be identified before design. Ground water mounding analysis should be performed to determine whether the hydraulic loading to the saturated zone (secondary design boundary), rather than the loading to the infiltration surface, controls system sizing (see Chapter 5). If the secondary boundary controls design, the size of the infiltration surface, its geometry, and even how wastewater is applied will be affected.

Infiltration surface sizing

Selection of the design flow is a very important consideration in infiltration surface sizing. State codified design flows for residential systems typically are 2 to 5 times greater than the average daily flow actually generated in the home. This occurs because the design flow is usually based on the number of bedrooms rather than the number of occupants. As a result, the actual daily flow is often a small fraction of the design flow.

This is not the case when the per capita flows for the population served or metered flows are used as the design flow. In such instances, the ratio of design flow to actual daily flow can approach unity. This is because the same factors of safety are typically not used to determine the design flow. In itself, this is not a problem. The problem arises when the metered or averaged hydraulic loading rates are used to size the infiltration surface. These rates can be more than two times what the soil below the undersized system is actually able to accept. As a result, SWISs would be significantly undersized. This problem is exacerbated where the waste strength is high.

To avoid the problem of undersizing the infiltration surface, designs must compensate in some way. Factors of safety of up to 2 or more could be applied to accurate flow estimates, but the more common practice is to design multiple cells that provide 150 to 200 percent of the total estimated infiltration surface needed. Multiple cells are a good approach because the cells can be rotated into service on a regular schedule that allows the cells taken out of service to rest and rejuvenate their hydraulic capacity. Further, the system provides standby capacity that can be used when malfunctions occur, and distribution networks are smaller to permit smaller and more frequent dosing, thereby maximizing oxygen transfer and the hydraulic capacity of the site. For high-strength wastewaters, advanced pretreatment can be specified or the infiltration surface loadings can be adjusted (see *Special Issue Fact Sheet 4*).

Contingency planning

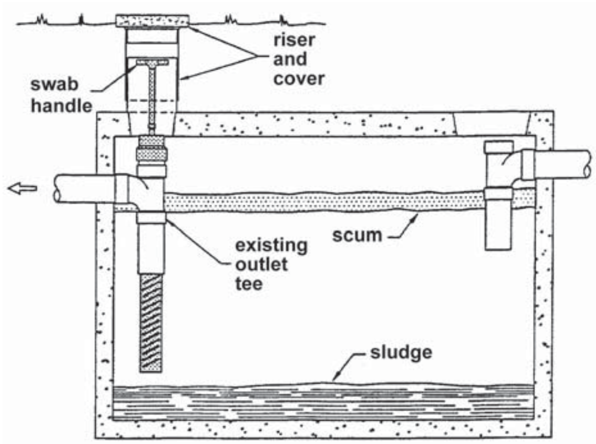
Malfunctions of systems that treat larger flows can create significant public health and environmental hazards. Therefore, adequate contingency planning is more critical for these systems than for residential systems. Standby infiltration cells, timed dosing, and flow monitoring are key design elements that should be included. Also, professional management should be required.

4.6 Septic tanks

The septic tank is the most commonly used wastewater pretreatment unit for onsite wastewater systems. Tanks may be used alone or in combination with other processes to treat raw wastewater before it is discharged to a subsurface infiltration system. The tank provides primary treatment by creating quiescent conditions inside a covered, watertight rectangular, oval, or cylindrical vessel, which is typically buried. In addition to primary treatment, the septic tank stores and partially digests settled and floating organic solids in sludge and scum layers. This can reduce the sludge and scum volumes by as much as 40 percent, and it conditions the wastewater by hydrolyzing organic molecules for subsequent treatment in the soil or by other unit processes (Baumann et al., 1978). Gases generated from digestion of the organics are vented back through the building sewer and out of the house plumbing stack vent. Inlet structures are designed to limit short circuiting of incoming wastewater across the tank to the outlet, while outlet structures (e.g., a sanitary "tee" fitting) retain the sludge and scum layers in the tank and draw effluent only from the clarified zone between the sludge and scum layers. The outlet should be fitted with an effluent screen (commonly called a septic tank filter) to retain larger solids that might be carried in the effluent to the SWIS, where it could contribute to clogging and eventual system failure. Inspection ports and manways are provided in the tank cover to allow access for periodically removing the tank contents, including the accumulated scum and sludge (figure 4-21). A diagram of a two-compartment tank is shown later in this section.

Septic tanks are used as the first or only pretreatment step in nearly all onsite systems regardless of

Figure 4-21. Profile of a single-compartment septic tank with outlet screen



daily wastewater flow rate or strength. Other mechanical pretreatment units may be substituted for septic tanks, but even when these are used septic tanks often precede them. The tanks passively provide suspended solids removal, solids storage and digestion, and some peak flow attenuation.

4.6.1 Treatment

A septic tank removes many of the settleable solids, oils, greases, and floating debris in the raw wastewater, achieving 60 to 80 percent removal (Baumann et al., 1978; Boyer and Rock, 1992; University of Wisconsin, 1978). The solids removed are stored in sludge and scum layers, where they undergo liquefaction. During liquefaction, the first step in the digestion process, acid-forming bacteria partially digest the solids by hydrolyzing the proteins and converting them to volatile fatty acids, most of which are dissolved in the water phase. The volatile fatty acids still exert much of the biochemical oxygen demand that was originally in the organic suspended solids. Because these acids are in the dissolved form, they are able to pass from the tank in the effluent stream, reducing the BOD removal efficiency of septic tanks compared to primary sedimentation. Typical septic tank BOD removal efficiencies are 30 to 50 percent (Boyer and Rock, 1992; University of Wisconsin, 1978; see table 4-10). Complete digestion, in which the volatile fatty acids are converted to methane, could reduce the amount of BOD released by the tank, but it usually does not occur to a significant extent because wastewater temperatures in septic tanks are typically well below the optimum temperature for methane-producing bacteria.

Gases that form from the microbial action in the tank rise in the wastewater column. The rising gas bubbles disturb the quiescent wastewater column, which can reduce the settling efficiency of the tank. They also dislodge colloidal particles in the sludge blanket so they can escape in the water column. At the same time, however, they can carry active anaerobic and facultative microorganisms that might help to treat colloidal and dissolved solids present in the wastewater column (Baumann and Babbit, 1953).

Septic tank effluent varies naturally in quality depending on the characteristics of the wastewater and condition of the tank. Documented effluent quality from single-family homes, small communities and cluster systems, and various commercial septic tanks is presented in tables 4-10 through 4-12.

Table 4-10. Characteristics of domestic septic tank effluent

Parameter	University of Wis. (1978)	Harkin, et al. (1979)	Ronayne, et al. (1982)	Ayres Associates (1993)	Ayres Associates (1996)
No. tanks sampled	7	33	8	8	1
Location	Wisconsin	Wisconsin	Oregon	Florida	Florida
(No. samples)	(150)	(140 - 215)	(56)	(36)	(3)
BOD_5 (mg/L)	138	132	217	141	179
COD (mg/L)	327	445	—	—	—
TSS (mg/L)	49	87	146	161	59
TKN (mgN/L)	45	82	57.1	39	66
TP (mgP/l)	13	21.8	—	11	17
Oil/Grease (mg/L)	—	—	—	36	37
Fecal coliforms (log#/L)	4.6	6.5	6.4	5.1-8.2	7.0

Table 4-11. Average septic tank effluent concentrations for selected parameters from small community and cluster systems

Parameter	Westboro, WI[a]	Bend, OR[b]	Glide, OR[c]	Manila, CA[d]	College Sta., TX[e]
BOD_5 (mg/L)	168	157	118	189	--
COD (mg/L)	338	276	228	284	266
TSS (mg/L)	85	36	52	75	--
TN (mgN/L)	63.4	41	50	--	29.5
TP (mgP/L)	8.1	--	--	--	8.2
Oil/Grease (mg/L)	--	65	16	22	--
Fecal coliforms (log#/L)	7.3	--	--	--	6.0
pH	6.9–7.4	6.4–7.2	6.4–7.2	6.5–7.8	7.4
Flow (gpcd)	36	40–60	48	40–57	--

[a] Small-diameter gravity sewer serving a small community collecting septic tank effluent from 90 connections (Otis, 1978).
[b] Pressure sewer collecting septic tank effluent from eleven homes (Bowne, 1982).
[c] Pressure sewer collecting septic tank effluent from a small community (Bowne, 1982).
[d] Pressure sewer serving a small community collecting septic tank effluent from 330 connections (Bowne, 1982).
[e] Effluent from one septic tank accepting wastewater from nine homes (Brown et al., 1977).

Table 4-12. Average septic tank effluent concentrations of selected parameters from various commercial establishments[a]

Wastewater Type	BOD_5 (mg/L)	COD (mg/L)	TSS (mg/L)	TKN (mgN/L)	TP (mgP/L)	Oil/Grease (mg/L)	Temp (^oC)	pH
Restaurant A	582	1196	187	82	24	101	8–22	5.6–6.4
Restaurant B	245	622	65	64	14	40	8–22	6.6–7.0
Restaurant C	880	1667	372	71	23	144	13–23	5.8–6.3
Restaurant D	377	772	247	30	15	101	16–21	5.7–6.8
Restaurant E	693	1321	125	78	28	65	4–26	5.5–6.9
Restaurant F	261	586	66	73	19	47	7–25	5.8–7.0
Motel	171	381	66	34	20	45	20–28	6.5–7.1
Country Club A	197	416	56	36	13	24	6–20	6.5–6.8
Country Club B	333	620	121	63	17	46	13–26	6.2–6.8
Country Club C	101	227	44	36	10	33	10–23	6.2–7.4
Bar/Grill	179	449	79	61	7	49	8–22	6.0–7.0

[a] Averages based on 2 to 9 grab samples depending on the parameter taken between March and September 1983.
Source: Siegrist et al., 1985.

4.6.2 Design considerations

The primary purpose of a septic tank is to provide suspended solids and oil/grease removal through sedimentation and flotation. The important factor to achieving good sedimentation is maintaining quiescent conditions. This is accomplished by providing a long wastewater residence time in the septic tank. Tank volume, geometry, and compartmentalization affect the residence time.

Volume

Septic tanks must have sufficient volume to provide an adequate hydraulic residence time for sedimentation. Hydraulic residence times of 6 to 24 hours have been recommended (Baumann and Babbitt, 1953: Kinnicutt et al., 1910). However, actual hydraulic residence times can vary significantly from tank to tank because of differences in geometry, depth, and inlet and outlet configurations (Baumann and Babbitt, 1953). Sludge and scum also affect the residence time, reducing it as the solids accumulate.

Table 4-13. Septic tank capacities for one- and two-family dwellings (ICC, 1995).

Number of bedrooms	Septic tank volume (gallons)
1	750[a]
2	750[a]
3	1,000
4	1,200
5	1,425
6	1,650
7	1,875
8	2,100

[a] Many states have established 1,000 gallons or more as the minimum size.

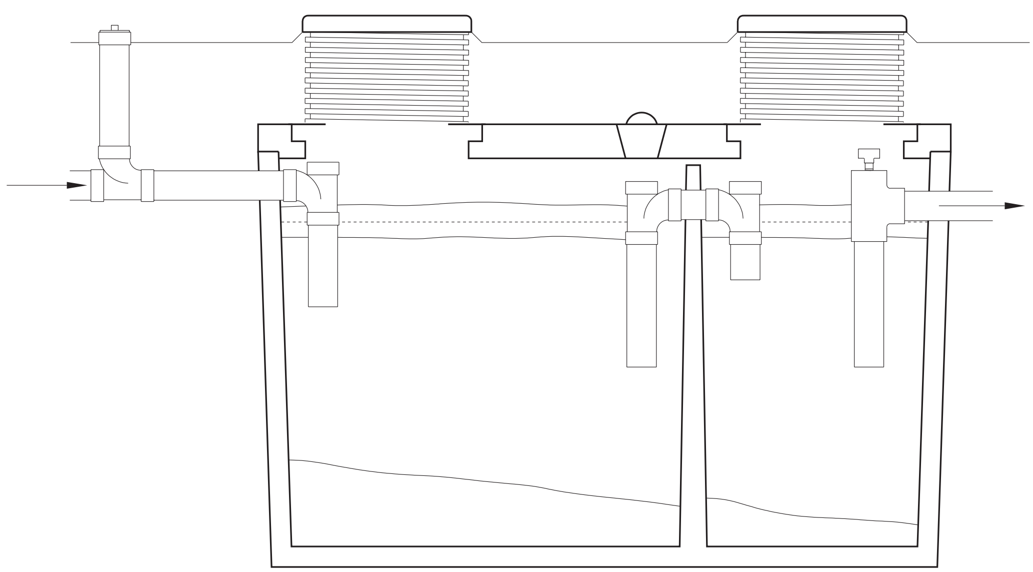
Most state and national plumbing codes specify the tank volume to be used based on the building size or estimated peak daily flow of wastewater. Table 4-13 presents the tank volumes recommended in the International Private Sewage Disposal Code specified for one- and two-family residences (ICC, 1995). The volumes specified are typical of most local codes, but in many jurisdictions the minimum tank volume has been increased to 1,000 gallons or more. For buildings other than one- or two-family residential homes, the rule of thumb often used for sizing tanks is to use two to three times the estimated design flow. This conservative rule of thumb is based on maintaining a 24-hour minimum hydraulic retention time when the tank is ready for pumping, for example, when the tank is one-half to two-thirds full of sludge and scum.

Geometry

Tank geometry affects the hydraulic residence time in the tank. The length-to-width ratio and liquid depth are important considerations. Elongated tanks with length-to-width ratios of 3:1 and greater have been shown to reduce short-circuiting of the raw wastewater across the tank and improve suspended solids removal (Ludwig, 1950). Prefabricated tanks generally are available in rectangular, oval, and cylindrical (horizontal or vertical) shapes. Vertical cylindrical tanks can be the least effective because of the shorter distance between the inlets and outlets. Baffles are recommended.

Among tanks of equal liquid volumes, the tank with shallower liquid depths better reduces peak outflow rates and velocities, so solids are less likely to remain in suspension and be carried out of the tank in the effluent. This is because the shallow tank has a larger surface area. Inflows to the tank cause less of a liquid rise because of the larger surface area. The rate of flow exiting the tank (over a weir or through a pipe invert) is propor-

Figure 4-22. Two-compartment tank with effluent screen and surface risers



Source: Washington Department of Health, 1998.

tional to the height of the water surface over the invert (Baumann et al., 1978; Jones, 1975). Also, the depth of excavation necessary is reduced with shallow tanks, which helps to avoid saturated horizons and lessens the potential for ground water infiltration or tank flotation. A typically specified minimum liquid depth below the outlet invert is 36 inches. Shallower depths can disturb the sludge blanket and, therefore, require more frequent pumping.

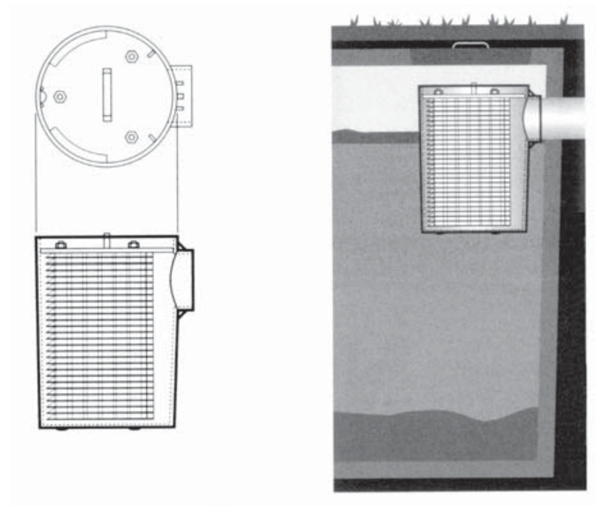
Compartmentalization

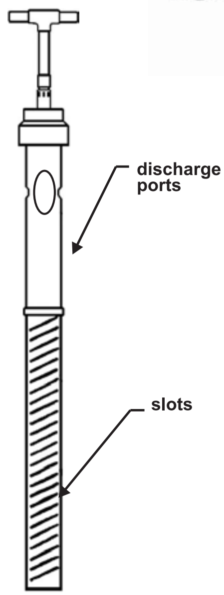
Compartmentalized tanks (figure 4-23) or tanks placed in series provide better suspended solids removal than single-compartment tanks alone, although results from different studies vary (Baumann and Babbitt, 1953; Boyer and Rock, 1992; Weibel et al., 1949, 1954; University of Wisconsin, 1978). If two compartments are used, better suspended solids removal rates are achieved if the first compartment is equal to one-half to two-thirds the total tank volume (Weibel et al., 1949, 1954). An air vent between compartments must be provided to allow both compartments to vent. The primary advantage of these configurations is when gas generated from organic solids digestion in the first compartment is separated from subsequent compartments.

Inlets and outlets

The inlet and outlet of a septic tank are designed to enhance tank performance. Their respective invert elevations should provide at least a 2- to 3-inch drop across the tank to ensure that the building sewer does not become flooded and obstructed during high wastewater flows (figure 4-24). A clear space of at least 9 inches should be provided above the liquid depth (outlet invert) to allow for scum storage and ventilation. Both the inlet and outlet are commonly baffled. Plastic sanitary tees are the most commonly used baffles. Curtain baffles (concrete baffles cast to the tank wall and fiberglass or plastic baffles bolted to the tank wall) have also been used. The use of gasket materials that achieve a watertight joint with the tank wall makes plastic sanitary tees easy to adjust, repair, or equip with effluent screens or filters. The use of a removable, cleanable effluent screen connected to the outlet is strongly recommended.

Figure 4-23. Examples of septic tank effluent screens/filters





Source: Adapted from various manufacturers' drawings.

The inlet baffle is designed to prevent short-circuiting of the flow to the outlet by dissipating the energy of the influent flow and deflecting it downward into the tank. The rising leg of the tee should extend at least 6 inches above the liquid level to prevent the scum layer from plugging the inlet. It should be open at the top to allow venting of the tank through the building sewer and out the plumbing stack vent. The descending leg should extend well into the clear space between the sludge and scum layers, but not more than about 30 to 40 percent of the liquid depth. The volume of the descending leg should not be larger than 2 to 3 gallons so that it is completely flushed to expel floating materials that could cake the inlet. For this reason, curtain baffles should be avoided.

The outlet baffle is designed to draw effluent from the clear zone between the sludge and scum layers. The rising leg of the tee should extend 6 inches above the liquid level to prevent the scum layer from escaping the tank. The descending leg should extend to 30 or 40 percent of the liquid depth. Effluent screens (commonly called septic tank filters), which can be fitted to septic tank outlets, are commercially available. Screens prevent solids that either are buoyant or are resuspended from the scum or sludge layers from passing out of the tank (figures 4-22 and 4-23). Mesh, slotted screens, and stacked plates with openings from 1/32 to 1/8 inch are available. Usually, the screens can be fitted into the existing outlet tee or retrofitted directly into the outlet. An access port directly above the outlet is required so the screen can be removed for inspection and cleaning.

Quality-assured, reliable test results have not shown conclusively that effluent screens result in effluents with significantly lower suspended solids and BOD concentrations. However, they provide an excellent, low-cost safeguard against neutral-buoyancy solids and high suspended solids in the tank effluent resulting from solids digestion or other upsets. Also, as the effluent screens clog over time, slower draining and flushing of home fixtures may alert homeowners of the need for maintenance before complete blockage occurs.

Tank access

Access to the septic tank is necessary for pumping septage, observing the inlet and outlet baffles, and servicing the effluent screen. Both manways and inspection ports are used. Manways are large openings, 18 to 24 inches in diameter or square. At least one that can provide access to the entire tank for septage removal is needed. If the system is compartmentalized, each compartment requires a manway. They are located over the inlet, the outlet, or the center of the tank. Typically, in the past manway covers were required to be buried under state and local codes. However, they should be above grade and fitted with an airtight, lockable cover so they can be accessed quickly and easily. Inspection ports are 8 inches or larger in diameter and located over both the inlet and the outlet unless a manway is used. They should be extended above grade and securely capped.

(*CAUTION: The screen should not be removed for inspection or cleaning without first plugging the outlet or pumping the tank to lower the liquid level below the outlet invert. Solids retained on the screen can slough off as the screen is removed. These solids will pass through the outlet and into the SWIS unless precautions are taken. This caution should be made clear in homeowner instructions and on notices posted at the access port.)*

Septic tank designs for large wastewater flows do not differ from designs for small systems. However, it is suggested that multiple compartments or tanks in series be used and that effluent screens be attached to the tank outlet. Access ports and manways should be brought to grade and provided with locking covers for all large systems.

Construction materials

Septic tanks smaller than 6,000 gallons are typically premanufactured; larger tanks are constructed in place. The materials used in premanufactured tanks include concrete, fiberglass, polyethylene, and coated steel. Precast concrete tanks are by far the most common, but fiberglass and plastic tanks are gaining popularity. The lighter weight fiberglass and plastic tanks can be shipped longer distances and set in place without cranes. Concrete tanks, on the other hand, are less susceptible to collapse and flotation. Coated steel tanks are no longer widely used because they corrode easily. Tanks constructed in place are typically made of concrete.

Tanks constructed of fiberglass-reinforced polyester (FRP) usually have a wall thickness of about 1/4 inch (6 millimeters). Most are gel- or resin-coated to provide a smooth finish and prevent glass fibers from becoming exposed, which can cause wicking. Polyethylene tanks are more flexible than FRP tanks and can deform to a shape of structural weakness if not properly designed. Concrete tank walls are usually about 4 inches thick and reinforced with no. 5 rods on 8-inch (20-centimeter) centers. Sulfuric acid and hydrogen sulfide, both of which are present in varying concentrations in septic tank effluent, can corrode exposed rods and the concrete itself over time. Some plastics (e.g., polyvinyl chloride, polyethylene, but not nylon) are virtually unaffected by acids and hydrogen sulfide (USEPA, 1991).

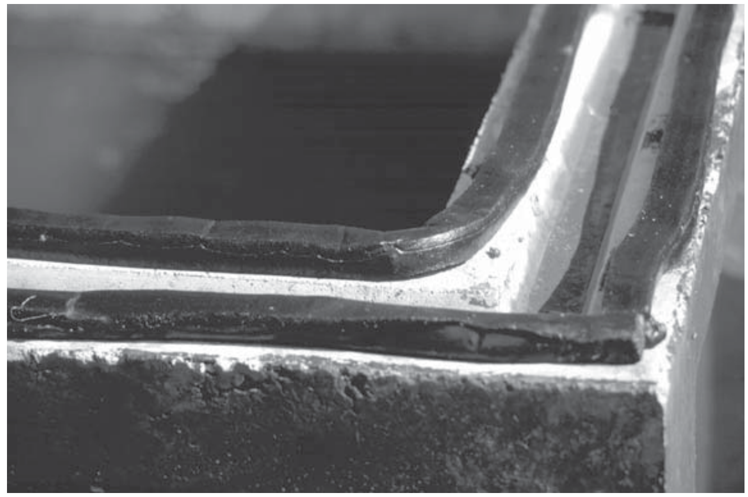
Quality construction is critical to proper performance. Tanks must be properly designed, reinforced, and constructed of the proper mix of materials so they can meet anticipated loads without cracking or collapsing. All joints must be watertight and flexible to accommodate soil conditions. For concrete tank manufacturing, a "best practices manual" can be purchased from the National Pre-Cast Concrete Association (NPCA, 1998). Also, a *Standard Specification for Precast Concrete Septic Tanks* (C 1227) has been published by the American Society for Testing and Materials (ASTM, 1998).

Watertightness

Watertightness of the septic tank is critical to the performance of the entire onsite wastewater system. Leaks, whether exfiltrating or infiltrating, are serious. Infiltration of clear water to the tank from the building storm sewer or ground water adds to the hydraulic load of the system and can upset subsequent treatment processes. Exfiltration can threaten ground water quality with partially treated wastewater and can lower the liquid level below the outlet baffle so it and subsequent processes can become fouled with scum. Also, leaks can cause the tank to collapse.

Tank joints should be designed for watertightness. Two-piece tanks and tanks with separate covers should be designed with tongue and groove or lap joints (figure 4-24). Manway covers should have similar joints. High-quality, preformed joint sealers should be used to achieve a watertight seal. They should be workable over a wide temperature range and should adhere to clean, dry surfaces; they must not shrink, harden, or oxidize. Seals should meet the minimum compression and other requirements prescribed by the seal manufacturer. Pipe and

Figure 4-24. Tongue and groove joint and sealer



Source: Ayres Associates

inspection port joints should have cast-in rubber boots or compression seals.

Septic tanks should be tested for watertightness using hydrostatic or vacuum tests, and manway risers and inspection ports should be included in the test. The professional association representing the materials industry of the type of tank construction (e.g., the National Pre-cast Concrete Association) should be contacted to establish the appropriate testing criteria and procedures. Test criteria for precast concrete are presented in table 4-14.

4.6.3 Construction considerations

Important construction considerations include tank location, bedding and backfilling, watertightness, and flotation prevention, especially with non-concrete tanks. Roof drains, surface water runoff, and other clear water sources must not be routed to the septic tank. Attention to these considerations

Table 4-14. Watertightness testing procedure/criteria for precast concrete tanks

Standard	Hydrostatic test		Vacuum test	
	Preparation	**Pass/fail criterion**	**Preparation**	**Pass/fail criterion**
C 1227, ASTM (1993)	Seal tank, fill with water, and let stand for 24 hours. Refill tank.	Approved if water level is held for 1 hour	Seal tank and apply a vacuum of 2 in. Hg.	Approved if 90% of vacuum is held for 2 minutes.
NPCA (1998)	Seal tank, fill with water, and let stand for 8 to 10 hours. Refill tank and let stand for another 8 to 10 hours.	Approved if no further measurable water level drop occurs	Seal tank and apply a vacuum of 4 in. Hg. Hold vacuum for 5 minutes. Bring vacuum back to 4 in. Hg.	Approved if vacuum can be held for 5 minutes without a loss of vacuum.

will help to ensure that the tank performs as intended.

Location

The tank should be located where it can be accessed easily for septage removal and sited away from drainage swales or depressions where water can collect. Local codes must be consulted regarding minimum horizontal setback distances from buildings, property boundaries, wells, water lines, and the like.

Bedding and backfilling

The tank should rest on a uniform bearing surface. It is good practice to provide a level, granular base for the tank. The underlying soils must be capable of bearing the weight of the tank and its contents. Soils with a high organic content or containing large boulders or massive rock edges are not suitable.

After setting the tank, leveling, and joining the building sewer and effluent line, the tank can be backfilled. The backfill material should be free-flowing and free of stones larger than 3 inches in diameter, debris, ice, or snow. It should be added in lifts and each lift compacted. In fine-textured soils such as silts, silt loams, clay loams, and clay, imported granular material should be used. This is a must where freeze and thaw cycles are common because the soil movement during such cycles can work tank joints open. This is a significant concern when using plastic and fiberglass tanks.

The specific bedding and backfilling requirements vary with the shape and material of the tank. The manufacturer should be consulted for acceptable materials and procedures.

Watertightness

All joints must be sealed properly, including tank joints (sections and covers if not a monolithic tank), inlets, outlets, manways, and risers (ASTM, 1993; NPCA, 1998). The joints should be clean and dry before applying the joint sealer. Only high-quality joint sealers should be used (see previous section). Backfilling should not proceed until the sealant setup period is completed. After all joints have been made and have cured, a watertightness test should be performed (see table 4-14 for precast concrete tanks). Risers should be tested.

Flotation prevention

If the tank is set where the soil can be saturated, tank flotation may occur, particularly when the tank is empty (e.g., recently pumped dose tanks or septic tank after septage removal). Tank manufacturers should be consulted for appropriate antiflotation devices.

4.6.4 Operation and maintenance

The septic tank is a passive treatment unit that typically requires little operator intervention. Regular inspections, septage pumping, and periodic cleaning of the effluent filter or screen are the only operation and maintenance requirements. Commercially available microbiological and enzyme additives are promoted to reduce sludge and scum accumulations in septic tanks. They are not necessary for the septic tank to function properly when treating domestic wastewaters. Results from studies to evaluate their effectiveness have failed to prove their cost-effectiveness for residential application. For most products, concentrations of suspended solids and BOD in the septic tank effluent increase upon their use, posing a threat to SWIS performance. No additive made up of organic solvents or strong alkali chemicals should be used because they pose a potential threat to soil structure and ground water.

Inspections

Inspections are performed to observe sludge and scum accumulations, structural soundness, watertightness, and condition of the inlet and outlet baffles and screens. *(Warning: In performing inspections or other maintenance, the tank should not be entered. The septic tank is a confined space and entering can be extremely hazardous because of toxic gases and/or insufficient oxygen.)*

Sludge and scum accumulations

As wastewater passes through and is partially treated in the septic tank over the years, the layers of floatable material (scum) and settleable material (sludge) increase in thickness and gradually reduce the amount of space available for clarified wastewater. If the sludge layer rises to the bottom of the effluent T-pipe, solids can be drawn through the effluent port and transported into the infiltration field, increasing the risk of clogging. Likewise, if the bottom of the thickening scum layer moves lower than the bottom of the effluent T-pipe, oils and other scum material can be drawn into the piping that discharges to the infiltration field. Various devices are commercially available to measure sludge and scum depths. The scum layer should not extend above the top or below the bottom of either the inlet or outlet tees. The top of the sludge layer should be at least 1 foot below the bottom of either tee or baffle. Usually, the sludge depth is greatest below the inlet baffle. The scum layer bottom must not be less than 3 inches above the bottom of the outlet tee or baffle. If any of these conditions are present, there is a risk that wastewater solids will plug the tank inlet or be carried out in the tank effluent and begin to clog the SWIS.

Structural soundness and watertightness

Structural soundness and watertightness are best observed after the septage has been pumped from the tank. The interior tank surfaces should be inspected for deterioration, such as pitting, spalling, delamination, and so forth and for cracks and holes. The presence of roots, for example, indicates tank cracks or open joints. These observations should be made with a mirror and bright light. Watertightness can be checked by observing the liquid level (before pumping), observing all joints for seeping water or roots, and listening for running or dripping water. Before pumping, the liquid level of the tank should be at the outlet invert level. If the liquid level is below the outlet invert, exfiltration is occurring. If it is above, the outlet is obstructed or the SWIS is flooded. A constant trickle from the inlet is an indication that plumbing fixtures in the building are leaking and need to be inspected.

Baffles and screens

The baffles should be observed to confirm that they are in the proper position, secured well to the piping or tank wall, clear of debris, and not cracked or broken. If an effluent screen is fitted to the outlet baffle, it should be removed, cleaned, inspected for irregularities, and replaced. Note that effluent screens should not be removed until the tank has been pumped or the outlet is first plugged.

Septic tank pumping

Tanks should be pumped when sludge and scum accumulations exceed 30 percent of the tank volume or are encroaching on the inlet and outlet baffle entrances. Periodic pumping of septic tanks is recommended to ensure proper system performance and reduce the risk of hydraulic failure. If systems are not inspected, septic tanks should be pumped every 3 to 5 years depending on the size of the tank, the number of building occupants, and household appliances and habits (see Special Issues Fact Sheets). Commercial systems should be inspected and/or pumped more frequently, typically annually. There is a system available that provides continuous monitoring and data storage of changes in the sludge depth, scum or grease layer thickness, liquid level, and temperature in the tank. Long-term verification studies of this system are under way. Accumulated sludge and scum material stored in the tank should be removed by a certified, licensed, or trained service provider and reused or disposed of in accordance with applicable federal, state, and local codes. (Also see section 4.5.5.)

4.6.5 Septage

Septage is an odoriferous slurry (solids content of only 3 to 10 percent) of organic and inorganic material that typically contains high levels of grit, hair, nutrients, pathogenic microorganisms, oil, and grease (table 4-15). Septage is defined as the entire contents of the septic tank—the scum, the sludge, and the partially clarified liquid that lies between them—and also includes pumpings from aerobic treatment unit tanks, holding tanks, biological ("composting") toilets, chemical or vault toilets, and other systems that receive domestic wastewaters. Septage is controlled under the federal regulations at 40 CFR Part 503. Publications and other information on compliance with these regulations can be found at **http://www.epa.gov/oia/tips/scws.htm**.

Septage also may harbor potentially toxic levels of metals and organic and inorganic chemicals. The exact composition of septage from a particular treatment system is highly dependent upon the type of facility and the activities and habits of its users.

Table 4-15. Chemical and physical characteristics of domestic septage

Parameter	Concentration (mg/L)	
	Average	Range
Total solids	34,106	1,132–130,475
Total volatile solids	23,100	353–71,402
Total suspended solids	12,862	310–93,378
Volatile suspended solids	9,027	95–51,500
Biochemical oxygen demand	6,480	440–78,600
Chemical oxygen demand	31,900	1,500–703,000
Total Kjeldahl nitrogen	588	66–1,060
Ammonia nitrogen	97	3–116
Total phosphorus	210	20–760
Alkalinity	970	522–4,190
Grease	5,600	208–23,368
pH	—	1.5–12.6

Source: USEPA, 1994.

For example, oil and grease levels in septage from food service or processing facilities might be many times higher than oil and grease concentrations in septage from residences (see Special Issues Fact Sheets). Campgrounds that have separate graywater treatment systems for showers will likely have much higher levels of solids in the septage from the blackwater (i.e., toilet waste) treatment system. Septage from portable toilets might have been treated with disinfectants, deodorizers, or other chemicals.

Septage management programs

The primary objective of a septage management program is to establish procedures and rules for handling and disposing of septage in an affordable manner that protects public health and ecological resources. When planning a program it is important to have a thorough knowledge of legal and regulatory requirements regarding handling and disposal. USEPA (1994) has issued regulations and guidance that contain the type of information required for developing, implementing, and maintaining a septage management program. Detailed guidance for identifying, selecting, developing, and operating reuse or disposal sites for septage is provided in *Process Design Manual: Surface Disposal of Sewage Sludge and Domestic Septage* (USEPA, 1995[b]), which is on the Internet at **http://www.epa.gov/ORD/WebPubs/sludge.pdf**. Additional information can be found in *Domestic Septage Regulatory Guidance* (USEPA, 1993), at **http://www.epa.gov/oia/tips/scws.htm**.

States and municipalities typically establish public health and environmental protection regulations for septage management (pumping, handling, transport, treatment, and reuse/disposal). Key components of septage management programs include tracking or manifest systems that identify acceptable septage sources, pumpers, transport equipment, final destination, and treatment, as well as procedures for controlling human exposure to septage, including vector control, wet weather runoff, and access to disposal sites.

Septage treatment/disposal: land application

The ultimate fate of septage generally falls into three basic categories—land application, treatment at a wastewater treatment plant, or treatment at a special septage treatment plant. Land application is the most commonly used method for disposing of septage in the United States. Simple and cost-effective, land application approaches use minimal energy and recycle organic material and nutrients back to the land. Topography, soils, drainage patterns, and agricultural crops determine which type of land disposal practice works best for a given situation. Some common alternatives are surface application, subsurface incorporation, and burial. Disposal of portable toilet wastes mixed with disinfectants, deodorizers, or other chemicals at land application sites is not recommended. If possible, these wastes should be delivered to the collection system of a wastewater treatment plant to avoid potential chemical contamination risks at septage land application sites. Treatment plant operators should be consulted so they can determine when and where the septage should be added to the collection system.

When disposing of septage by land application, appropriate buffers and setbacks should be provided between application areas and water resources (e.g., streams, lakes, sinkholes). Other considerations include vegetation type and density, slopes, soils, sensitivity of water resources, climate, and application rates. Agricultural products from the site must not be directly consumed by humans. Land application practices include the following:

Spreading by hauler truck or farm equipment

In the simplest method, the truck that pumps the septage takes it to a field and spreads it on the soil. Alternatively, the hauler truck can transfer its septage load into a wagon spreader or other specialized spreading equipment or into a holding facility at the site for spreading later.

Spray irrigation

Spray irrigation is an alternative that eliminates the problem of soil compaction by tires. Pretreated septage is pumped at 80 to 100 psi through nozzles and sprayed directly onto the land. This method allows for septage disposal on fields with rough terrain.

Ridge and furrow irrigation

Pretreated septage can be transferred directly into furrows or row crops. The land should be relatively level.

Subsurface incorporation of septage

This alternative to surface application involves placing untreated septage just below the surface. This approach reduces odors and health risks while still fertilizing and conditioning the soil. The method can be applied only on relatively flat land (less than 8 percent slope) in areas where the seasonally high water table is at least 20 inches. Because soil compaction is a concern, no vehicles should be allowed to drive on the field for 1 to 2 weeks after application. Subsurface application practices include the following:

- *Plow and furrow irrigation:* In this simple method, a plow creates a narrow furrow 6 to 8 inches (15 to 20 centimeters) deep. Liquid septage is discharged from a tank into the furrow, and a second plow covers the furrow.
- *Subsurface injection:* A tillage tool is used to create a narrow cavity 4 to 6 inches (10 to 15 centimeters) deep. Liquid septage is injected into the cavity, and the hole is covered.

Codisposal of septage in sanitary landfills

Because of the pollution risks associated with runoff and effluent leaching into ground water, landfill disposal of septage is not usually a viable option. However, some jurisdictions may allow disposal of septage/soil mixtures or permit other special disposal options for dewatered septage (sludge with at least 20 percent solids). Septage or sludge deposited in a landfill should be covered immediately with at least 6 inches of soil to control odors and vector access (USEPA, 1995b). *(Note: Codisposal of sewage sludge or domestic septage at a municipal landfill is considered surface disposal and is regulated under 40 CFR Part 258.)*

Septage treatment/disposal: treatment plants

Disposal of septage at a wastewater treatment plant is often a convenient and cost-effective option. Addition of septage requires special care and handling because by nature septage is more concentrated than the influent wastewater stream at the treatment plant. Therefore, there must be adequate capacity at the plant to handle and perhaps temporarily store delivered septage until it can be fed into the treatment process units. Sites that typically serve as the input point for septage to be treated at a wastewater treatment plant include the following:

Upstream sewer manhole

This alternative is viable for larger sewer systems and treatment plants. Septage is added to the normal influent wastewater flow at a receiving station fitted with an access manhole.

Treatment plant headworks

The septage is added at the treatment plant upstream of the inlet screens and grit chambers. The primary concern associated with this option is the impact of the introduced wastes on treatment unit processes in the plant. A thorough analysis should be conducted to ensure that plant processes can accept and treat the wastes while maintaining appropriate effluent pollutant concentrations and meeting other treatment requirements. In any event, the treatment plant operator should be consulted before disposal.

Sludge-handling process

To reduce loading to the liquid stream, the septage can be sent directly to the sludge-handling process. Like the headworks option, the impact on the sludge treatment processes must be carefully analyzed to ensure that the final product meets treatment and other requirements.

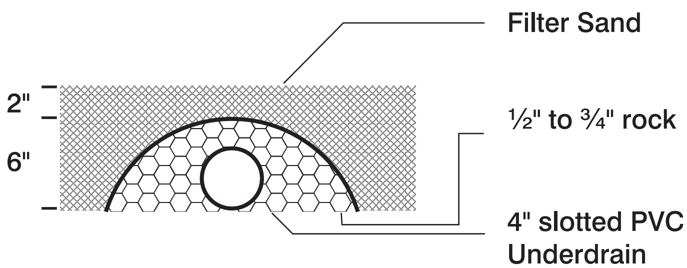
Treatment at a special septage treatment plant

This method of septage disposal is usually employed in areas where land disposal or treatment at a wastewater treatment plant is not a feasible option. There are few of these facilities, which vary from simple lagoons to sophisticated plants that mechanically and/or chemically treat septage. Treatment processes used include lime stabilization, chlorine oxidation, aerobic and anaerobic digestion, composting, and dewatering using pressure or vacuum filtration or centrifugation. This is the most expensive option for septage management and should be considered only as a last resort.

Public outreach and involvement

Developing septage treatment units or land application sites requires an effective public outreach program. Opposition to locating these facilities in the service area is sometimes based about incomplete or inaccurate information, fear of the unknown, and a lack of knowledge on potential impacts. Without an effective community-based program of involvement, even the most reasonable plan can be difficult to implement. Traditional guidance on obtaining public input in the development of disposal or reuse facilities can be found in *Process Design Manual: Surface Disposal of Sewage Sludge and Domestic Septage* (USEPA, 1995b), which is on the Internet at **http://www.epa.gov/ORD/WebPubs/sludge.pdf**.

Figure 4-25. Underdrain system detail for sand filters



Additional information can be found in *Domestic Septage Regulatory Guidance* (USEPA, 1993), posted at **http://www.epa.gov/oia/tips/scws.htm**. General guidance on developing and implementing a public outreach strategy is available in *Getting In Step: A Guide to Effective Outreach in Your Watershed*, published by the Council of State Governments (see chapter 2) and available at **http://www.epa.gov/owow/watershed/outreach/documents/**.

4.7 Sand/media filters

Sand (or other media) filters are used to provide advanced treatment of settled wastewater or septic tank effluent. They consist of a lined (lined with impervious PVC liner on sand bedding) excavation or watertight structure filled with uniformly sized washed sand (the medium) that is normally placed over an underdrain system (figure 4-25). These contained media filters are also known as packed bed filters. The wastewater is dosed onto the surface of the sand through a distribution network and is allowed to percolate through the sand to the underdrain system. The underdrain collects the filtrate for further processing, recycling, or discharging to a SWIS. Some "bottomless" designs directly infiltrate the filtered effluent into the soil below.

4.7.1 Treatment mechanisms and filter design

Sand filters are essentially aerobic, fixed-film bioreactors used to treat septic tank effluent. Other very important treatment mechanisms that occur in sand filters include physical processes such as straining and sedimentation, which remove suspended solids within the pores of the media, and chemical adsorption of dissolved pollutants (e.g., phosphorus) to media surfaces. The latter phenomenon tends to be finite because adsorption sites become saturated with the adsorbed compound, and it is specific to the medium chosen. Bioslimes from the growth of microorganisms develop as attached films on the sand particle surfaces. The microorganisms in the slimes absorb soluble and colloidal waste materials in the wastewater as it percolates around the sand surfaces. The absorbed materials are incorporated into new cell mass or degraded under aerobic conditions to carbon dioxide and water.