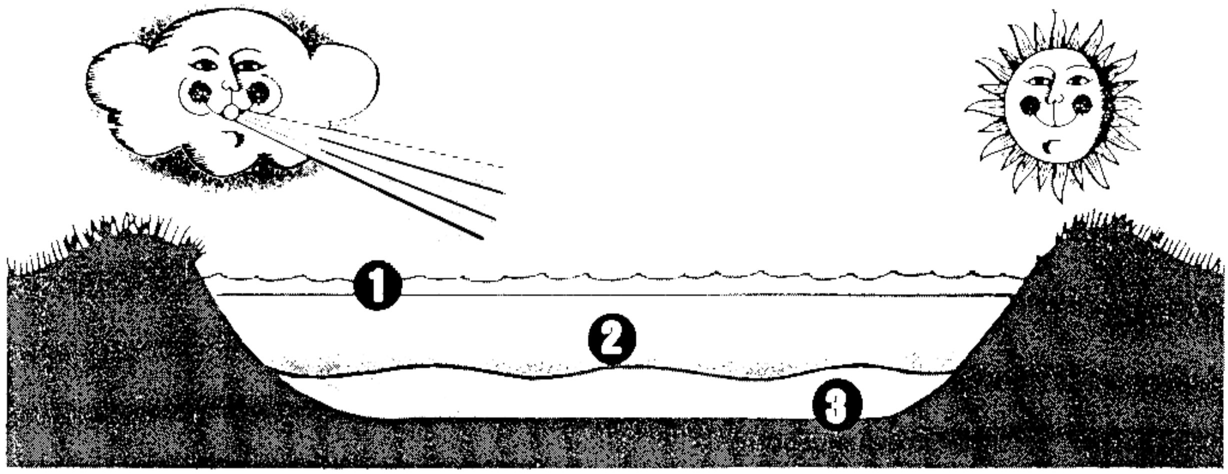
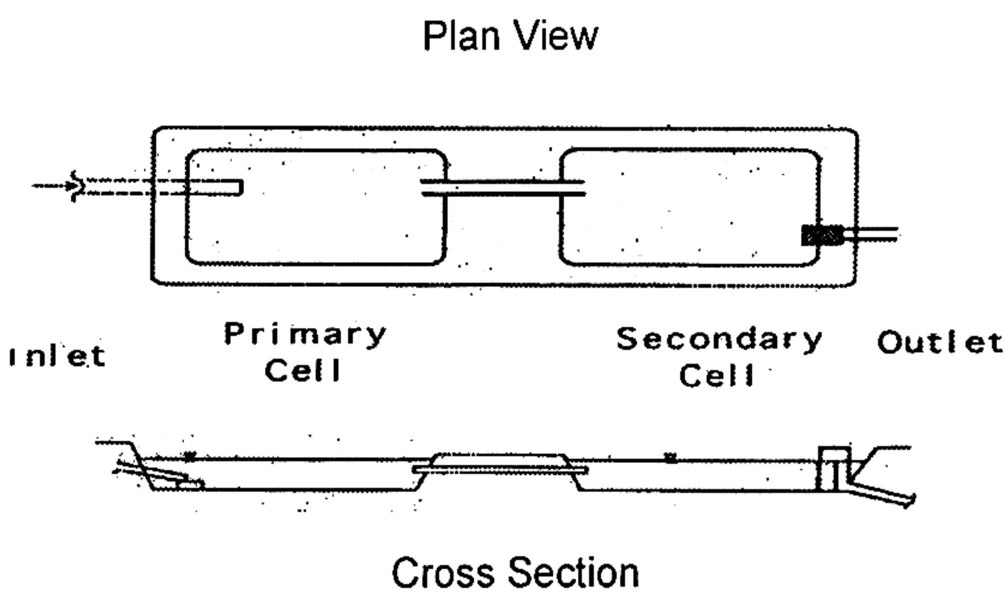
**Figure 4-1 Facultative Lagoon**




*The top layer ❶ in a facultative lagoon is called the aerobic zone, the second layer ❷ is called the facultative zone, and the third layer ❸ is the anaerobic zone.*

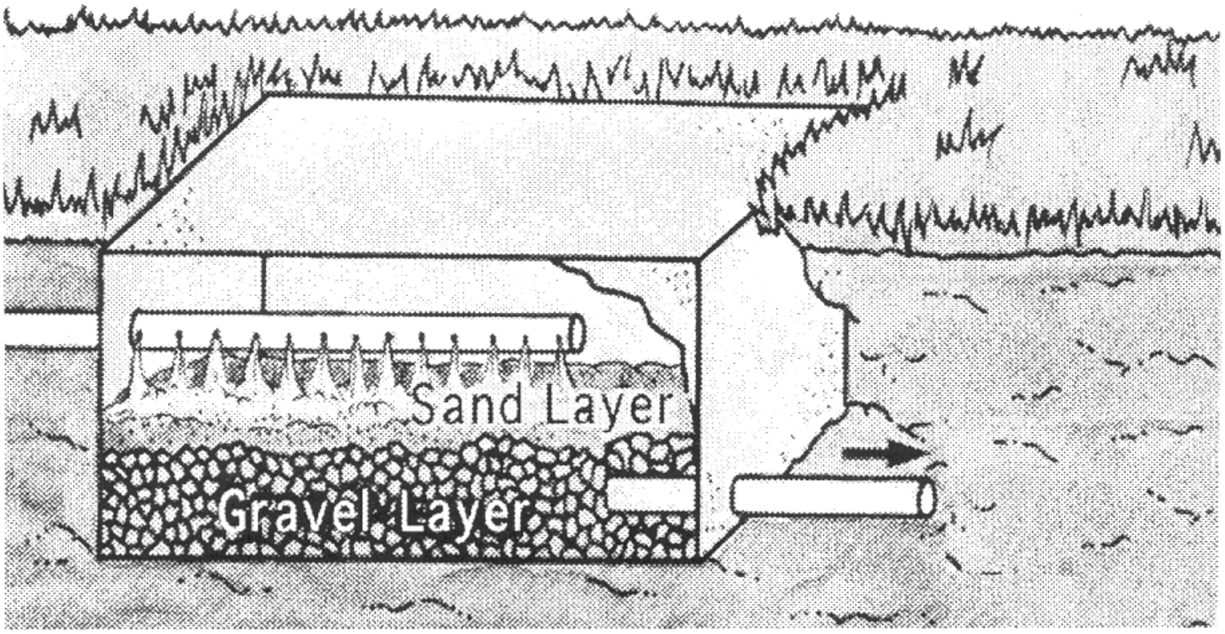
Source: Pipeline, Spring 1997

**Figure 4-2 Multi-Cell Lagoons**



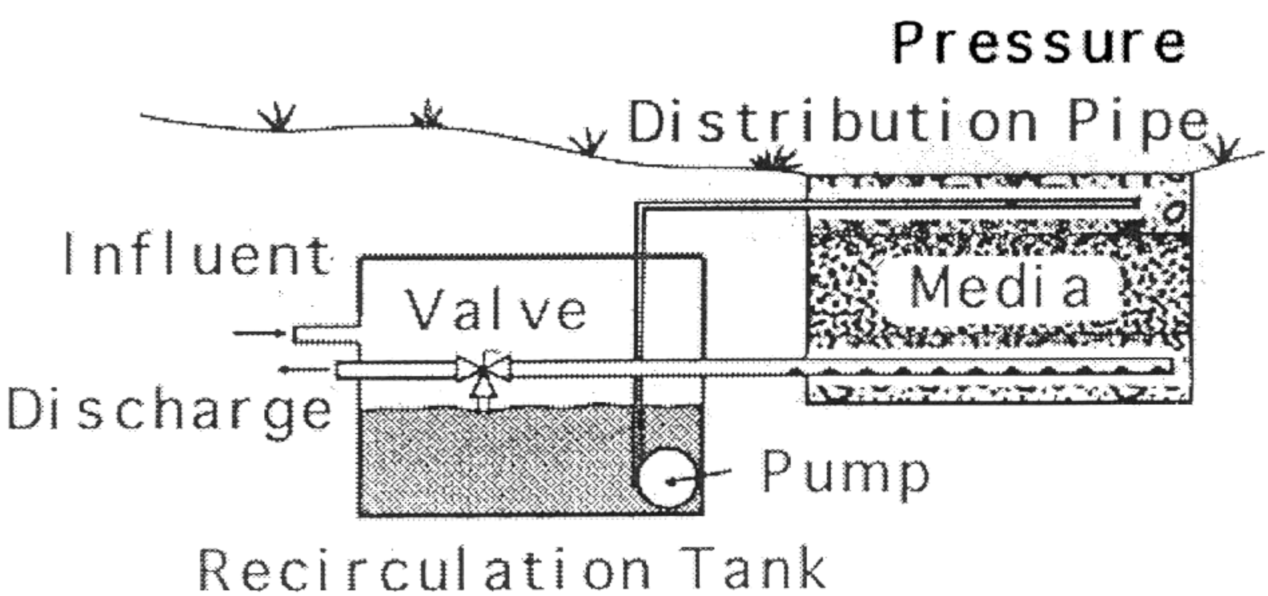

Source: National Environmental Training Center for Small Communities

**Figure 4-3  Intermittent Sand Filter**



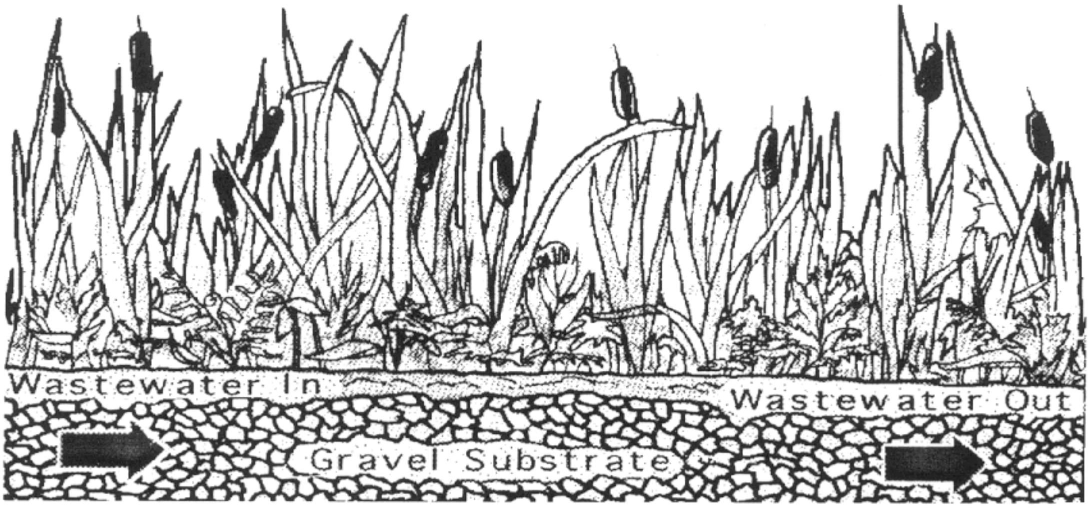

Source: National Environmental Training Center for Small Communities

**Figure 4-4   Recirculating Sand Filter**




Source: National Environmental Training Center for Small Communities

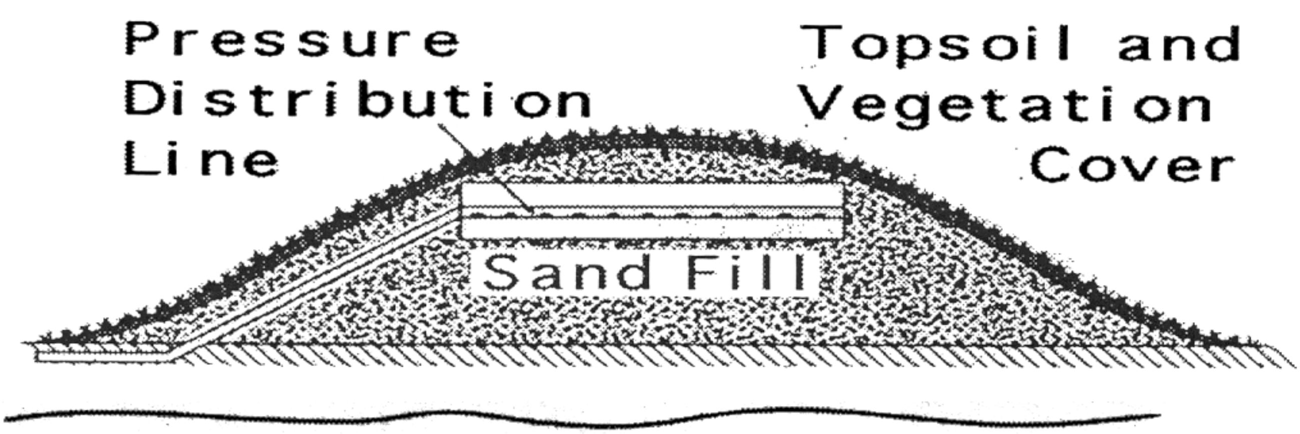
**Figure 4-5 Rock-Plant Filters and Constructed Wetlands**




**Surface Flow Wetland**

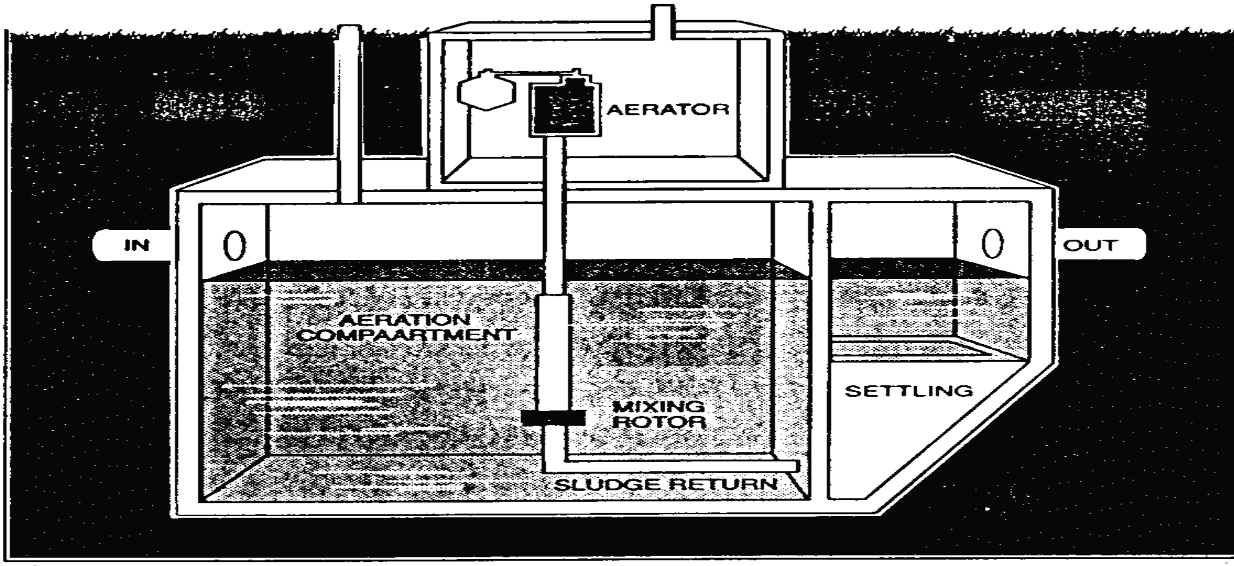
Source: National Environmental Training Center for Small Communities

**Figure 4-6 Mound System**



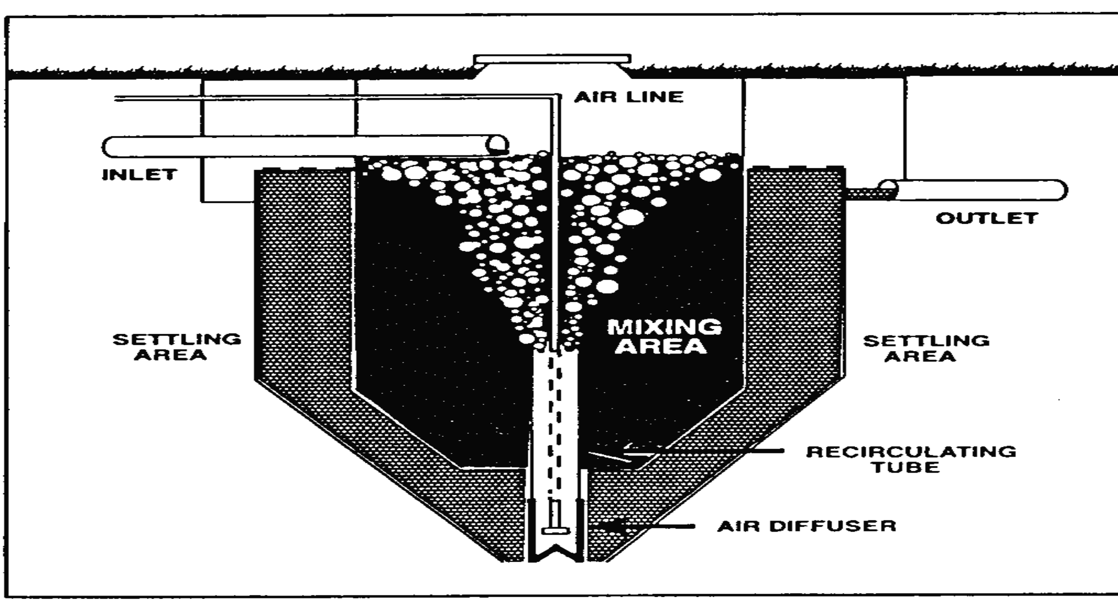

Source: National Environmental Training Center for Small Communities

## Figure 4-7 Aeration System



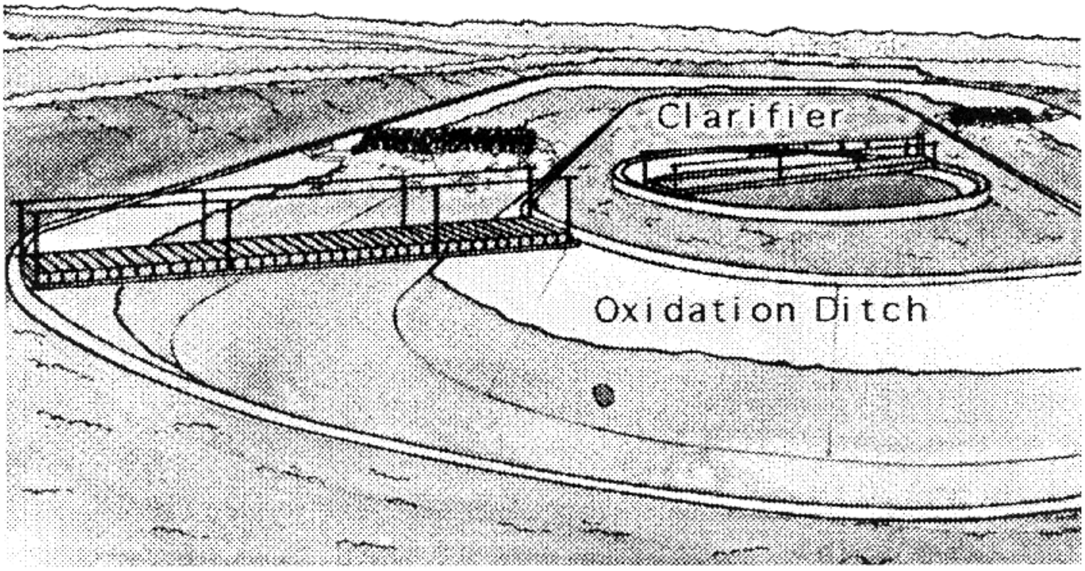

Source: Pipeline, Winter 1996

## Figure 4-8 Aeration System



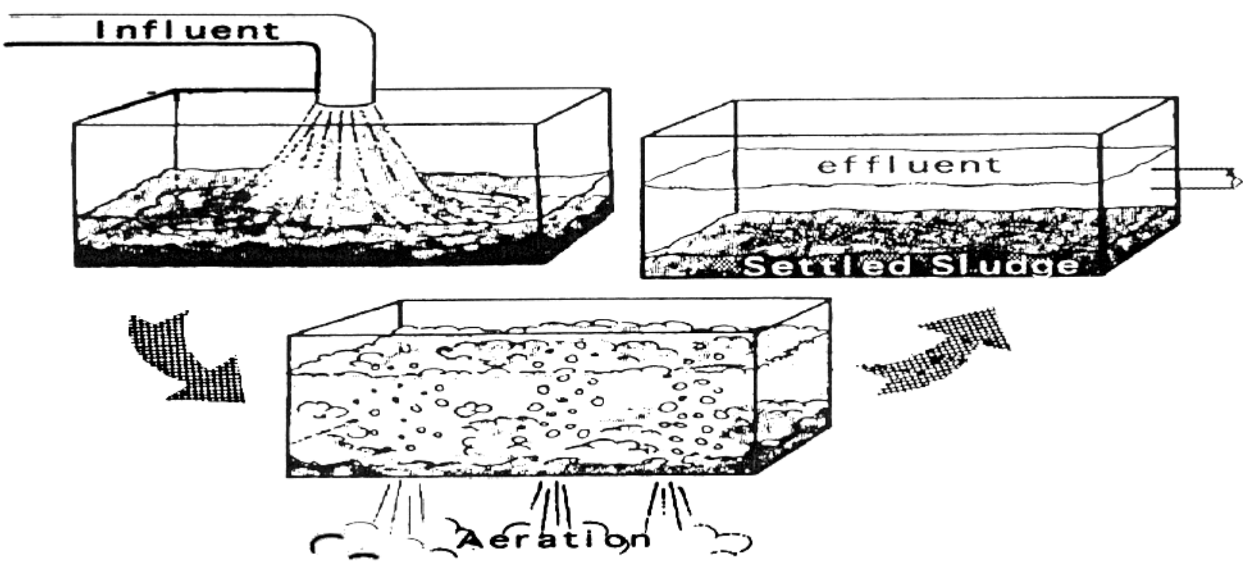

Source: Pipeline, Winter 1996

**Figure 4-9 Oxidation Ditch**



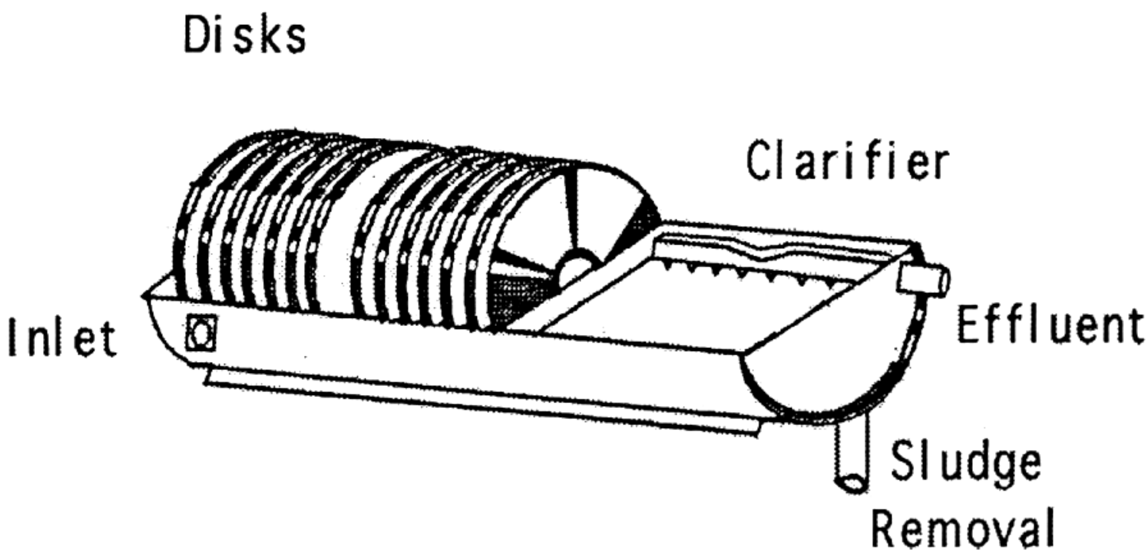

Source: National Environmental Training Center for Small Communities

**Figure 4-10 Sequencing Batch Reactor (SBR)**



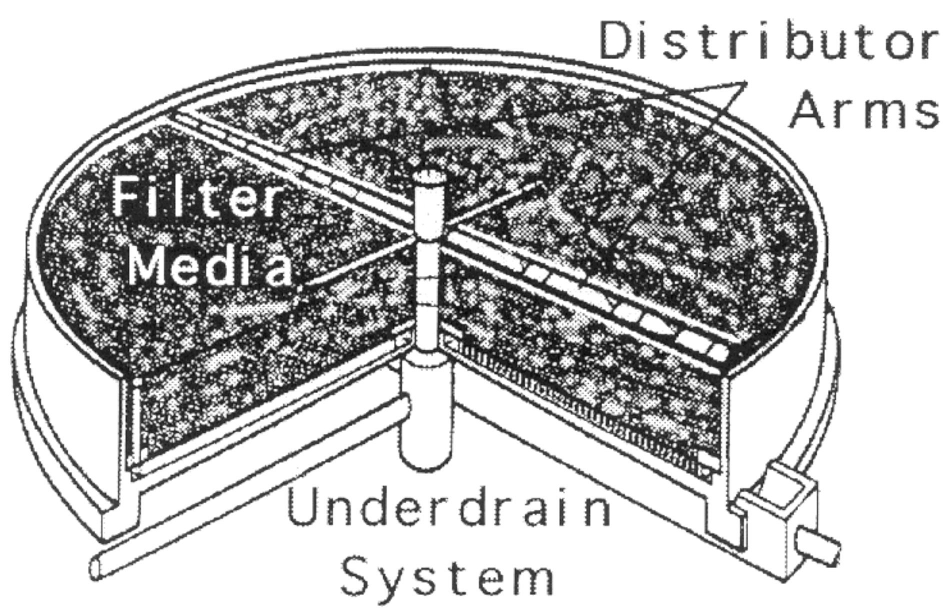

Source: National Environmental Training Center for Small Communities

**Figure 4-11 Rotating Biological Contactor**




Source: National Environmental Training Center for Small Communities

**Figure 4-12 Trickling Filter**




Source: National Environmental Training Center for Small Communities

**Figure 5-1 Conventional Sewer Systems**

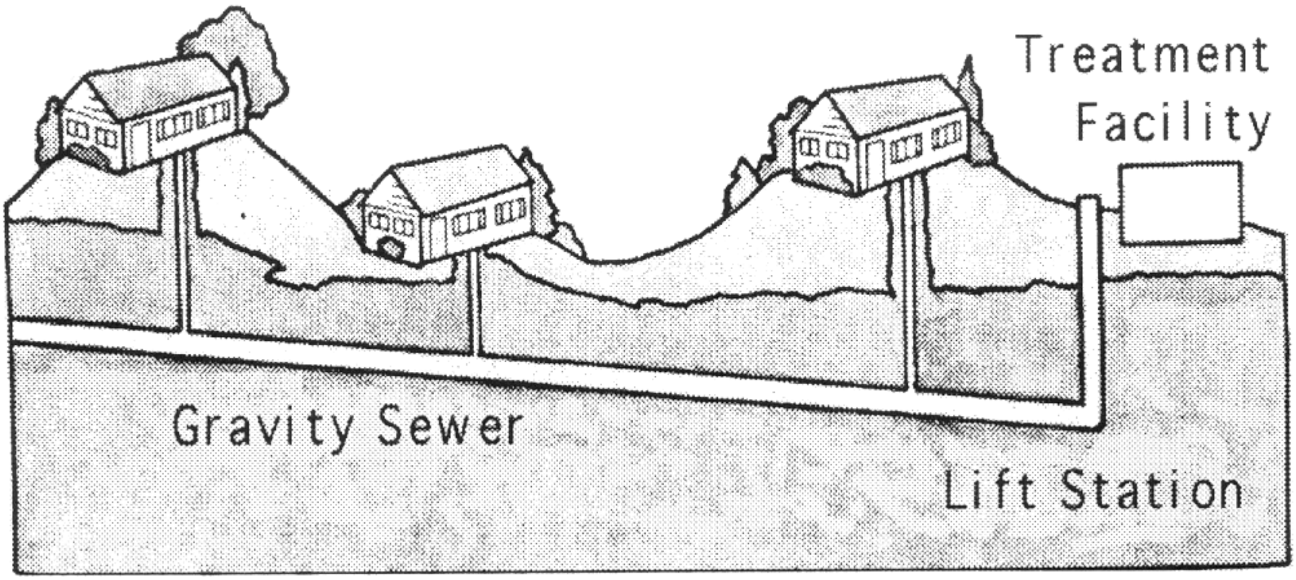



**Figure 5-2 STEP System**
**(Septic Tank Effluent Pump)**

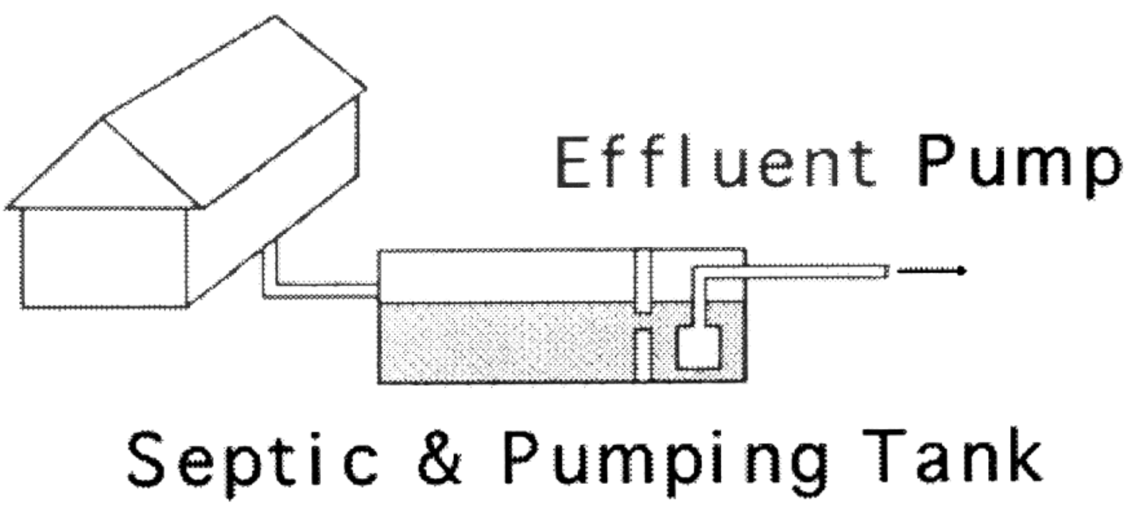


Figure 5-3 Grinder Pump System

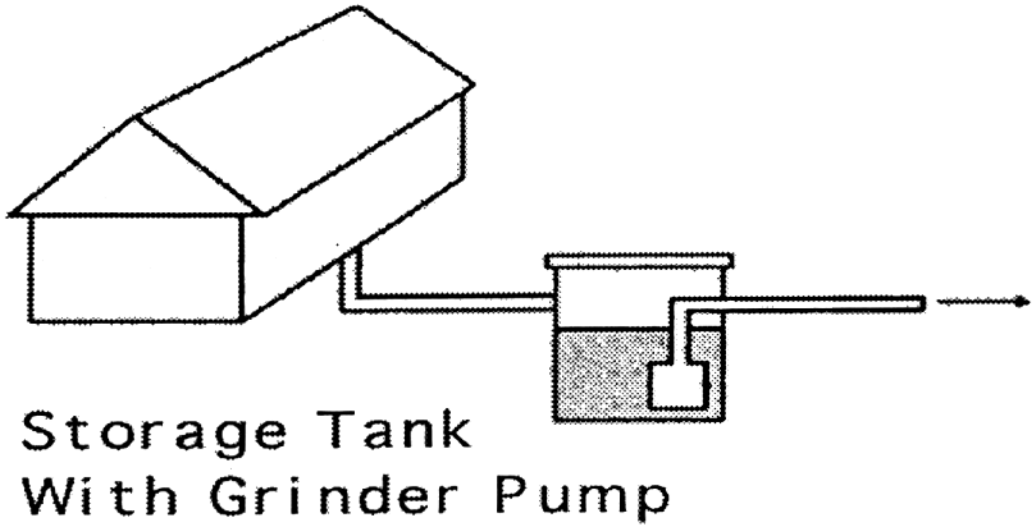



Figure 5-4 Vacuum Sewer System

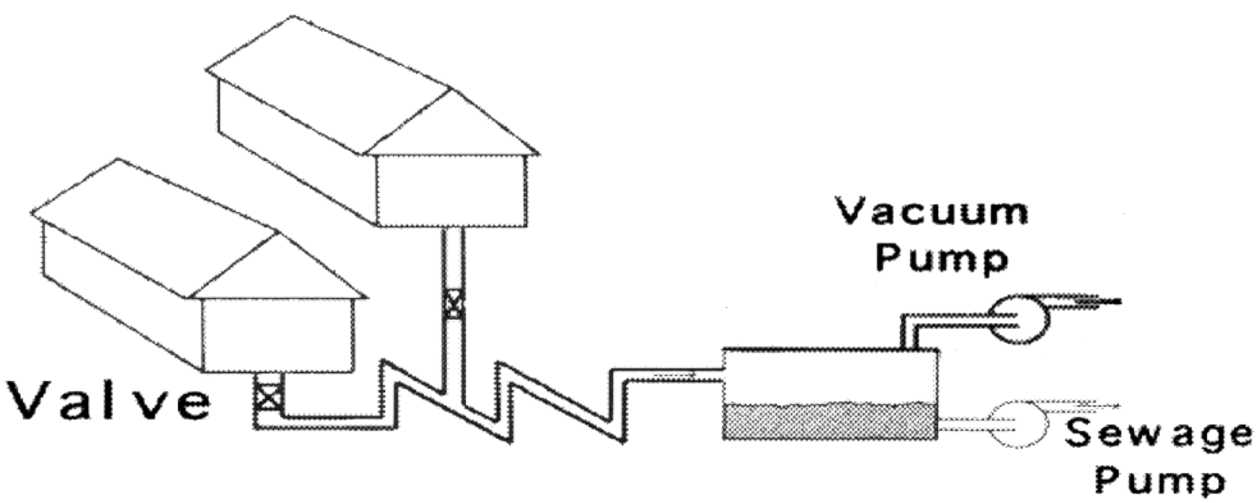


**Figure 5-5 Gravity Sewer in Variable Topography**

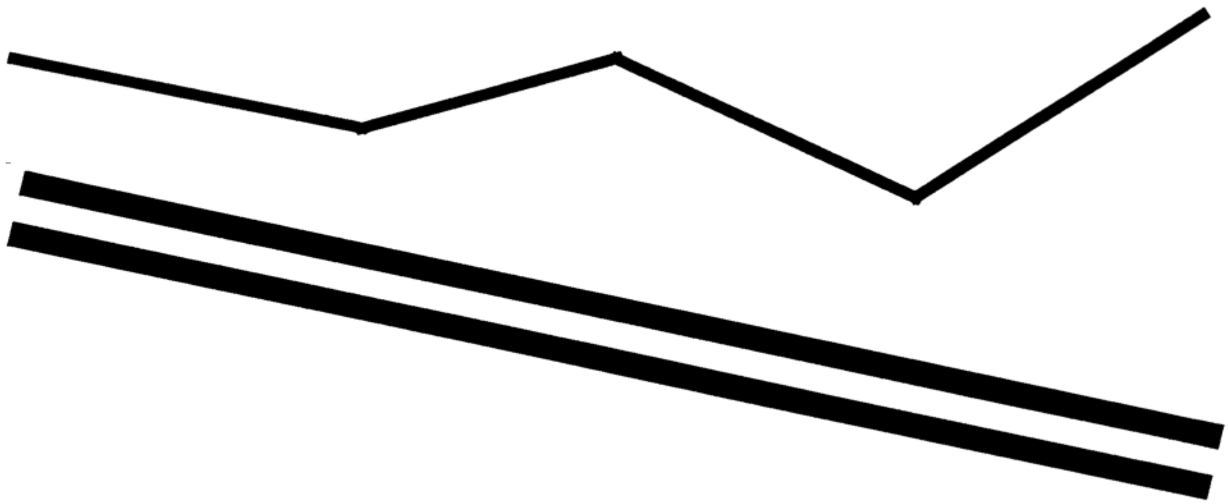


**Figure 5-6 Low Pressure Sewer Variable Topography**

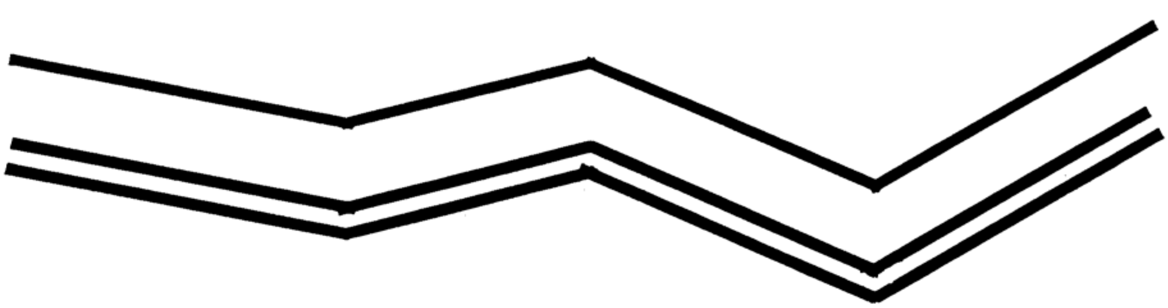


**Figure 5-7 Gravity Sewer in High Bedrock**

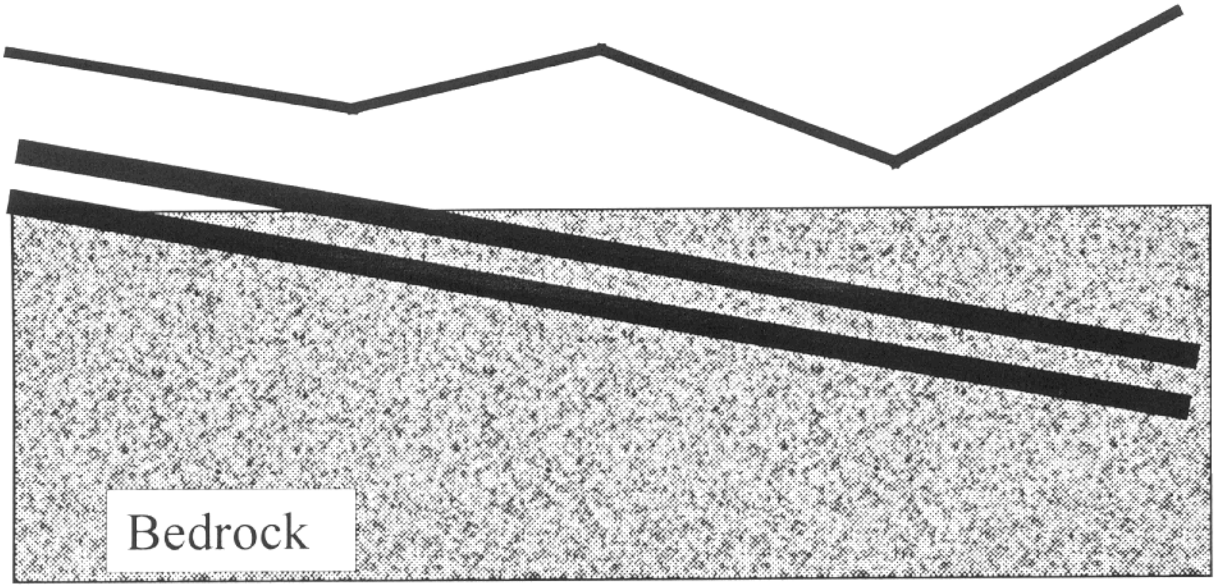



**Figure 5-8 Low Pressure Sewer in High Bedrock**

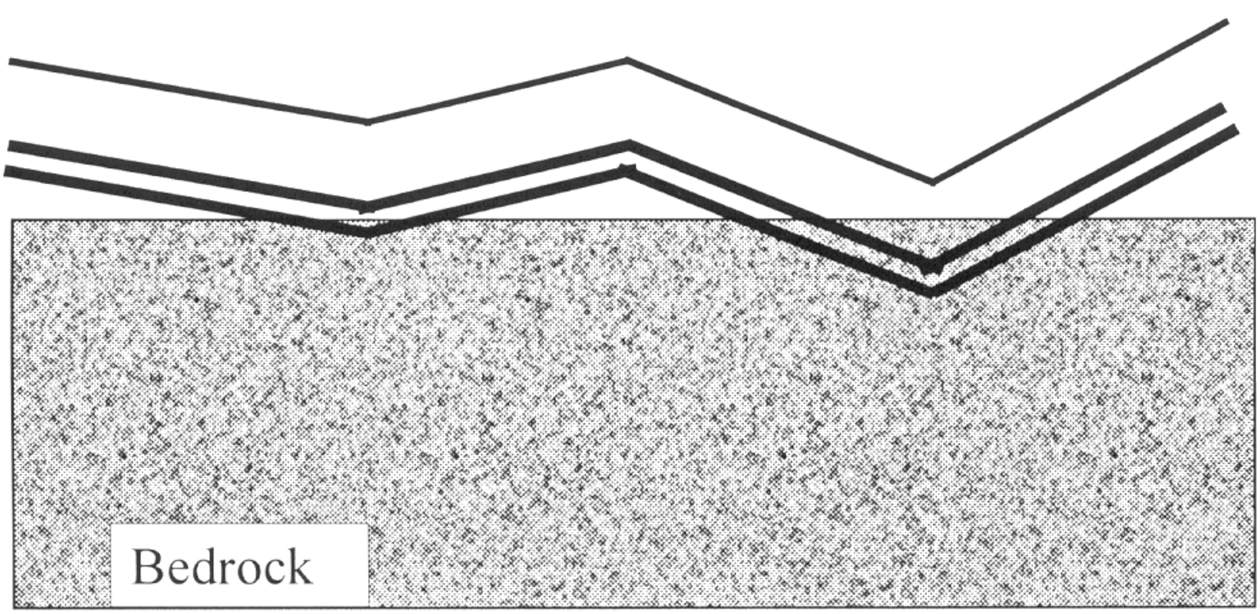


Figure 5-9   Sewer for Small Lots

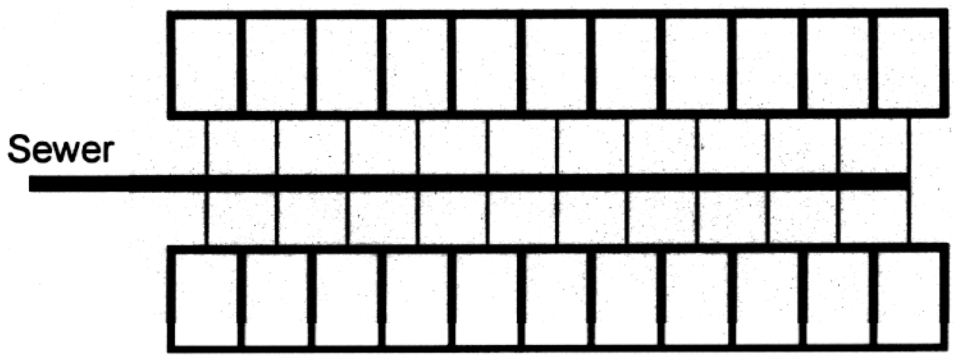



Figure 5-      Sewer for Large Lots

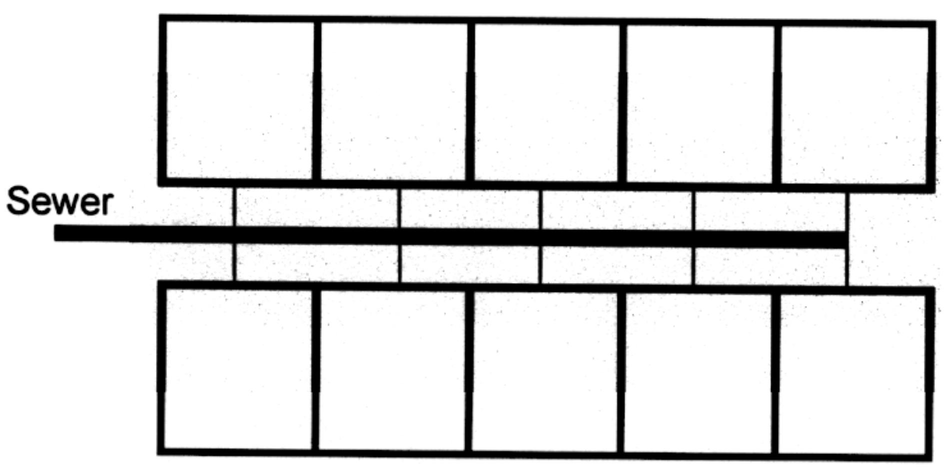
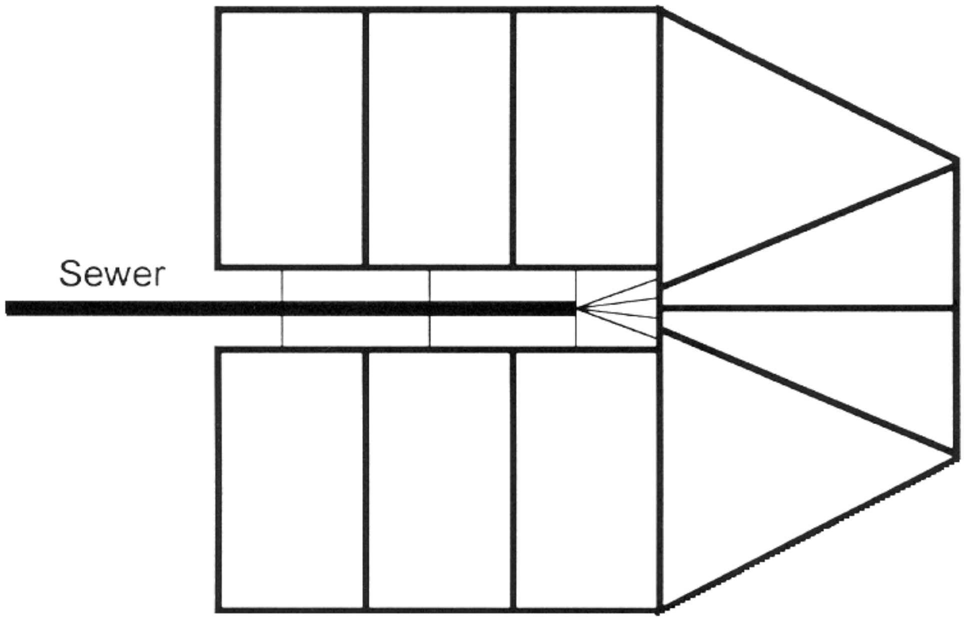


**Figure 5- Lot Layout to Reduce Sewer Length**



# Alternative Sewers: A Good Option for Many Communities

If you are fortunate enough to own a home in a small or rural community, you probably appreciate certain aspects of country living. Being close to nature and far from the noise and complications of life in the city are among the popular reasons for choosing a home in a rural area.

Although the advantages are many, rural life isn't always simpler than big city life. One example is the problem of how to best collect, treat, and dispose of wastewater from all the homes and businesses located in different parts of the community.

A variety of factors help determine which wastewater technologies are best suited for a particular home or area. Often, communities will use a combination of different approaches for different circumstances to save money, control development, and protect public health and the environment.

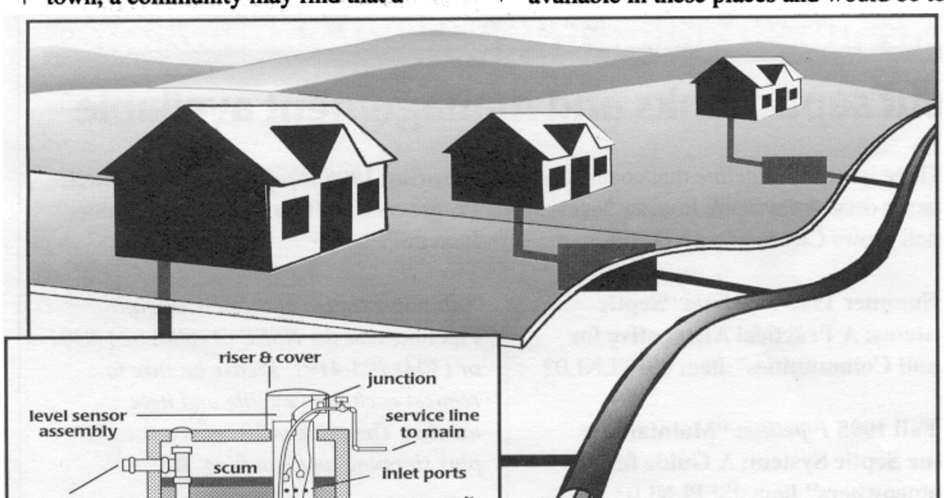
For example, in densely populated areas, like the main business section of town, a community may find that a conventional gravity sewer system (like those used in large towns and cities) and a centralized wastewater treatment plant is the most cost-effective and environmentally-sound way to collect, transport, and treat the wastewater. In more sparsely populated areas, where lot sizes are large and homes are spaced widely apart, onsite wastewater treatment with subsurface discharge may be more practical and cost-effective.

## Alternative Sewer Option

But what about homes in locations that don't fit either of the above descriptions? And what about areas where onsite treatment can't be used?

Many small towns have clusters of homes and housing developments located far from other populated areas of the community. Groups of homes may be located in low-lying areas near water, or in areas with a high water table or with rugged, rocky, or hilly terrain. Often, hookups to conventional sewers are not available in these places and would be too costly to build—yet small lot sizes, poor soil conditions, or other site-related limitations make onsite wastewater treatment alternatives inappropriate or expensive.

Alternative sewers should be considered as a possible option for groups of homes and businesses in areas like these, or anywhere they can cost-effectively fulfill the health and environmental goals of the community.




## Advantages and Disadvantages

One of the best features of alternative sewer systems is that they use plastic pipes much smaller in diameter than conventional sewer pipes to collect and transport the wastewater to final treatment. This is possible because the wastewater that goes into alternative sewers always first receives treatment of some kind (in a septic tank or grinder pump, for example) so that any large, solid materials are separated out or ground into smaller pieces.

These small-diameter plastic pipes are less expensive and easier to install than conventional sewer pipes, which saves money for both the community and the individual homeowner. This is especially significant considering that collection system construction is often responsible for as much as two-thirds of the total wastewater treatment project costs.

Another advantage of alternative sewers is that the construction of the lines and other design factors makes it less likely for wastewater to seep out or for other water to infiltrate the system. Extra water coming through cracked pipes and leaky

*Continued on page 2*

# Alternative Sewers: A Good Option for Many Communities

Continued from page 1

manhole covers is a common problem with conventional sewers that can be avoided with alternative sewers. However the septic tanks, pump tanks, risers, and other system components must be correctly designed and constructed to be watertight. Extra water adds to the flow received by the treatment facility or other method of final treatment, which can reduce the life of the system and add to the community's costs.

In addition, because some alternative sewers don't need to rely on gravity to operate, they also don't have to continuously slope downward like conventional sewers. Instead, they can be buried at very shallow depths, just below the frost line, and can follow the natural contours of the land. This saves money on excavation costs for communities.

These features make some alternative sewer designs appropriate for areas with very hilly terrain, extremely flat terrain, shallow bedrock, high water table, or anywhere the costs and environmental impact of excavating for traditional gravity sewers would be prohibitively high. Trenchless installations and other new techniques can further reduce the costs and impact of construction.

The plastic pipes also can be routed around ponds, lakes, trees, houses, and other obstacles, which can minimize disruption to the environment and save money for homeowners and communities.

Finally, some alternative sewer system designs allow developers and community planners the advantage of more flexibility, because the most expensive system components for each connection do not need to be purchased or installed until after the individual houses are built. However, this can be viewed as a disadvantage for homeowners because the costs of the onsite components are directly shifted to them. On the other hand, homeowners may pay more in the long run for conventional sewers through higher sewer taxes and fees.

The major drawbacks to alternative sewers have to do with operation and maintenance costs and requirements. Alternative sewers have components conventional sewers do not have, such as septic tanks that need to be inspected and pumped and mechanical parts that use electricity. These may cost more to operate and require more frequent and regular maintenance than conventional sewers.

Other potential disadvantages with alternative sewers include the possibility of disruption in service due to mechanical breakdowns and power outages. Also, systems may be poorly designed or installed if engineers or contractors have little experience with the technology.

This issue of *Pipeline* gives an overview of some of the alternative sewer technologies currently in use. Please feel free to share, copy, or distribute this information to others in your community.

## Alternative Sewers May Be a Good Option if . . .

- ✓ conventional gravity sewers and onsite wastewater treatment technologies have been determined to be inappropriate or too expensive;
- ✓ the population in an unsewered area is such that there would be 50 to 100 homes or less per mile of sewer line;
- ✓ homes are located in hilly, rocky, low-lying or very flat areas, or areas with shallow bedrock, a high water table or other site conditions that would make installing gravity sewers impractical; or
- ✓ areas are experiencing potentially costly problems with existing conventional sewers that are leaking or otherwise deteriorating.



*If you have questions about any of the technologies described in this issue, contact the National Small Flows Clearinghouse at (800) 624-8301 or (304) 293-4191.*

has become much more widespread in recent years.

## What are pressure sewers?

A pressure sewer is a small-diameter pipe into which partially-treated wastewater is pumped and then transported under pressure to a final treatment facility or to a conventional gravity sewer main.

Small-diameter pipes can be used with pressure sewers because large and solid materials in the wastewater are separated out or ground up in initial treatment. The pipes are usually made of plastic, which gives them the advantage of being more flexible and more likely to remain watertight than sewers made of clay or concrete. Watertightness is important for maintaining pressurization.

The pressure in pressure sewers is created by the wastewater being pumped into the pipes at several connections. The pressurized lines eliminate the need for gravity as a force to move the wastewater to its destination. Because of this, the pipe can be laid to follow the natural contour of the land in shallow trenches just below the frost line and deep enough to be kept safe from the traffic above.

There are two main types of pressure sewer systems: the septic tank effluent pump (STEP) system and the grinder pump system.

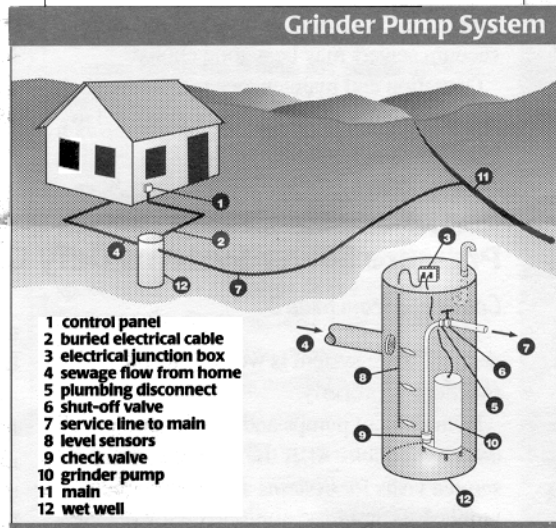
## STEP systems

A STEP system consists of a septic tank to pretreat the wastewater and a submersible, low-horsepower sump pump to push the wastewater through the system.

All of the wastewater from each home or business (i.e., the water from sinks, baths, laundry, kitchen, and toilets) enters the septic tank from the conventional gravity sewer leaving the building. No

middle. The wastewater in the middle layer will eventually be pumped into the pressure sewers. Once this partially treated wastewater leaves the septic tank it is called effluent. Some septic tanks also have filters at the outlet end of the septic tank to further reduce the risk of solids leaving the tank.

The effluent pump is located in a pumping chamber either inside the tank or next




Grinder Pump System

to the tank. The effluent enters the pumping chamber and triggers a sensor when it rises to a certain level. The effluent is then pumped out for a few minutes until the water level is reduced and a lower level sensor shuts the pump off. There is also a sensor that triggers an alarm if, for some reason, effluent levels get too high in the pumping chamber.

All the components of the effluent pump must be resistant to corrosion, since septic tank effluent is particularly corrosive. The PVC plastic pipes typically used for pressure sewers are very resistant to corrosion. However, the corrosiveness of the effluent can present a problem if the pressure sewer empties into a conventional sewer main made of less resistant material.

comparison to conventional sewers, which are normally required to have a minimum diameter of eight inches.

## Grinder pump systems

Grinder pump pressure sewer systems work somewhat differently than STEP systems. In a grinder pump system, there is no septic tank. Preliminary treatment is performed by the grinder pump itself, which sits in a plastic chamber, called a wet well, that usually has about a 30-gallon capacity.

The grinder pump works something like a garbage disposal. Solid materials in the wastewater are cut up and ground into tiny pieces. All of the wastewater is then pumped out into the pressurized line.

Grinder pumps are usually one or more horsepower and turn on and off according to the levels in the pumping chamber. They also are usually equipped with one or more alarms.

Because the wet well does not provide much room for extra wastewater if the system were to malfunction, and because there is no septic tank, it is very important that same-day emergency service is available for grinder pump connections.

## Operation and maintenance

Pressure sewer systems have different operation and maintenance requirements than conventional sewer systems because they use electricity. However, effluent pumps, which are less than one horsepower, and grinder pumps, which are usually one or two horsepower, usually run for only a few minutes per day, so not much energy is used. Grinder pumps are the more expensive of the two technologies to operate, and power costs for them usually range from $10 to $30 method or methods of final treatment should be used needs to be part of a community's overall wastewater management plan.

Many alternative sewer systems empty into a conventional sewer main that leads to a centralized treatment facility. This is sometimes the most cost-effective plan for communities that have this option. However, many small communities do not have a wastewater treatment plant, or the facility may be too far away or too small to handle the extra wastewater flow. There are several other treatment alternatives that communities may consider.

For example, it is often practical to treat the septic tank effluent from septic tank effluent pump systems and small-diameter gravity sewers in a large, community sub-surface soil absorption field similar to the smaller ones used for individual homes with septic systems. If site conditions are unsuitable for a soil absorption field, sometimes mound systems, sand filters, or other options can be constructed and combined with subsurface discharge.

Wastewater treatment lagoons often work well for treating wastewater that contains solids, like sewage from grinder pump and vacuum sewer systems. Sometimes wastes from these alternative sewer systems can be transported to a large community septic tank and soil absorption field.

*Communities needing additional information or assistance concerning wastewater treatment technologies should contact the National Small Flows Clearinghouse at (800) 624-8301 or (304) 293-4191. Also refer to the list of contacts on page 7.*

conditions make some alternative sewer technologies more appropriate and cost-effective than others.

For example, if the homes or businesses to be served by the sewer are all located at a much higher elevation than the final treatment facility, then small-diameter gravity sewers might be the most cost effective technology. If homes are located in a relatively flat area where it would be too expensive to excavate to install septic tanks, vacuum sewers may be a good choice.

Operation and maintenance requirements and community planning issues also need to be considered when choosing an alternative sewer system. Communities may have to

combined with other technologies. For example, many communities have houses located at both high and low elevations. Communities can take advantage of gravity where it's available to save money. For example, a system could make use of small-diameter gravity sewers for some homes and pressure sewers for others.

Although alternative sewer technologies can be flexible, systems must be properly designed to fit each individual situation. Minimum velocity requirements and other design considerations require the expertise of a wastewater or sanitary engineer who has experience with a particular system.

## Pressure Sewer Systems Defy Gravity

*Continued from page 3*

per year if the system is watertight and functioning properly.

Both effluent pumps and grinder pumps are very reliable. After the first year, when service visits for systems are most frequent, pumps may not require servicing for as long as five to 10 years. Preventative maintenance for pressure sewers includes annual inspections for the pumps, septic tanks, and overall system.

Both types of pressure sewer systems use cleanouts instead of manholes as access points for cleaning and monitoring the lines. Cleanouts are smaller, less costly, and, if properly designed and installed, are less likely to leak or require maintenance themselves. Systems need to be designed with cleanouts near any pumps, filters, or other parts that may need maintenance or service.

With STEP systems, solids need to be pumped from the septic tank periodically. How often depends on the size of the tank, the number of people in the household, and their particular habits. Most sources suggest once every three to five years as a general

Conserving water, spacing out activities that use a lot of water (like laundry), and being careful about what is flushed into the system can greatly improve the performance of the septic tank and extend the time between pumpings. Pumping frequencies can be more precisely determined based on information obtained at annual system inspections.

Depending on the size of the system, communities often have a maintenance management program or a full-time maintenance employee or staff to ensure that the system is being properly operated and maintained at each connection and to handle emergencies. Preventative maintenance is important with this technology because an overloaded septic tank or broken pump at one connection can potentially affect other parts of the system. Educating homeowners about proper system operation and maintenance is also important.

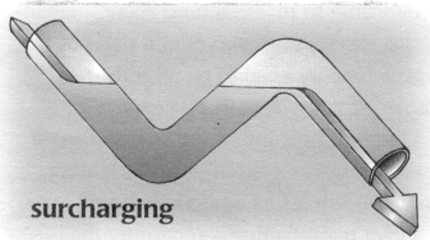
*For more about septic tank inspections, operation and maintenance, pumping frequencies, management programs, and homeowner education, refer to the offer for* Pipeline *back issues at the bottom* effluent sewers, small bore sewers, and Australian sewers.

Whatever name is used, this technology, which has been used in Australia successfully for many years, is becoming more and more popular in the U.S. as a low-cost alternative to conventional gravity sewers.

## What are SDGS systems?

Like conventional sewers, SDGS systems use gravity, rather than pumps or pressure, as the main force to collect and transport wastewater to a facility for final treatment or to empty into a conventional sewer main.

And like septic tank effluent pump (STEP) pressure sewer systems, SDGS systems use septic tanks to provide




primary treatment to the household wastewater and to allow the bulk of the solid materials to settle out. Because the sewers will be collecting and transporting fewer solids, they can be smaller in diameter than conventional sewers.

However, the pipes used for SDGS systems need to be somewhat larger (usually a minimum of three to four inches in diameter) than those used for pressure sewers, for example. This is necessary to accommodate any stray solids that may escape in the effluent of a septic tank that is malfunctioning or overloaded—a particular concern with SDGS systems because there are no pumps or pressure in the SDGS lines to further break up or prevent solids from

variable grades, unlike conventional sewers which must continuously slope downward. This flexibility can save money in areas with rock outcroppings or other geographical features that would make deep excavation particularly expensive.

## How do SDGS systems work?

Because SDGS systems rely on gravity to transport the effluent through the system, the point where the sewer system begins must always be higher than where it ends, and no part of the system can be higher in elevation than the starting point.

The sewer is often designed to be laid at variable grades throughout the system. The variable grade of the pipe creates low spots at different points in the system (refer to the figure at left). The effluent backs up at these low points until more and more pressure is created and the effluent is actually propelled over the "hump" in the pipe. This process is called surcharging.

Surcharging is an especially helpful process in extremely flat areas where the excavation would need to be particularly deep if the pipe were laid at a continuous downward slope, and there would be no downhill stretches to increase the velocity of the flow.

Another option often used with SDGS systems is to have homes that are located at lower elevations than the system use STEP systems to pump effluent up from the home to the SDGS main.

## Operation and maintenance

Because there is a septic tank at each connection, operation and maintenance for SDGS connections is similar to STEP systems and septic systems. Annual inspection of the septic tank is recommended and solids need to be periodically

inches in diameter so they will accommodate the smallest cleaning tools.

## Study of onsite systems complete

The National Small Flows Clearinghouse's (NSFC) study on the status of onsite wastewater treatment in small communities has been completed and a report of the results will soon be available to the public.

The goals for the study include:

- to identify and contact local health departments and agencies in each state that work with onsite systems,
- to create a database of this information that will allow NSFC to track the status of onsite systems in the future,
- to help formulate a national health department network/alliance,
- to disseminate the information gathered from local health departments, and
- to identify products that can be used to help homeowners understand and maintain their onsite systems and to inform health departments about alternative onsite systems and other information beneficial to them.

Some of the interesting information gathered from the 1,567 health departments that participated in the study includes system costs, the types of systems being used, system failures, and the reasons health departments deny permits.

The price will be determined when copies of the report become available. For more information, please contact the NSFC at (800) 624-8301 or (304) 293-4191.

systems, like the other alternative sewer technologies described in this newsletter, weren't used in the U.S. until the 1970s.

## What are vacuum sewers?

Vacuum sewers rely on the suction of a vacuum, created by a central pumping station and maintained in the small-diameter mains, to draw and transport wastewater through the system to final treatment.

There are several different manufacturers of vacuum systems, and although the basic technology behind them is the same, some manufacturers' designs work a little differently than others.

Vacuum sewers, like other alternative sewers, can be designed to suit a variety of site conditions. But because they have limited capabilities for transporting wastewater uphill (usually a maximum of 15 to 20 feet), they are more suited for areas with flat or gently rolling terrain.

## How do vacuum sewers work?

The vacuum in the vacuum sewer is drawn by one or more vacuum pumps located in a central pumping station. There are no electrical components at the individual connections to the system.

Most of the vacuum system designs used in the U.S. don't require vacuum toilets or any special plumbing inside the the house through the house sewer by gravity to a holding tank.

When the wastewater in the holding tank reaches a certain level, usually three to 10 gallons, a sensor prompts a pneumatic valve to open, and the entire plug of wastewater is violently sucked into the lines by the vacuum in the sewer main. The valve stays open a few seconds to also allow some air to be sucked in after the wastewater.

The alternate plugs of wastewater and air from many connections then travel through the mains, drawn by the vacuum to the central pumping station. Along the way, the pipe is designed to follow the contour of the land where the ground slopes naturally, and in other areas is laid at a slight downward grade. Small lifts in the pipe may be used when necessary to keep excavation shallow.

At the pumping station, the mains empty into a collection tank. The wastewater is then treated nearby or pumped to another location for treatment.

The vacuum pumps are equipped with alarms and an emergency backup generator in case a power outage or other problem develops.

Because the initial force of the vacuum taking the wastewater from the valve pit is usually enough to break up any solids in the wastewater, small-diameter plastic pipe can be used for vacuum systems.

lines very clean, so manholes and clean-out points are generally unnecessary.

## Operation and maintenance

Depending on system size, communities using vacuum sewers may employ a full- or part-time operation and maintenance employee or staff.

The pumps at the pumping station need to be checked and gauge readings need to be taken daily. Vacuum systems also require a working emergency generator at the pumping station, which also should be checked periodically.

Division valves that connect different parts of the sewer lines need to be checked at least twice a year, and the pneumatic vacuum valves at each connection should be checked annually. According to manufacturer recommendations, the vacuum valves and parts of the valve pit may need to be rebuilt or replaced every five to 10 years.

Communities interested in installing a vacuum sewer system or investigating vacuum sewers as an option should contact manufacturers regarding the design, costs, installation, and proper system operation and maintenance. *(Refer to the article below for information about how to contact vacuum sewer manufacturers.)*

# NSFC Database Offers Information on System Manufacturers

Communities that would like more information about alternative sewers or other wastewater technologies should take advantage of a valuable resource at the National Small Flows Clearinghouse (NSFC).

The NSFC's Manufacturers and Consultants Database can provide callers with the names and addresses of system manufacturers and consulting engineers and other wastewater professionals in their area. For example, communities may want to request a search of manufacturers and consultants who have installed vacuum sewers in the U.S. These contacts can often provide information about costs; requirements; and contacts for other communities using a particular system design.

*To order a customized search of the Manufacturers and Consultants Database, contact the NSFC at (800) 624-8301 or (304) 293-4191 and ask to speak with a technical assistance specialist. The price is 15 cents per page.*

**Free 1996 NSFC Catalog**
Call NSFC today to request a free copy of the *1996 NSFC Guide to Products and Services.* NSFC has many more resources available on alternative sewer systems than can be listed here, including case studies, design manuals, computer software, computer searches, and videos.

**STEP and Grinder Pump Information**
These packages, "*Septic Tank Effluent Pump Pressure Sewer Systems: Information Package,*" Item #WWPCGN41, and "*Grinder Pump Information Package,*" Item #WWPCGN80, include general system characteristics, design information, performance data, operation and maintenance costs, and tips on septage characteristics and disposal alternatives for STEP systems. The price for the STEP system package is $27.60. The price for the grinder pump package is $16.10.

**Alternative Sewers Manual**
"*Alternative Wastewater Collection Systems*" provides information about

tion for a Contacts and Referrals Database, which will provide information about organizations involved with wastewater issues at the national, state, and local levels. If you know an organization that should be included in the new database, please contact Crystal Stevens, coordinator, at (800) 624-8301, ext. 5550.

**Design Software for Alternative Sewers**
NSFC offers four design software packages for alternative sewer systems. The programs "Airvac v. 3.2," Item #WWSWDM39, "Enviro v. 2.0," Item #WWSWDM54, and "Program Station v. 3.0," Item #WWSWDM55, help engineers to design different aspects of vacuum sewer systems. "Variable Grade Effluent Sewer Design Program v. 2.2," Item #WWSWDM79, is a spreadsheet program for designing pressure and small-diameter effluent sewer systems. The price for each program is $20, which includes a user's guide. Contact NSFC for more information about the individual software packages and hardware requirements.

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West Virginia University
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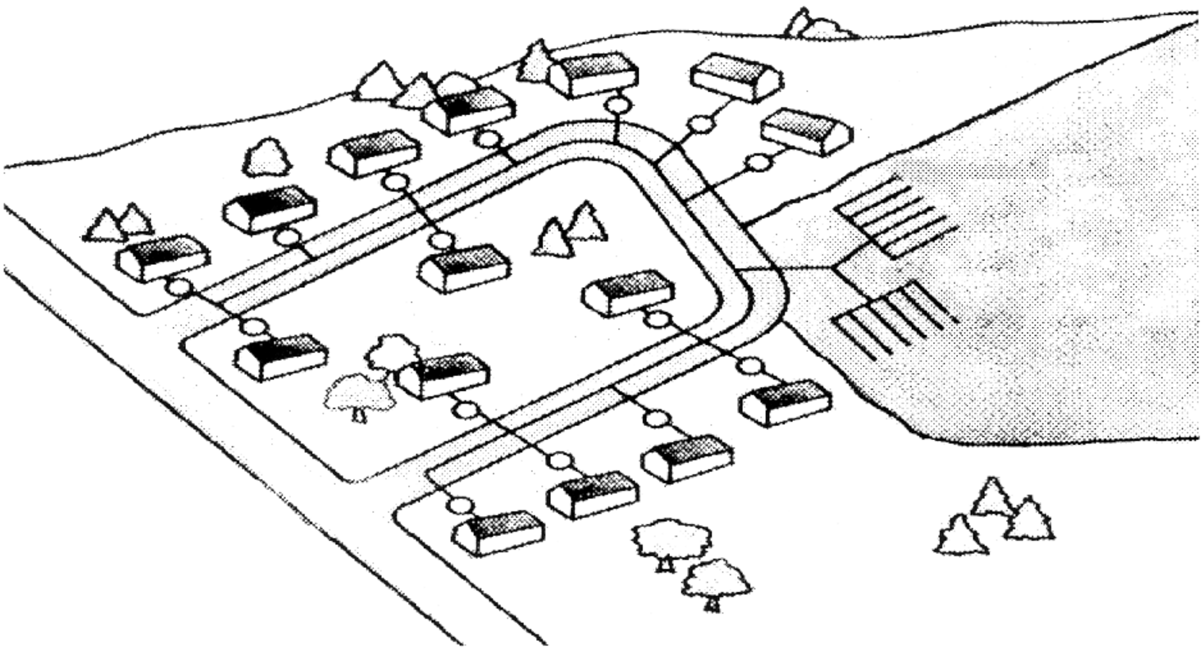
**Figure 6-1 Cluster System with Common Absorption Field**



Source: National Environmental Training Center for Small Communities

**Figure 6-2 Small Community with Several Cluster Systems**