure 90 feet long by 10 feet wide. In each situation, the effluent pipe from the tank is brought to each drain line, either through a header pipe or a distribution box. The design concept is to evenly distribute the flow to each line and along each pipe. Beds are further equipped with a connection pipe at the end of the system that reconnects all the lines to equalize flow distribution; thus the closed-loop concept.

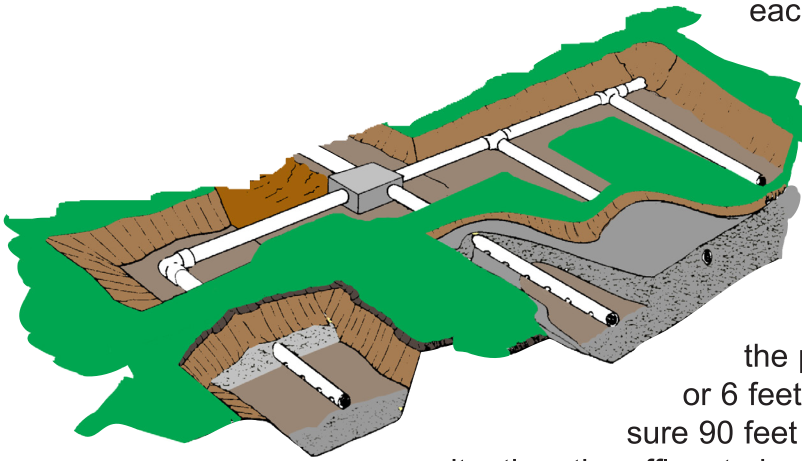


Figure 5: Typical trench layout

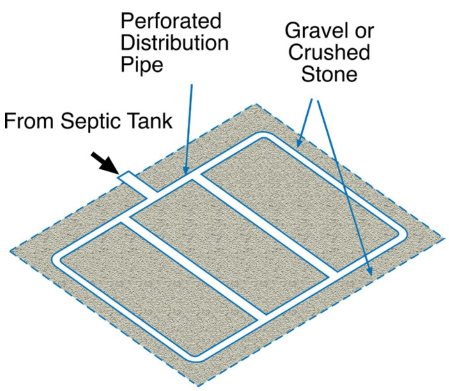


Figure 6: drainbed

DESIGN: Serial Distribution

For soil absorption systems on slopes, the serial drainfield is most common. In this design, the three trenches would be placed across the slope, with the second trench farther down the hill than the first and the third lowest of all. Connections between the trenches are by crossover relief pipes, coming out of the top of each drain line. Serial distribution forces one trench to accept all the design flow, so a biomat will rapidly develop. As the biomat builds up, the serial trench makes full use of the bottom and sidewall infiltration surfaces, and the ponding in the trench serves to force water through the biomat or on to the next drain line. However, this ponding also leads serial drainfields to suffer hydraulic failure more rapidly than normal trenches or beds because the infiltrative surfaces can not be regenerated. (EPA 2002)

An alternative method of hillside distribution is to use distribution boxes to get

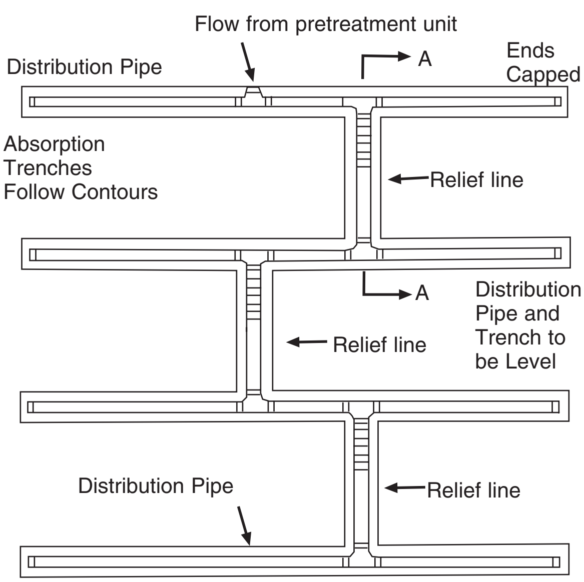


Figure 7a: Typical serial drain field layout.

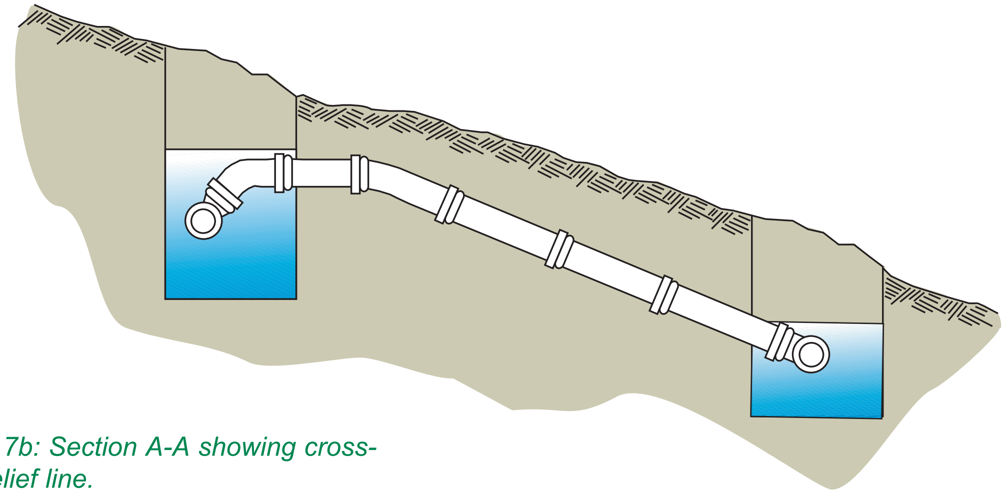


Figure 7b: Section A-A showing cross-over relief line.

more even gravity distribution among all the lines. This leads to a slightly more complicated system but will protect the life of the drainfield longer. When the hillside is above the septic tank, a pump can be used to lift the water to the drain lines. This is the essence of the pressure trench. Trench design and sizing is similar to a normal trench system, but a pump chamber and pump must be added after the septic tank.

DESIGN: Contour Trenches

Contour trenches can also be used for effluent dispersal on sloped sites, especially ones with high bedrock. In this system, one trench is laid along the contour of the hill. The underlying concept is a bit different, however, as it assumes effluent will descend to the bedrock and then flow along the bedrock down the hill. The vertical separation distance used is along the slope of the ground rather than straight down.

Figure 8: Distribution boxes on gravity manifold to equalize flow among drainfield lines.

Contour trench systems require a more detailed site evaluation, since the depth to and inclination of the bedrock must be determined. If the bedrock does not parallel the ground slope, it may cause a premature break-out of the effluent along the slope.

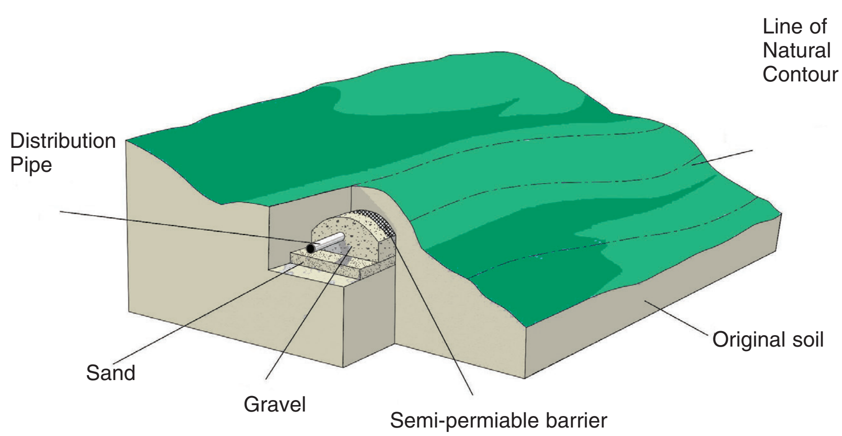


Figure 9: Typical cross section of a contour trench.

DESIGN: Low Pressure Pipes

Low pressure systems are the culmination of the absorption system theory. In this design, pressure is used along with smaller pipes to fully spread the effluent out over the entire drainfield. This reduces the hydraulic load on the soil while the dosing allows periods of rest for the soil to recover. This maximizes the flow of air through the soil while keeping biomat growth low.

Figure 10: Demonstration of LPP systen with pipes above ground.

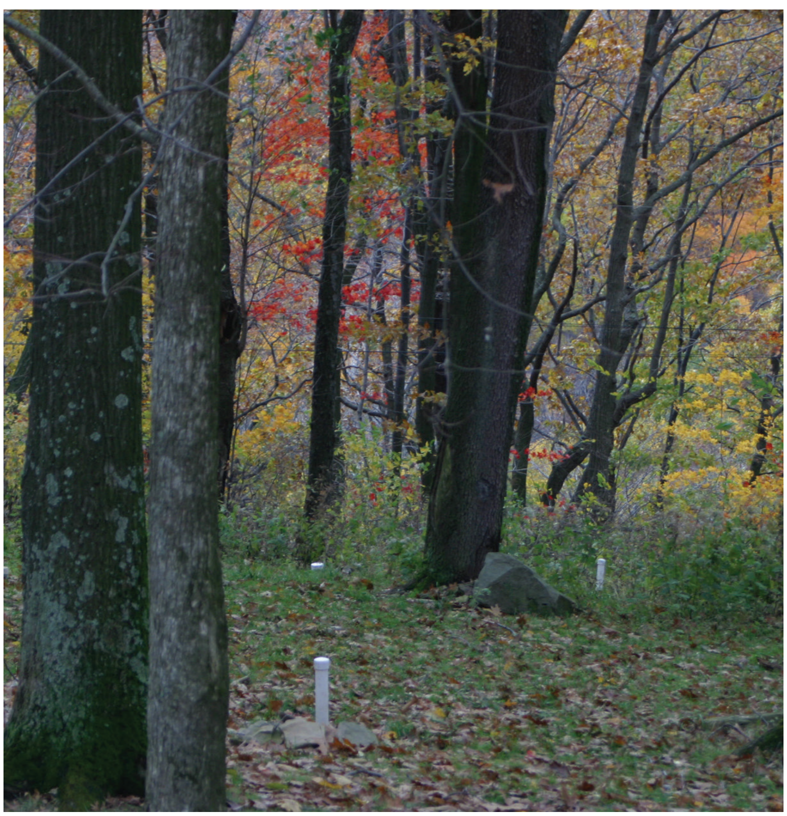


Figure 11: LPP system in ground, showing inspection ports.

To achieve pressure, a pump is used to raise the effluent above the level of the septic tank, requiring an additional construction and maintenance cost. Further, the system requires more detailed design to properly size the pump, the amount of effluent dosed, and the pressure in the system. These additions make LPP systems more expensive than gravity trench systems. However, they do have the advantage of less required area and are sometimes allowed with less vertical separation. This allows their placement on sites too restrictive for gravity trenches or beds.

If the drainfield location is below the septic tank, gravity can be used to pressurize the system. In this system, a dosing siphon is used instead of the pump. The siphon sends out effluent in doses, allowing the system to rest, while the elevation difference between the siphon tank and the drainfield provides the necessary pressure to evenly distribute the flow.

SITING ADVANTAGES AND DISADVANTAGES

Several advantages are commonly cited for onsite systems. Treating wastewater in small batches and at the source provides good environmental protection and recharges the groundwater. In rural areas, onsite treatment is by far the most cost-effective. In some areas, it is not possible to sewer, and onsite systems are the only possibility to achieve proper wastewater treatment.

Figure 12: Siphon in dosing tank

Opposing these advantages are the drawbacks. The major drawback is that onsite systems must be maintained by the homeowner, who frequently does not want to be bothered thinking about sewage. Management by an outside responsible entity will alleviate this problem, but at a cost to the homeowner in monthly fees. Further, there is usually little oversight by community officials to ensure that systems are properly maintained. Finally, good soils and large areas are not always present for constructing onsite systems.

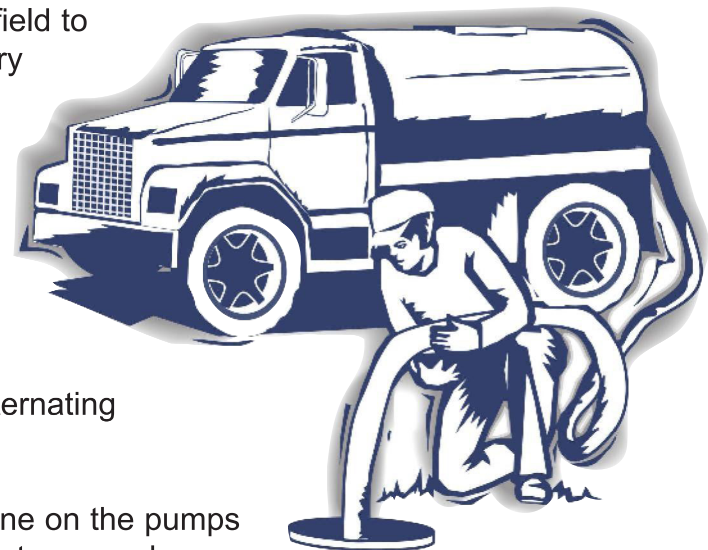
Site conditions are the lynchpin of soil absorption systems. When enough area is present and good soils exist to the proper depth, the conventional septic tank-SAS provides excellent treatment at the lowest cost. On sloping sites, different configurations for the SAS can be used, from serial drainfields to contour trenches to LPP systems. Where a site lacks area or depth of soil, some form of secondary treatment may be used before the SAS to gain reductions and allow subsurface dispersal to be safely used.

However, with small lots, shallow soils and/or high housing densities, individual on-site systems may not be the best alternative. When houses are crowded together, some form of clustered sewer and community treatment may be more feasible in protecting both public health and environmental quality.

Figure 13: Using a "sludge judge" to inspect solids accumulation in a septic tank.

OPERATION AND MAINTENANCE

Taking care of the SAS is part and parcel of onsite system maintenance. The septic tank or ATU should be pumped regularly to ensure that solids are not washed into the SAS. Water conservation measures should be practiced in the house to prevent hydraulically overloading the drainfield. Trees and large shrubs (especially the roots) should be kept away from the drainfield to protect the pipes. Cars or heavy machinery should be kept away from the SAS so as not to compact the soil.



To prolong the life of the drainfield, two fields can be installed and used alternatively. For more information on this aspect of drainfield maintenance, see the National Small Flows Clearinghouse's Technical Overview 1, Alternating Drainfields. WWBKTO01

For LPPs, maintenance must be done on the pumps or siphons. Pumps require a bit more maintenance, having more components, but both types of pressure systems should be checked regularly by trained maintenance personal. All mechanical and electrical components should be serviced by personnel approved by the system installer or local health department. Ideally, a perpetual service contract will be provided along with installation.

Additives are not needed to maintain the system, and in most cases, only result in the homeowner flushing money down the drain. Chemical additives, however, can wash solids out of the septic tank into the drainfield and cause early failure of the SAS. Regular pumping of the tank is the most effective maintenance for the system and is usually less expensive than a monthly additive, anyway.

COSTS

The major cost in constructing an SAS is usually labor. Costs will vary by geographic region, size of the system, and choice of materials, but in general, a typical single-family SAS would cost in the neighborhood of $2—3,000. This would include a day or two of labor and backhoe operation, around 300 feet of 4-inch PVC pipe, 40 tons of gravel, and all the plumbing connections. A bed system would be slightly more expensive, as there is more excavation required and more gravel to lay in the bed than in trenches. A typical bed would cost around $4,000. To complete the system, a septic tank must be installed at a typical cost of $500 to $1000.

LPP systems would be slightly more expensive. There are some savings in using less pipe and smaller trenches, but the pump or siphon chamber adds to the costs. These systems, including the septic tank, are usually $5—6,000.

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