Texas Agricultural Extension Service
THE TEXAS A&M UNIVERSITY SYSTEM

B-6098
8-00

On-site wastewater treatment systems

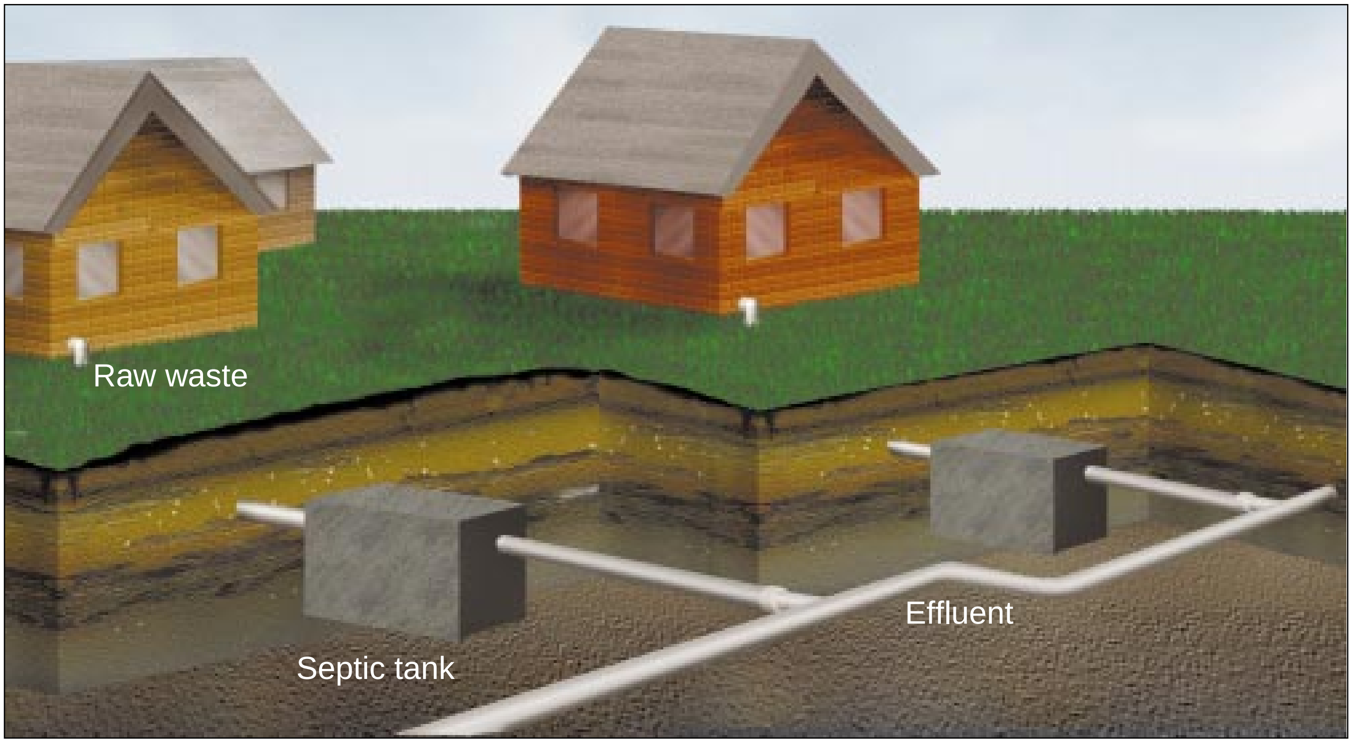

Figure 1: A small-diameter gravity sewer system.

Alternative collection systems

Bruce Lesikar
Extension Agricultural Engineering Specialist
The Texas A&M University System

There's great news for rural Texas communities needing to develop wastewater management infrastructure. Today, rural Texans have more options than ever before to manage wastewater. These options offer:

- ✓ Protection for the environment,
- ✓ Flexibility for communities to plan for future economic growth, and
- ✓ Lower installation costs than traditional centralized wastewater management systems.

Wastewater in rural areas is usually treated at first by on-site treatment systems—often septic systems—at each home. These work well in areas where the population is low and the environment can accommodate the amount of waste produced.

But if the population grows or if the land cannot handle the wastewater, the community as a whole must take steps to address its wastewater problems. Before, communities whose septic systems were failing had only one choice in managing wastewater adequately: to install an extensive pipe network to collect wastewater to a centralized, highly maintained wastewater treatment plant.

Now rural communities have a new option: They can use a combination of conventional septic systems, advanced on-site systems, and cluster or other land-based treatment systems to manage wastewater (Fig. 1). This new approach is called decentralized wastewater treatment.

According to the Environmental Protection Agency (EPA), decentralized systems:

- ✓ Protect public health and the environment,
- ✓ Are appropriate for low-density communities,
- ✓ Can be used in varying site conditions,
- ✓ Provide additional benefits for ecologically sensitive areas, and
- ✓ Can save significant amounts of money while recharging local aquifers and providing other water reuse opportunities close to where the wastewater is generated.

In fact, in a 1997 report to the U.S. Congress, the EPA found that the decentralized approach to wastewater management favors rural communities and frequently is less expensive than centralized sewage systems.

Because Texas has no comprehensive, statewide strategy that provides for the cost-effective treatment of municipal wastewater in rural areas, many rural Texas communities need to devise wastewater management systems to effectively protect public health and environmental quality, accommodate future housing needs and facilitate growth.

Centralized approach favored previously

Thanks to major federal funding during the 1970s and ’80s, most urban communities across Texas installed centralized wastewater systems to meet their citizens’ needs. The Clean Water Act of 1972 provided federal money to plan, design and build public wastewater infrastructure. Usually, larger communities were favored over smaller ones to receive most of the federal funds.

The federal money, combined with the communities’ failure to adequately maintain traditional septic systems, justified the construction of sewers and wastewater treatment plants.

These centralized systems have been termed the “big pipe” or “sewer the country” approach. They involve installing an extensive network of large sewer pipes throughout a community to collect wastewater and bring it to a central treatment plant. After being treated, the wastewater is discharged into a stream or body of water.

Today, however, major federal funding for wastewater management projects has been reduced, and Texas communities must bear the cost of installation, operation and maintenance. Sewer systems cannot be expanded throughout rural areas because they cost too much and because increasingly strict environmental requirements make it difficult and costly to discharge treated wastewater into rivers, streams and coastal waters.

Decentralized options

Today there are many alternatives to centralized sewers, including:

- ✓ Conventional septic systems, which are dependable options where soil conditions are favorable and the systems are properly maintained.
- ✓ Advanced on-site systems (sand filters, aerobic treatment units, trickling filters, constructed wetlands, pressure distribution systems, drip distribution systems, spray distribution systems and disinfection systems) and community facultative lagoons/spray irrigation systems. These can be used over a much broader range of site and soil conditions than can conventional septic systems.
- ✓ Cluster systems, which use small collection networks to bring wastewater from a limited number of houses (usually five to 100) to a common treatment and disposal area. Cluster systems use small-diameter gravity sewers and pressure sewer systems that are less expensive to install than the large pipes used in the centralized approach (Fig. 2).

Communities frequently use a combination of systems: cluster systems in areas that are more densely populated or that have poor soil conditions; and on-site systems where soil conditions are favorable.

Although these land-based, alternative wastewater systems are viable options, many rural areas have not considered implementing them. The treatment strategies are relatively new and seldom recommended by some consultants. In the past, these treatment techniques were not considered to be mainstream options that communities could depend on.

But land-based systems are the most cost-effective and environmentally sound wastewater treatment options for rural communities, now and in the future. Because these systems affect streams and rivers only minimally, communities need to consider developing land-based systems to protect their streams and other water resources.

Management, maintenance and inspections are key

The decentralized approach can be successful only if a management program is established to ensure that the systems are inspected and maintained regularly. Although rural communities are best served by wastewater technologies that are decentralized, they require a centralized management network to oversee them.

Trained, certified system operators can ensure that the systems function effectively. Centralized management can be used for a community, a county or a multiple-county area.

New long-term strategy needed

Many rural communities need to create wastewater management infrastructure, not only to effectively protect public health and the environment, but also to provide for future housing needs and to facilitate sound growth.

Many rural communities have no reliable wastewater management infrastructure, while nearby cities and towns have public sewers and wastewater treatment plants. So the rural areas miss out on economic benefits even when industries move in, because the population leapfrogs into nearby urban centers. Eventually, the additional wastewater load exceeds the municipal treatment plant's capacity, a development moratorium is imposed, and the economic vitality of the area is threatened.

Rural communities need to develop comprehensive, long-term strategies for the timely and cost-effective treatment of wastewater. They cannot meet current and future discharge requirements quickly with just one project. Although land-based systems are the most cost-effective and environmentally sound system for rural communities under present and anticipated future conditions, they require extensive planning and implementation in phases, depending on the area to be served.

Needs assessment

To develop a comprehensive wastewater management plan, a community should begin by assessing local needs. The first step is to define the problem clearly. The community should compile information on current wastewater problems, document obvious signs of system failure, compile water use data, and define the service area.

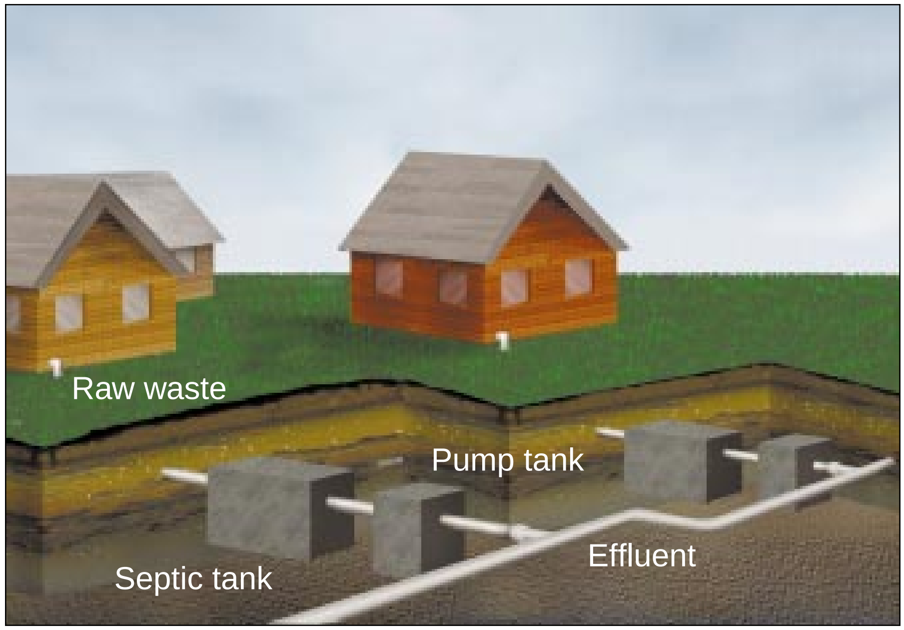

Figure 2: A septic tank effluent pump (STEP) system.

Planning process

Once the needs have been assessed, the planning process should begin. A community needs to:

- ✓ Organize. This requires identifying local leaders and available talent.
- ✓ Establish planning goals and identify issues relevant to wastewater management. Often these address public health and environmental quality, but also should include economic development and growth issues.
- ✓ Gather data. Study environmental factors such as soil resources, groundwater quantity and quality, surface water quality and the ability of these waters to accept and treat additional wastewater loads and site conditions for individual or community systems.
- ✓ Examine the financial ability of residents to pay for design, construction and operation of wastewater infrastructure options.

Treatment options

Wastewater can be treated and disposed of using either land-based technologies or surface-water discharge systems. Community leaders must consider the many options between conventional septic systems and traditional surface water discharge systems. Often the soils in a community may be suited for a land-based system, but because of documented septic system failure, the leaders assume that the soils cannot support this approach.

However, government regulators prefer the land-based alternatives because they have minimal environmental impacts on streams and rivers.

Land-based systems include land application systems that discharge on top of the ground (called surface application systems) and those that discharge underground into the soil (called subsurface disposal systems).

Land-based systems are considered nondischarge because the wastewater does not discharge directly into our water resources. Typically, surface-water discharge systems use mechanical devices to aerate the wastewater before discharging it into a stream or river.

Ultimately, community leaders must select a consultant to help design the program. However, some consultants who conduct community needs assessments are unfamiliar with land-based options. As a result, their first recommendation often is to develop a treatment facility that discharges to surface water.

When using land-based technologies, communities must determine the most cost-effective balance between on-site and cluster or community systems. To generate and analyze alternatives:

- ✓ Determine if individual lots could be improved by using advanced on-site systems on problem sites where septic systems are failing.
- ✓ Evaluate the feasibility of combining individual on-site systems and small cluster land-based systems.
- ✓ Assess the merits of providing a communitywide wastewater collection and treatment system. All too often, land-based options are ignored and decision makers are guided to surface-water discharge options as the preferred choice.

The more information the community provides about local needs and wants, the better the guidance they can give the consultant. Leaders must insist on a comprehensive review of alternatives that includes on-site treatment improvements, community cluster land-based treatment options and a communitywide collection system.

By insisting that the consultant provide a system that will meet the needs of the community, leaders can ensure that the best interests of all residents are served.

Community options

Communities may choose from several collection, treatment and disposal technologies.

Collection technologies

Most sewer systems in large cities have the traditional network of large-diameter pipes that collect wastewater from homes and take it by gravity to a wastewater treatment plant. Gravity sewers, as the name suggests, convey wastewater by using the natural slope of the land.

Gravity sewers have several disadvantages. They need lift stations when the slope of the land requires that the wastewater be carried to a higher elevation. Because the lines must be laid at a sharp enough angle to move solids through the line, the excavation costs can be substantial to install sewers deep enough to function via gravity flow.

Large-diameter pipe must be used, drastically increasing construction costs. Large sewers can also have problems with inflow and infiltration of water through the pipe joints and connections. Inflow and infiltration increases the total amount of water that the wastewater treatment system. must handle.

Yet many areas can use alternative wastewater collection networks, including small-diameter gravity sewers, small-diameter pressure sewers and vacuum sewers.

- ✓ **Small-diameter gravity sewers** (Fig. 1), sometimes called effluent sewers, use a septic tank at each home to remove the large solids. Because only liquids flow through the collection network, the wastewater collection pipes can be of a smaller diameter. The smaller pipes can be installed nearly on grade, making construction costs much lower than for traditional gravity sewers.
- ✓ **Small-diameter pressure sewers** include septic tank effluent pump systems (STEP) and grinder pump systems. The STEP system (Fig. 2) uses gravity to convey wastewater from a house to a septic tank. Then the effluent flows to the pump vault, where it is pumped under pressure to the treatment system or to other gravity lines.

  Like the STEP system, the grinder pump system uses gravity to convey wastewater from a house to a holding tank. But a pump inside the tank grinds and shreds solid particles in the wastewater as it pumps. Then the wastewater is pumped under pressure to the treatment system or to a gravity line.
- ✓ **Vacuum sewers** include a holding tank with a vacuum valve at the home connected by a collection network to a vacuum pumping station at a central wastewater treatment plant. When the holding tank has a specific volume of wastewater, the vacuum valve meters the wastewater into the collection line while maintaining the vacuum in the line. Both water and solids are transported to the wastewater treatment plant.

The installation costs for small-diameter pressure systems and vacuum sewers are usually relatively low for the same reasons as for small-diameter gravity sewers. These systems follow contours, which lowers costs. However, operation and maintenance costs are potentially higher because they use a pump to move the water rather than gravity.

Pressure sewer collection networks typically have fewer problems with inflow and infiltration than traditional gravity sewers. One potential problem, though, is that they can be affected by grease buildup, other blockages in the pipes and electrical outages. Also, the accumulated solids in the septic tanks must be removed periodically as part of operation and maintenance.

Treatment and disposal

Mechanical treatment processes include preliminary treatment (which provides the least treatment and pollutant removal), primary treatment, secondary treatment and tertiary treatment (which treats wastewater the most).

Some wastewater treatment plants can meet their surface-water discharge permit limits by providing a secondary level of treatment. However, in nutrient-sensitive watersheds and other environmentally sensitive areas, the treatment plants must include more advanced (and expensive) processes to meet surface-water discharge permit limits.

Land-based treatment and disposal technologies include:

- ✓ A variety of lagoons;
- ✓ Fixed media filters, including sand filters, gravel filters, textile filters, and other biofilters;
- ✓ Subsurface dispersal systems, such as a large variety of advanced on-site systems, including the traditional gravity distribution technologies, pressure manifold distribution and pressure distribution, including low-pressure pipe and drip distribution technologies; and
- ✓ Surface dispersal systems, which are sometimes called spray distribution systems.

One of the advanced pressure distribution technologies is drip distribution (Fig. 3), which can be installed at a home site or over a multi-acre site to treat and distribute wastewater from a small community.

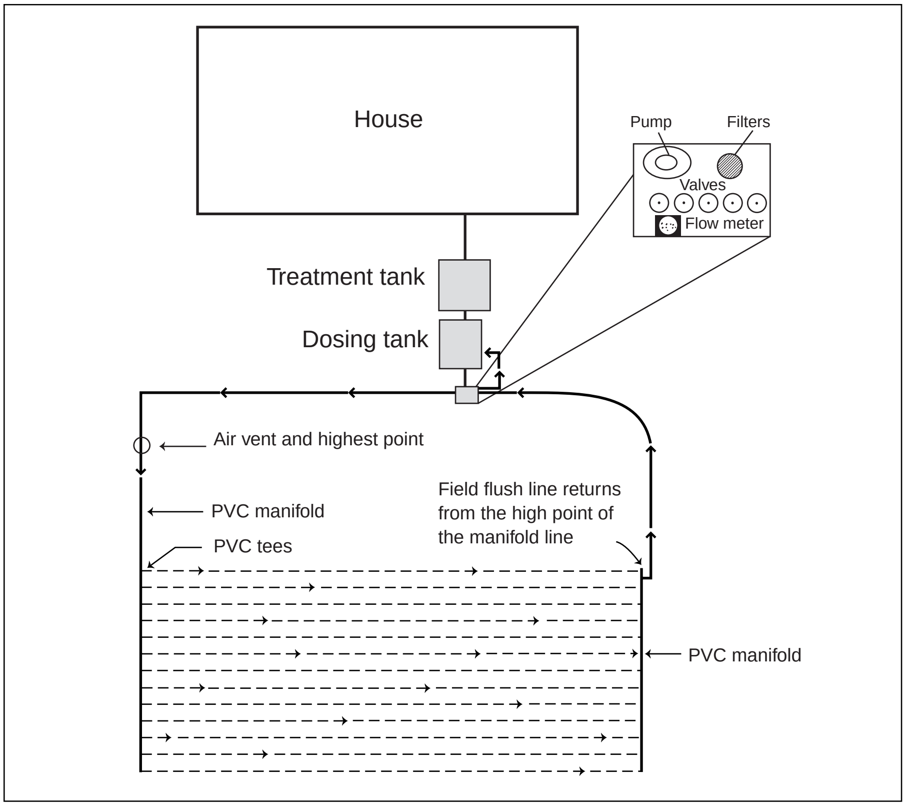

Figure 3: A drip distribution system for treatment and dispersal.

Surface dispersal systems include slow-rate spray distribution and reuse systems. These disperse the wastewater onto the ground.

The slow-rate spray distribution system is designed to have a very low application rate; a reuse system supplies the water needs of the grass and vegetation growing at the site. Slow-rate spray distribution systems require the greatest amount of land area; the reuse system uses a smaller land area and generally requires 3 months of storage for the months when the plants use less water, especially during winter.

Both the subsurface and surface dispersal land-based technologies use natural physical, chemical and biological soil processes to treat the wastewater as it passes through the soil.

As with any mechanical wastewater treatment system, land-based treatment sites must have enough land to accommodate future expansion. However, planning for these needs is important, because land-based treatment systems have a defined, finite capacity for growth without available additional land.

Cost-effectiveness

When considering wastewater management systems, rural communities must consider two main components: the collection system, which is the first and often most costly; and the wastewater treatment and disposal system.

The costs for wastewater infrastructure include the capital expenditures as well as the costs of operation and maintenance. Often costs are measured in dollars per thousand gallons for operation and maintenance, or in dollars per gallon for initial capital.

Although the costs for wastewater management vary dramatically from system to system, land-based systems generally cost less than those discharging into streams.

Approaches compared

The decentralized approach to wastewater management has seldom been compared evenly with the centralized approach. However, Congress asked the EPA to evaluate the capabilities and cost-effectiveness of the decentralized approach to wastewater management, and to identify barriers and solutions to implementing this approach.

The agency's report, *EPA Response to Congress* (EPA, 1997), includes a detailed analysis of costs in a hypothetical rural community (Fig. 4), comparing the decentralized approach with the traditional centralized approach to establish a wastewater management infrastructure.

The rural community was assumed to have 450 people living in 135 homes located on 1-acre lots or larger than were serviced by conventional septic systems. It was assumed that 50 percent of the septic systems (67 systems) were failing.

Three wastewater management options were considered for the rural community's installation and long-term operation and maintenance:

- ✓ A centralized system,
- ✓ Cluster systems, and
- ✓ Managed on-site systems.

Expenditures included the capital costs to install the systems and annual costs to operate and maintain them. Capital costs were annualized over 30 years (the life of the system) for each technology using a discount rate of 7 percent. Costs are presented in 1995 dollars in Table 1.

This analysis revealed that the decentralized approach (using either managed on-site systems or cluster systems) frequently is more cost-effective than centralized sewers for sparsely developed rural communities. The cost of estimates included establishing a management program to provide long-term maintenance of each technology.

The most cost-effective option for meeting performance goals is to use new on-site systems of advanced designs to replace failing conventional septic systems. Using cluster systems with alternative collection systems to replace failing septic systems is not significantly more expensive. If soils were unsuitable for on-site systems, the cluster alternative would be the best choice.

As the distance between homes in the rural area increases, however, cluster system collection costs increase. Compared to on-site or cluster system options, centralized collection and treatment is not cost-effective in this case.

More and more on-site systems are being managed in the United States. People in the northwest region are leading the country in using alternative collection systems to manage their wastewater. They are collecting data on the effectiveness of the technologies and the associated cost for management of the technologies.

Summary

The viability of waste treatment technologies varies substantially, depending on a community's development density, financial resources, site conditions and surface-water discharge requirements throughout the watershed.

Infrastructure limitations, however, are rapidly changing because many communities are realizing that land-based treatment technologies are often the most cost-effective and environmentally protective way to handle municipal wastewater in rural and small communities.

Today, many infrastructure choices—ranging from centralized to decentralized and all options in between—are available to serve communities' needs (Table 2). These include a variety of on-site treatment systems, small-scale community collection and treatment systems, and large-scale municipal wastewater collection and treatment systems. These options provide effective management of a community's

Table 1. Comparison of hypothetical EPA rural community technology costs for three types of wastewater management systems.

Technology option	Total capital cost (1995 $)	Annual O&M* cost (1995 $)	Total annual cost (annualized capital plus O&M* - 1995 $)
Centralized systems	$2,321,840 - $3,750,530	$29,740 - $40,260	$216,850 - $342,500
Alternative SDGS** collection and small cluster systems	$598,100	$3,720	$55,500
On-site systems	$510,000	$13,400	$54,500

Note: The rural community consists of 450 people in 135 homes. (Adapted from EPA, 1997)
* O&M: Operation and maintenance.
** SDGS: Small-diameter gravity sewers.

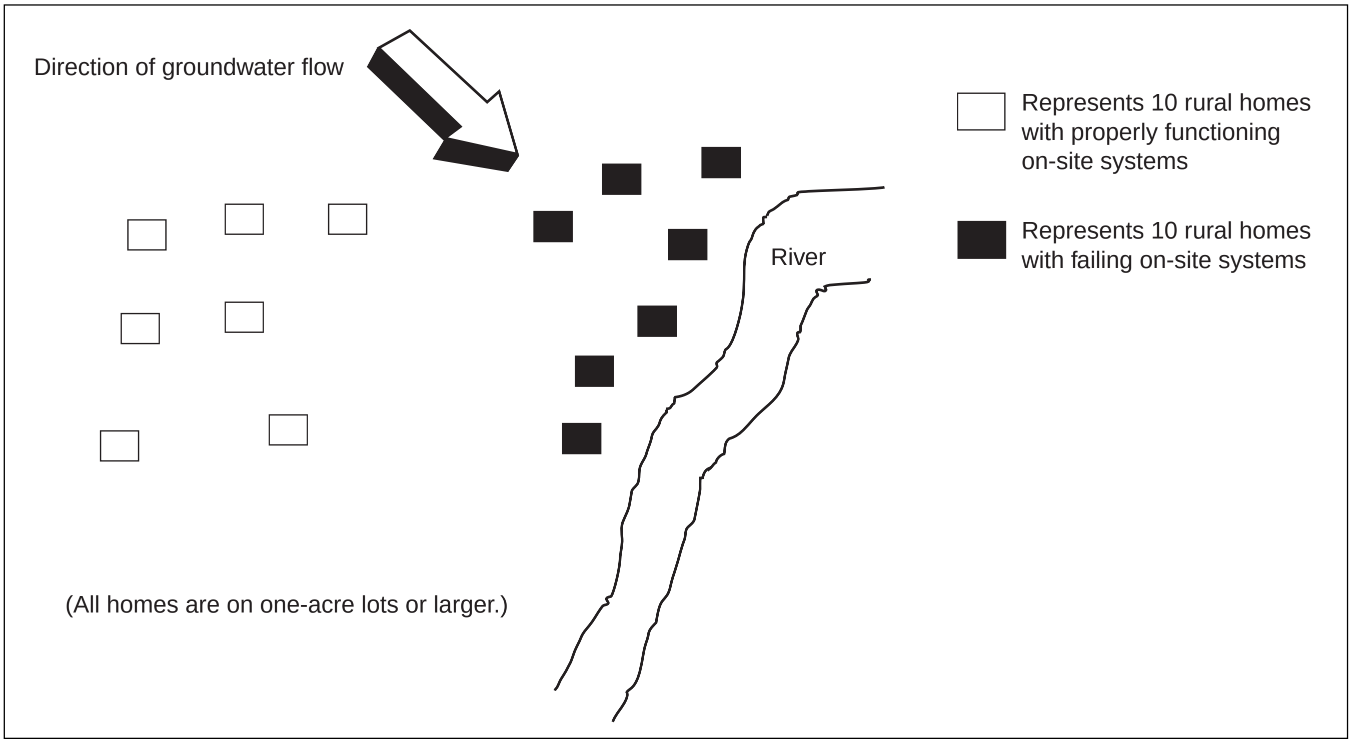

Figure 4: Base map of EPA hypothetical rural community (adapted from EPA, 1997).

wastewater regardless of the density of development in the area.

In fact, frequently the best approach in a given community is a combination of centralized and decentralized systems. The location of each depends not only on the density of development, but also on plans for locating future growth, cost issues and water quality and quantity concerns regarding nutrient-sensitive watersheds.

Land-based options, such as on-site systems, cluster systems and land application systems, are often a more environmentally friendly approach where surface waters are particularly valuable or vulnerable to contamination.

New funding initiatives are being developed in Texas to establish a dependable wastewater infrastructure in rural communities that will sustain growth and protect the environment. As these initiatives come to fruition, the available funding should be used to provide economically sound, dependable solutions to the largest number of communities possible.

More rural communities will benefit if they embrace land-based wastewater treatment options to meet future community needs.

Table 2. Advantages and requirements of small-scale alternative, on-site and cluster systems over the two extremes of conventional septic systems and centralized treatment plants.

Advantages	Requirements
Can be used in areas with low to very high development density	Regular operation and maintenance review and adjustment
Appropriate for rural to urban landscapes	Assessment of environmental impacts
Moderate costs	System technology upgrades to meet emerging community and environmental needs
Moderately complex technology	

The On-Site Wastewater Treatment Systems series of publications is a result of collaborative efforts of various agencies, organizations and funding sources. We would like to acknowledge the following collaborators:

Texas State Soil and Water Conservation Board
Texas On-Site Wastewater Treatment Research Council
Texas Natural Resource Conservation Commission
USDA Water Quality Demonstration Projects
Consortium of Institutes for Decentralized Wastewater Treatment
USEPA 319(h) Program
Texas Agricultural Extension Service
Texas Agricultural Experiment Station
Texas On-Site Wastewater Association
USDA Natural Resources Conservation Service

This publication was adapted from *Choices for Communities: Wastewater Management Options for Rural Areas*, by the North Carolina Cooperative Extension Service. It was developed in cooperation with the Houston-Galveston Area Council of Government's On-Site Wastewater Project.

Produced by Agricultural Communications, The Texas A&M University System

All publications in the On-site Wastewater Treatment Systems series can be downloaded free from the World Wide Web at:

http://agpublications.tamu.edu/pubs/ewaste

Issued in furtherance of Cooperative Extension Work in Agriculture and Home Economics, Acts of Congress of May 8, 1914, as amended, and June 30, 1914, in cooperation with the United States Department of Agriculture. Chester P. Fehlis, Deputy Director, The Texas Agricultural Exension Service, The Texas A&M University System.
30,000 copies, New

For sale only: $1