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Report to the Chairman, Subcommittee on Investigations and Oversight, Committee on Public Works and Transportation, House of Representatives

September 1994

WATER POLLUTION

Information on the Use of Alternative Wastewater Treatment Systems

GAO/RCED-94-109

GAO United States
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Resources, Community, and
Economic Development Division

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September 26, 1994

The Honorable Robert A. Borski
Chairman, Subcommittee on
Investigations and Oversight
Committee on Public Works and
Transportation
House of Representatives

Dear Mr. Chairman:

As requested, this report discusses whether wastewater treatment costs could be reduced by using alternative treatment systems. The report addresses (1) whether there are cost-effective alternatives to conventional systems for collecting and treating wastewater, (2) whether barriers are limiting the use of these alternatives, and (3) how EPA is addressing the development of future technologies.

As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after the date of this letter. At that time, we will send copies to the appropriate congressional committees; the Administrator, EPA; and the Director, Office of Management and Budget. We will make copies available to others upon request.

Please call me at (202) 512-6111 if you or your staff have any questions. Major contributors to this report are listed in appendix I.

Sincerely yours,

Peter F. Guerrero
Director, Environmental
Protection Issues

Executive Summary

Purpose

The costs of treating the nation's wastewater are huge and rapidly rising. According to the Environmental Protection Agency (EPA), the cost of municipalities' unmet needs for wastewater treatment facilities rose about $17.7 billion from 1988 to 1992 and totaled $108 billion in 1992. Small communities' needs represent about 12 percent of municipalities' total needs, or about $13 billion.

Concerned about the nation's ability to meet these needs, the Chairman, Subcommittee on Investigations and Oversight, House Committee on Public Works and Transportation, asked GAO whether the costs of wastewater treatment could be reduced by using alternative treatment systems. Specifically, GAO agreed to determine (1) whether there are cost-effective alternatives to conventional systems for collecting and treating wastewater, (2) whether barriers are limiting the use of these alternatives, and (3) how EPA is addressing the development of future technologies.

Background

During the 1970s and 1980s, EPA provided construction grants authorized by the Clean Water Act to local governments for building wastewater treatment facilities. Under the 1987 amendments to the act, the grant program was phased out and replaced by state revolving funds, which provide loans to local governments. As GAO reported in 1992 (see GAO/RCED-92-35), the revolving funds are an efficient alternative to grants, but they will not suffice to finance the nation's wastewater treatment needs, especially the needs of small communities. Also phased out was an EPA incentive program to promote alternative technologies.

Results in Brief

Alternative systems for collecting and treating wastewater offer the potential for cost savings in certain circumstances. In such cases, the alternatives may help communities—particularly small ones, which have not been able to afford conventional treatment systems—meet their wastewater treatment needs. Alternative systems include (1) alternative collection systems that use smaller-diameter pipe buried at shallower depths than conventional sewer systems and (2) natural treatment systems that utilize soil, vegetation, and aquatic environments as a treatment and/or disposal medium, such as constructed wetlands and land application. Natural treatment systems employ few mechanical parts, use little energy, and have lower construction and operation and maintenance costs than conventional treatment systems.

While alternative systems may be cost-effective, there are barriers to their use. The primary barrier is a lack of knowledge on the part of engineers and state and local officials about the alternatives' applicability, performance, and cost. Other barriers include (1) financial disincentives within the private sector to designing and/or constructing facilities that employ alternative systems and (2) restrictive state and local codes and regulations.

Hesitancy about using available alternative systems discourages the private sector's investment in future cost-effective technology. In addition, EPA's funding for engineering research on wastewater treatment has dropped over the past 15 years. However, EPA is considering undertaking three limited projects that would provide additional information on alternative systems and ways to reduce barriers to their use. These projects would be a helpful start in addressing the barriers to the use of alternative wastewater systems.

Principal Findings

Alternative Systems Can Sometimes Yield Substantial Savings

Although the data are not available for a broad assessment of their savings potential, some alternative systems have been shown to save substantial amounts compared with conventional systems. For example, a West Virginia community using a vacuum collection system saved about $920,000, or about 42 percent of the cost of a conventional collection system that would have used larger and more expensive pipe buried at greater depth than the vacuum collection system. Also, a small community in Virginia found that it could save about $334,000, or over 65 percent, by constructing a wetland to treat its wastewater instead of constructing a conventional wastewater treatment facility. EPA and state officials identified a number of communities where the use of alternative systems had resulted in significant savings.

The cost savings obtained through the use of alternative systems have enabled some communities to afford wastewater treatment. According to state officials, reducing costs by 30 to 40 percent can make wastewater treatment affordable for many small communities.

Barriers Limit the Use of Alternative Systems

Alternative systems are sometimes avoided even when they offer potentially substantial cost savings because of uncertainties about their performance and/or costs. For example, state and local officials have been reluctant to invest in an alternative wastewater system for a city in Massachusetts even though an engineering study concluded that (1) despite the city's limiting soil conditions, on-site treatment was viable for much of the city and (2) a system using alternative technologies would cost only about one-half as much as a conventional system. Proponents of alternative wastewater systems and skeptics agree that credible, up-to-date performance and cost data are needed to reduce the uncertainties.

The lack of credible performance data also heightens engineers' concerns about financial liability and damage to their professional reputation if a system fails to perform to design specifications. In addition, state and local codes and regulations can restrict or prohibit the use of alternative systems because many were written with conventional systems in mind. Few states and localities have (1) encouraged or required the use of alternative fee structures and methods to share risk and liability among the municipality, contractor, and engineer and/or (2) revised codes and regulations to allow greater flexibility in the use of nonconventional systems.

Two of the three projects EPA is considering for addressing these barriers would begin to develop additional information about the applicability, performance, and cost of alternative wastewater systems. The third project would develop recommendations for addressing other barriers to the use of alternative systems. These projects are estimated to cost about $1.2 million.

Barriers Impede the Development of Future Technologies

The private sector has invested relatively little in developing new technologies, in part because members of the engineering, regulated, and regulatory communities have been reluctant to accept alternative systems. Investment is further limited by the private sector's uncertainty about what technologies will be needed to meet future regulatory requirements. A private foundation that conducts a large share of the nation's wastewater treatment research and development reports that it is able to undertake only about one-quarter of the needed engineering research and development activities because of funding constraints.

The public sector's funding of wastewater treatment research and development is also severely limited. EPA's funding of research and development for wastewater engineering activities has declined from a peak of about $19 million in fiscal year 1979 to less than $1 million in fiscal year 1993. EPA officials said that current funding levels have prevented the agency from keeping abreast of emerging technologies.

Over the past 2 years, EPA has taken steps to better target the limited public and private funds for research and development. In 1992, the agency created the Innovative Technology Council to serve as an in-house advisory and advocacy group that coordinates EPA's technology development activities. Although the Council's plans are not final, EPA is taking steps to (1) promote innovation in technology, (2) strategically invest in promising technologies, and (3) accelerate the use of these technologies.

Agency Comments

GAO discussed its findings with officials of EPA's Office of Water and Office of Research and Development, including the Director, Office of Wastewater Management. These officials generally agreed with the information presented. Specifically, they agreed with the potential savings from the use of alternative wastewater treatment systems and the barriers to their use and development. These officials also indicated that they planned to consider funding projects that would begin to address these barriers. As agreed, GAO did not obtain written agency comments on a draft of this report.

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Abbreviations

EPA	Environmental Protection Agency
GAO	General Accounting Office
I&A	innovative and alternative wastewater treatment technology (program)
NACEPT	National Advisory Council for Environmental Policy and Technology
ORD	Office of Research and Development
QBS	qualification-based selection
STEP	septic tank and effluent pump

Introduction

The Federal Water Pollution Control Act Amendments of 1972 (Clean Water Act) required the Environmental Protection Agency (EPA) and the states to set limits on the discharge of pollutants into rivers, lakes, and other bodies of water. In addition to placing controls on industry, the act required cities and towns to build and maintain wastewater treatment plants that meet national standards for discharged pollutants. If these treatment requirements were not sufficient, more stringent controls—such as advanced levels of wastewater treatment—would be required in order to meet water-quality-based standards.

EPA has reported that, since 1972, progress made in controlling water pollution under the technology-based approach has been considerable. According to EPA, the number of people served by improved levels of wastewater treatment has risen significantly, and the health of many rivers has been restored after sewage and industrial wastewater treatment facilities have been constructed or upgraded.[1]

Despite these improvements, some waters are still not suitable for swimming or fishing. EPA's 1988 National Water Quality Inventory states that persistent pollution problems remain. For example, out of 519,412 river miles that were assessed, 158,081 miles (30 percent) did not fully meet state water quality standards.

The 1972 act created the Construction Grants Program and also substantially increased federal financial support to local governments for wastewater treatment projects. For example, the act set the maximum federal contributions for eligible projects at 75 percent of eligible construction costs. Although federal wastewater treatment grants were provided under previous legislation, the 1972 act increased federal grants significantly—to a total of $18 billion for fiscal years 1972 through 1976.

Concerns were raised in the 1980s about the efficiency of providing federal grants to finance wastewater treatment. For example, EPA reported in 1984 that the availability of federal funds had discouraged state and local governments from providing funding. As a result, the federal share of eligible project costs was reduced from 75 to 55 percent, and total appropriations for the Construction Grants Program were gradually reduced.

[1]The Quality of Our Nation's Water: A Summary of the 1988 National Water Quality Inventory, EPA (Washington, D.C.: May 1990).

The Congress changed the federal role in the 1987 amendments to the Clean Water Act by eliminating the Construction Grants Program and creating the State Water Pollution Control Revolving Fund Program. This change was phased in, starting in fiscal year 1989. Capital for the state revolving funds is provided by federal funds and a 20-percent state match. These revolving funds are operated by the states and provide loans to local governments to finance wastewater treatment and certain other water pollution projects; the repayment of these loans replenishes the funds.

According to EPA, the nation's total documented wastewater treatment needs rose to $108 billion in 1992—about $17.7 billion more than in 1988. However, the Congress authorized only $8.4 billion in the 1987 amendments to capitalize the state revolving funds for fiscal years 1989 through 1994. Although some additional funds will be available through the state matching funds, leveraging, and some other federal and state grant and loan programs, these sources are too limited to close the gap between local needs and available resources, as discussed in our 1992 report on state revolving funds.[2]

Wastewater Treatment Needs of Small Communities

In our 1992 report, we noted that small communities did not receive a fair proportion of the construction grants. We also noted that insufficient resources in the state revolving funds will affect small communities disproportionately. According to EPA's Administrator, small communities have unmet wastewater treatment needs of over $13 billion, which represent about 12 percent of the nation's total needs. Many states reported that their revolving funds will not meet the needs of small communities, and many of these states expect that these unmet needs will have significant effects on health and the environment.

Small communities are unable to compete with large communities for financing because, in making a loan, states (except for Wisconsin) consider a community's ability to pay back a loan. Because per-household costs for wastewater treatment are higher in small communities, which cannot achieve economies of scale, small communities pose a greater credit risk. When these high per-household costs are combined with low per-capita income in small communities, debt may be unsupportable at any interest rate.

[2]As we stated in our report Water Pollution: State Revolving Funds Insufficient to Meet Wastewater Treatment Needs (GAO/RCED-92-35, Jan. 27, 1992), state revolving funds are an efficient alternative to the grants program for providing a subsidy to local governments.

Innovative and Alternative Wastewater Treatment Technologies

Wastewater treatment technologies are classified as innovative, alternative, and conventional. Innovative technologies are considered cutting edge and not fully proven, while alternative technologies are considered relatively more proven and have been used or demonstrated. Conventional collection and treatment technologies collect wastewater in large gravity sewers, treat it centrally using proven or established mechanical techniques, and discharge it directly into surface water.

In the 1972 Clean Water Act, the Congress promoted the development and use of innovative and alternative wastewater treatment technologies. However, financial incentives were not added to promote these cost-saving technologies until the 1977 amendments to the Clean Water Act established the innovative and alternative wastewater treatment technology (I&A) program.

Under the 1977 amendments, the I&A program increased the federal share for innovative and alternative technology projects from 75 percent of total costs (the federal share for conventional technology projects) to 85 percent of total costs. Starting in fiscal year 1985, the federal share for conventional technologies dropped to 55 percent and the federal share for innovative and alternative technologies dropped to 75 percent. In addition, as a kind of risk insurance, the I&A program provided grants for up to 100 percent of the cost of modifying or replacing new technologies that failed to perform to their design standards.

Under the 1987 amendments to the Clean Water Act, the I&A program was terminated after fiscal year 1990; the Construction Grants Program was also terminated after fiscal year 1990. Although the state revolving funds have replaced construction grants, the 1987 amendments made no distinction between the funding of innovative or alternative technologies and conventional technologies under the state revolving fund program.

For fiscal years 1979 through 1987, about $4.4 billion was invested in 600 innovative projects and 2,100 alternative projects under the I&A program. According to a 1989 EPA report to the Congress,[3] the I&A program moved some alternative technologies—such as land treatment of wastewater, land spreading of sludge, alternative collection systems, and on-site systems—from relative obscurity to more widespread acceptance and application.

[3]Effectiveness of the Innovative and Alternative Wastewater Treatment Technology Program: Report to Congress, EPA (Washington, D.C.: Sept. 1989).

EPA has maintained a research and development program for wastewater and sludge. The research objective is to develop the technology and methods necessary to ensure the most cost-effective and environmentally sound management and disposal of wastewater and sludge. Wastewater and sludge research focuses on three areas: (1) municipal wastewater/sludge treatment, (2) urban wet-weather discharges, and (3) industrial wastewater management. EPA's development of technology for treating municipal wastewater/sludge is operated by the Office of Research and Development's (ORD) Risk Reduction Engineering Laboratory in Cincinnati, Ohio.

Objectives, Scope, and Methodology

In a June 4, 1992, letter, the Chairman, Subcommittee on Investigations and Oversight, House Committee on Public Works and Transportation, requested that we provide information on whether the nation could reduce its wastewater treatment costs by using new or unconventional methods. Specifically, he asked us to determine (1) whether there are cost-effective alternatives to conventional systems for collecting and treating wastewater, (2) whether barriers are limiting the use of these alternatives, and (3) how EPA is promoting the development of future technologies.

To address these objectives, we contacted the Illinois, Maryland, Massachusetts, and Virginia environmental protection agencies and/or health agencies. We also contacted various local communities in these states that are using or considering alternative systems, including the Village of Browns, Illinois; Garrett County, Maryland; Gloucester, Massachusetts; and Monterey, Virginia. During these contacts, we interviewed local officials from organizations such as the mayor's office, the public works agency, the consulting engineering firm, and citizen groups. We also met with local Rural Development Administration officials who are helping local communities resolve their wastewater treatment problems.

We attempted to identify states and communities that had been successful in using alternative wastewater treatment systems and had overcome existing barriers. EPA officials referred us to the agency's National Small Flows Clearinghouse in Morgantown, West Virginia, because it had the most current knowledge on state and community activities concerning alternative wastewater systems. We selected the above states and local communities because officials of the National Small Flows Clearinghouse told us that these areas would exemplify the successful use of alternative systems, barriers to these systems, and ways of overcoming these barriers.

We interviewed EPA officials at headquarters, several regional offices, the agency's research laboratories in Cincinnati, and the National Small Flows Clearinghouse, as well as other federal officials at the Tennessee Valley Authority, the National Aeronautics and Space Administration, the National Science Foundation, and the Department of Energy. We also interviewed officials from a number of professional associations representing consulting engineers, water pollution professionals, and equipment manufacturers, among others. These included the American Society of Civil Engineers, American Consulting Engineers Council, Water Environment Federation, and National Association of Towns and Townships.

We also reviewed appropriate EPA documents, including EPA's technical manuals and guidance on wastewater treatment technologies, EPA's report to the Congress on the I&A program, and the available literature on communities' experiences with alternative wastewater treatment technologies.

We conducted our review from January 1993 through July 1994 in accordance with generally accepted government auditing standards.

Alternative Wastewater Treatment and Collection Systems Can Yield Substantial Savings

Alternative wastewater treatment systems can provide lower-cost treatment than conventional treatment systems, when applied in appropriate situations. Also, alternative collection systems can save significant amounts over conventional gravity sewers, particularly in small communities. The cost savings associated with alternative systems may allow communities that cannot afford conventional facilities to effectively meet their wastewater treatment needs.

Use and Development of Alternative Systems

Many alternative wastewater treatment systems are based on "natural" systems, such as land application or artificial wetlands, which rely on the environment's ability to treat wastewater. Natural systems employ few mechanical parts, use little energy, and have lower construction and operation and maintenance costs than conventional treatment systems.

Alternative collection systems reduce the costs of construction by allowing small-diameter pipes to be installed at shallow depths and variable gradients not permitted by conventional gravity sewers. In comparison, conventional collection systems require larger pipes to be buried at a minimum slope and greater depth. Small communities can save significant costs by selecting alternative collection systems because the collection system can represent 70 to 90 percent of a wastewater system's total construction costs.

Major metropolitan areas and larger communities often use conventional systems with large sewers and mechanized treatment plants that employ biological, physical, or chemical processes. These mechanical systems are highly engineered, treat relatively large quantities of wastewater in a small amount of space, and are advantageous in urban areas where land is costly and/or unavailable. The use of conventional treatment and collection systems in sparsely developed areas with relatively few users will produce higher per-capita costs than the use of such systems in the densely developed areas typical of large communities. Conventional treatment processes usually need more attention by operators and more energy than natural systems do. Mechanical systems also produce greater quantities of sludge, which must be treated and disposed of, than natural systems. In the 1960s and 1970s, wastewater technology focused on developing these large centralized systems.

In the last 15 years or so, alternative wastewater treatment and collection systems have been revived from the past and developed for application. Alternative natural systems use the assimilative capacity of the local environment to remove pollutants from wastewater. Some alternative systems apply wastewater to the land, where it interacts with soil and vegetation. Other natural systems use an aquatic environment, such as lagoons and constructed or natural wetlands. These natural treatment and collection systems can provide the equivalent of secondary treatment.[1] Some organizations are looking at industrial applications of alternative systems such as constructed wetlands to remove heavy metals and nutrients from industrial wastewater. However, these systems are designed to treat municipal wastewater in a manner that conforms to secondary treatment standards and are best suited for areas of low-density development and small communities.

Natural systems generally require larger amounts of land than mechanical systems but are simpler and usually much less costly to operate.[2] Natural systems can cost less to construct, and their facilities can require fewer and less-skilled staff to operate, consume less energy, and produce less sludge than conventional facilities. Large communities can also use natural systems alone or in combination with mechanical systems, but land requirements tend to reduce the advantages of natural systems in densely developed areas.

The selection of the appropriate wastewater treatment technology will depend on many factors, such as the physical characteristics of the site, the configuration of the community, the level of treatment needed, and the characteristics of the wastewater. For example, the performance of a soil-based treatment system is affected by such factors as the characteristics of the soil, the quantity of wastewater applied, the climate, and the depth of the soil above the groundwater.

The remainder of this chapter discusses specific wastewater treatment and collection systems and provides examples of these systems. The cost savings estimated for these examples were reported to us by the individual communities using or planning to use these systems or were reported in case studies prepared by the National Small Flows Clearinghouse. These examples were judgmentally selected and are not meant to be representative of all cases where these systems have been applied. We did not verify the accuracy of the reported cost savings.

[1]Secondary treatment is a level of treatment that removes at least 85 percent of several key conventional pollutants.

[2]It's Your Choice: A Guidebook for Local Officials on Small Community Wastewater Management Options, EPA (Washington, D.C.: Sept. 1987).

Alternative Wastewater Treatment Systems

Wastewater treatment systems can be categorized as on-site systems, cluster systems, or centralized systems where effluent is collected and treated at a central location. On-site systems are individual on-lot treatment systems. Cluster systems are similar to centralized systems, since both collect wastewater or effluent and transport it to a treatment facility. However, cluster systems are smaller and handle wastewater for a neighborhood or a few homes rather then a whole town or community. Generally, wastewater treatment technologies for small communities include natural treatment systems as well as mechanical, conventional technologies.

On-Site Treatment Systems

About 25 percent of the U.S. population lives in areas that use individual on-site treatment systems. On-site systems often consist of a septic tank and a subsurface wastewater infiltration system. Septic tanks allow raw wastewater to flow through the tank at a rate slow enough to remove heavy solids by settlement and grease by floatation. In addition, bacteria in the tanks break down some solids.

Where fewer than 50 households will be connected to each mile of sewer, EPA suggests that communities look closely at on-site systems. Eliminating sewers can save a community significant costs because sewers represent a significant portion of the total cost of constructing a wastewater treatment system. On the proper site, a well designed, installed, and maintained on-site system can provide years of low-cost, trouble-free service. We reported in 1978 that on-site septic systems can function as effectively and permanently as centralized treatment facilities and are generally more cost-effective.[3]

Nevertheless, today, many older on-site systems are not performing properly, allowing wastewater to bubble up in homeowners' yards or back up into homes. Such situations often create pressure on a community to construct a costly centralized wastewater treatment facility. However, these problems are usually the result of poor design or siting, inadequate construction, or poor maintenance.[4]

Much of the land area in the United States does not have the drainage characteristics or minimum percolation rates required for soil absorption

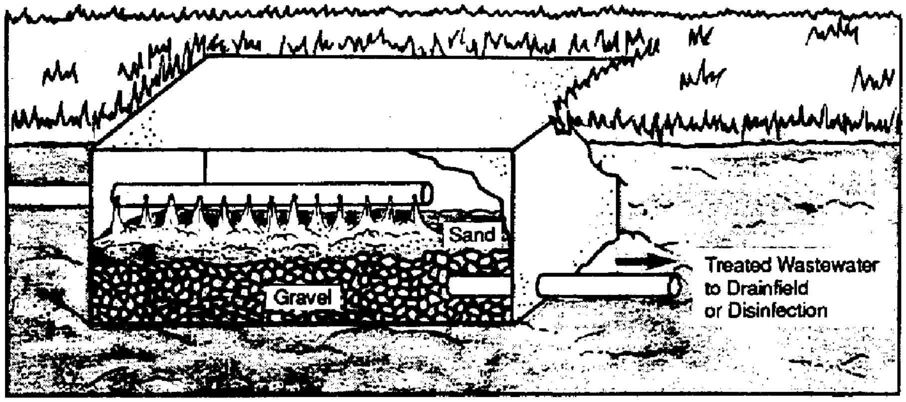
[3] Community-Managed Septic Systems—A Viable Alternative to Sewage Treatment Plants (CED-78-168, Nov. 3, 1978).

[4] In our 1978 report, we noted on the cover summary that "Because of inadequate controls over the design, installation, and operation, septic systems have become unreliable and temporary."

systems. Also, areas with high groundwater tables are inappropriate for these systems, since the shallow soil depth does not allow for adequate purification of wastewater before it reaches the groundwater. Where soil absorption systems cannot be used, alternative natural systems, such as sand filters or mound systems, may be used.

A sand filter—illustrated in figure 2.1—consists of a bed of granular material through which the partially treated sewage flows. A mound system—illustrated in figure 2.2—raises the absorption field above the natural soil by using a fill material that is permeable. Both mound systems and sand filters are suitable in areas where the soil has a low permeability, where the groundwater table is high, or where there is a shallow layer of natural soil. These systems are considerably more expensive than soil absorption systems.

Figure 2.1: Sand Filter



Notes:

Filters are used when the soil is too shallow or too permeable.

A bed of sand is built over a drainpipe that collects the wastewater after it has been filtered.

Filters provide a high degree of treatment.

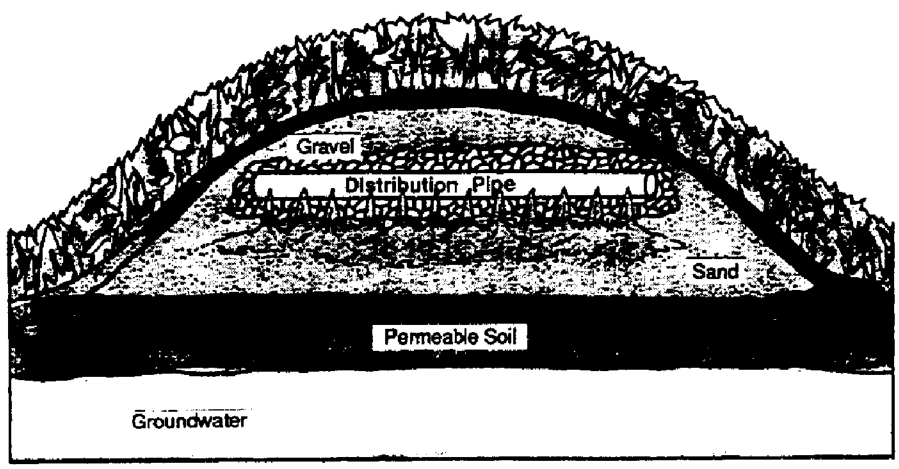
Treated wastewater goes to a drain field or to a stream or lake (after disinfection).

Two types are used—an intermittent filter (wastewater travels through the filter only once) and a recirculating filter (wastewater goes through the filter several times).

Periodic maintenance is required and may include the occasional removal and replacement of the top sand layer.

Source: It's Your Choice: A Guidebook for Local Officials on Small Community Wastewater Management Options, EPA (Washington, D.C.: Sept. 1987).

Figure 2.2: Mound System



Notes:

This system is used when the soil is too shallow for a standard septic system.

Septic tank effluent is pumped into a drain field built into the mound.

Sand fill and gravel are mounded on top of the natural soil to filter the septic tank effluent before it reaches the natural soil.

Source: It's Your Choice.

Georgetown, California, has been operating an on-site wastewater management program since 1971. Following extensive studies from 1978 through 1981, which compared the merits of on-site disposal systems with those of both conventional and alternative forms of sewage collection, treatment, and disposal, the Georgetown Divide Public Utility District concluded that an on-site option was the most desirable alternative despite earlier expectations that the growth in population would lead to the construction of a centralized system. For each lot, the on-site management program calls for (1) an evaluation of the soil and geology at the building site, (2) a design for the system based on the site's evaluation, (3) managed and inspected construction work, (4) scheduled maintenance and surveillance of the system, and (5) chemical and biological sampling of the watershed. Currently, the district charges homeowners a one-time design/inspection fee of $540 when they build their homes and $12.50 per month thereafter.

Cluster Systems and Larger Centralized Treatment Facilities

Cluster systems collect and transport wastewater to small neighborhood treatment facilities. Even where land is not suitable for on-site systems, a useable site may not be too far away. Cluster systems may be economical where houses are too close together to use on-site systems but too far away to connect with a larger collection system. The treatment methods associated with cluster systems are often larger versions of on-site systems, such as septic tanks with soil absorption systems or sand filters.

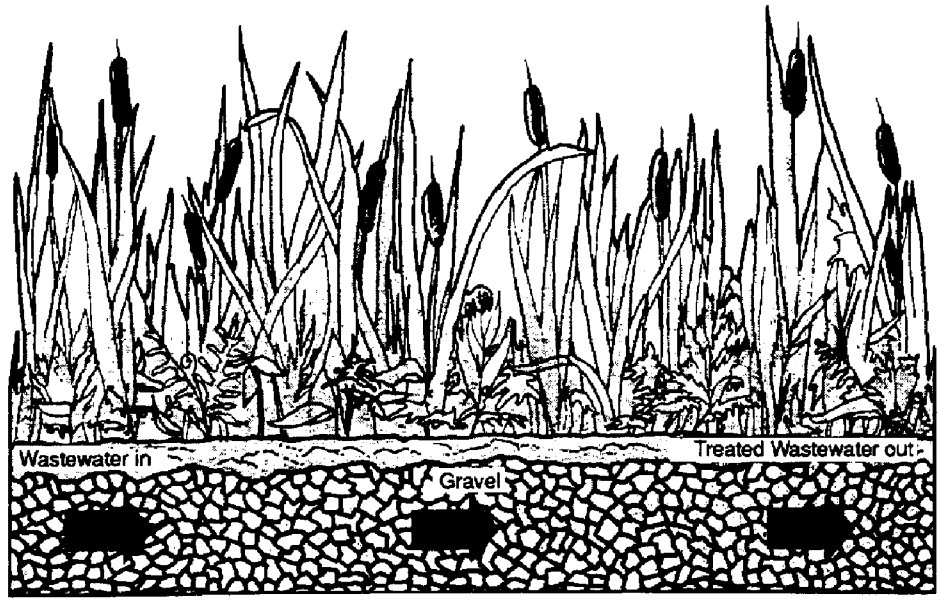
Larger centralized treatment systems (as well as cluster systems) can use soils, vegetation, and aquatic environments including constructed wetlands, overland flow systems, slow-rate land application, and lagoons.

Constructed Wetlands

Wetlands/aquaculture/marsh systems can be used to further reduce the pollutant levels from the effluent of another treatment process. Wetland systems can also treat raw or partially treated sewage. Figure 2.3 illustrates a constructed wetland.

Constructed wetlands can produce significant savings for some small communities. In the early 1980s, the small town of Monterey, Virginia, was required to upgrade its existing treatment facility to secondary treatment by adding additional treatment processes. According to the Mayor of Monterey, the town's consulting engineer estimated that adding a conventional treatment process would cost about $500,000, which the town considered unaffordable because of its low average household income. With the assistance of the National Aeronautics and Space Administration, which developed this technology for potential future space applications, Monterey is completing a subsurface wetland with bulrushes—a common aquatic plant—and a rock filter process over a liner. According to the Mayor, the wetland uses little energy, requires little maintenance, and was constructed for about $166,000. Over 30 such systems have been financed by EPA's I&A program through fiscal year 1990. A number of states have been experimenting with on-site wetlands to replace failing drain fields or to work in conjunction with a drain field where soils would clog or otherwise be unsuitable for treating wastewater.

Figure 2.3: Constructed Wetland



Notes:

Marsh plants (cattails, reeds, etc.) are grown in beds of soil or gravel through which wastewater flows.

Wetlands are useful to further treat wastewater from a lagoon.

This is a low-cost system that needs minimal attention from an operator. Periodically, plants need to be checked and sometimes harvested at the end of the growing season.

The system requires relatively less land than many land treatment systems.

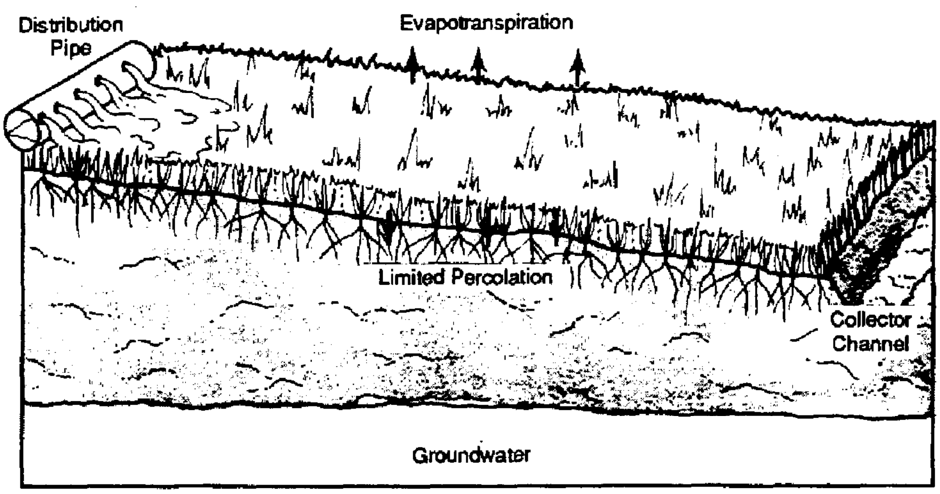
The system may be operated year-round in most climates.

Source: It's Your Choice.

Overland Flow Systems

Other types of natural systems use land as well as vegetation for treating wastewater. One of these systems—called the overland flow system—applies wastewater at the top of a gently sloping hill and collects it at the bottom of the hill. Figure 2.4 illustrates this system.

Figure 2.4: Overland Flow System



Notes:

This system is well suited for rural areas with large amounts of pasture or meadow land having tight soils.

Wastewater is applied at the top of a gently sloping grass-covered hill and allowed to flow over the ground's surface to the bottom of the hill, where it is collected, disinfected, and discharged.

The system is useful to further treat wastewater from a lagoon.

In cold climates, a storage lagoon capable of holding flows during nonoperational periods is needed.

The system requires minimal attention; the operator should periodically mow and remove the grass. (The system may produce marketable hay.)

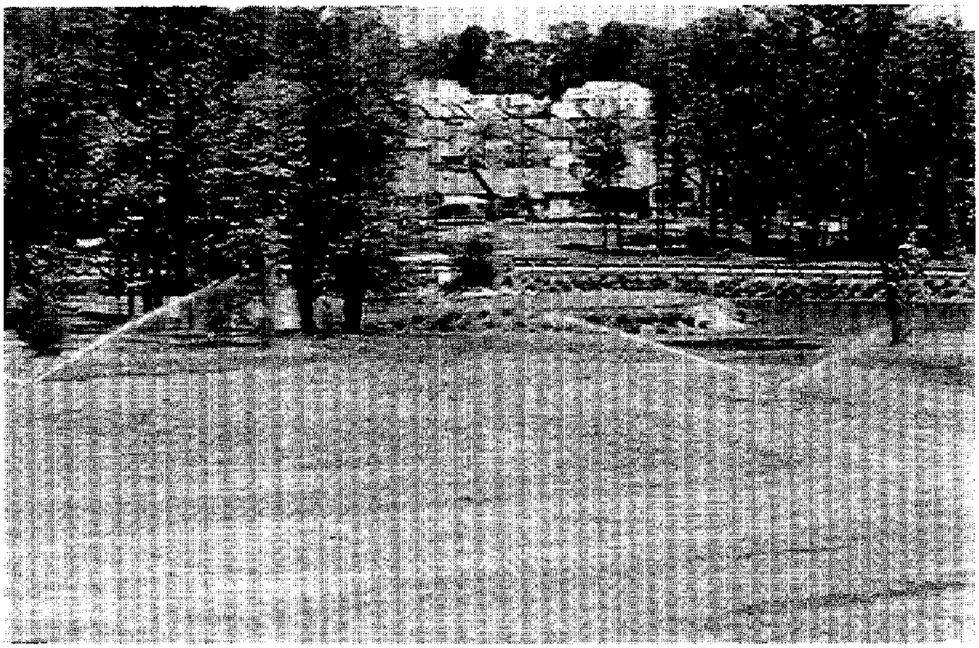
Source: It's Your Choice.

Kenbridge, Virginia, was required to upgrade its existing treatment plant to meet discharge requirements. Initially, the facility plan proposed an aerated lagoon. The plan was later modified on the basis of an evaluation of land treatment technologies. Land adjacent to the plant was found to be ideally suited to an overland flow system. An economic analysis showed that an overland flow system would cost $88,000 per year compared with $168,800 per year for an aerated lagoon system. Some 57 communities have received grants from EPA to construct overland flow systems.

Slow-Rate Land Application

Slow-rate land application, or spray irrigation, is another soil-based treatment method that applies effluent at a controlled rate to a vegetated soil surface of moderate to slow permeability. The wastewater is used as a form of irrigation and is applied by spraying or the flooding of furrows. Figure 2.5 illustrates a spray irrigation system.

Figure 2.5: Spray Irrigation



Notes:

This system does not generally discharge effluent into surface water. Hence, it is particularly appropriate in areas where discharge regulations would require a costly facility.

Sprinklers apply wastewater to cropland, woodland, golf courses, or other vegetated areas.

The system can be used with lagoon effluent.

The system is relatively simple to operate. The sprinkler system needs regular maintenance, and the rate at which wastewater is applied must be adjusted to suit crops' needs.

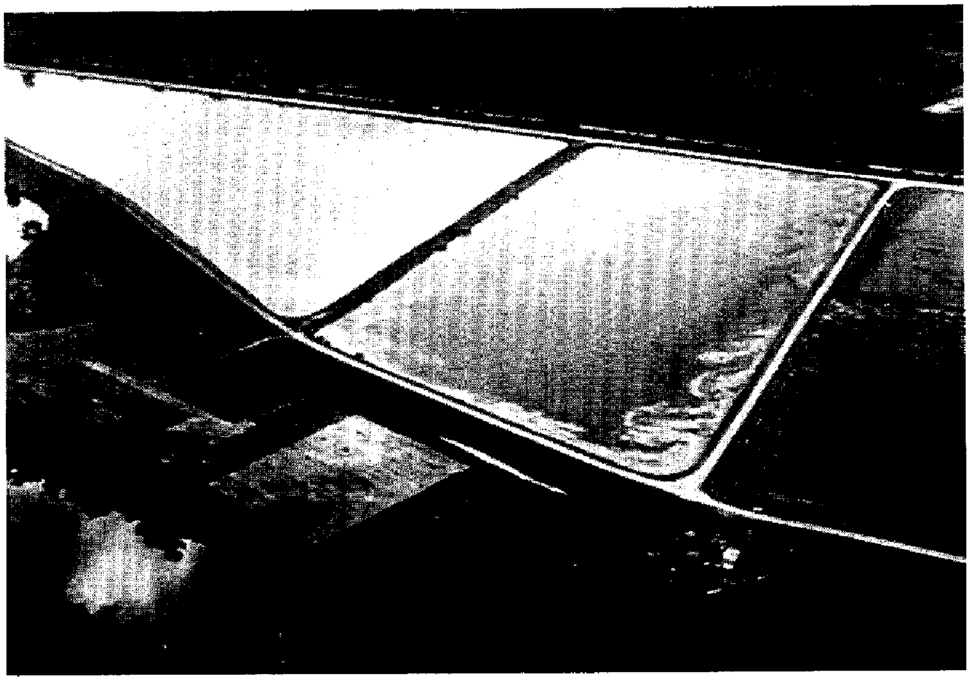
Source: It's Your Choice.

Craigsville, Virginia, had failing on-site septic systems and hired a consulting engineering firm that proposed an advanced wastewater treatment plant. This plant would have discharged effluent into a local river. But because the costs of construction and operation were so high, the system was never constructed. Craigsville's sewage disposal problems remained unresolved until a prison was constructed adjacent to the town, and a wastewater treatment facility for both the town and the prison was evaluated. The treatment system that was finally selected discharged no effluent into the local waterways. Instead, this system, which included primary treatment tanks and aerated lagoons, disposed of effluent by slow-rate land treatment. The cost to treat each gallon of wastewater, computed on the basis of the design flow, was half that of an advanced wastewater system. Through the I&A program, EPA provided grants to 312 communities that chose a slow-rate treatment system.

Lagoons

Another system using natural treatment processes is a lagoon. A lagoon refers to either a stabilization pond or an aerated (oxygenated) lagoon. Figure 2.6 illustrates a lagoon. A stabilization pond is simply a shallow impoundment in which wastewater is treated by natural processes without the aid of mechanical equipment or chemical additives. An aerated lagoon is the same except that it uses mechanical equipment to enhance the aeration process.

Figure 2.6: Lagoon



Notes:

This system employs a low-cost and simple treatment method requiring only a part-time maintenance staff.

The system is suitable for areas that do not have strict discharge regulations.

Primary treatment is not generally required.

The system may require watertight liners to protect groundwater.

Some lagoons may qualify for equivalent secondary discharge standards.

Stabilization ponds require about 1 acre for every 200 people served.

Aerated lagoons require only one-third to one-tenth as much land as stabilization ponds.

Regardless of the type, several smaller lagoons in a series are better than one big lagoon.

The system may eliminate the need for a higher level of treatment if the discharge from the lagoon is controlled. Controlled release lagoons discharge only when streamflow is high.

Total containment lagoons never discharge. All wastewater evaporates. They are used only in dry climates.

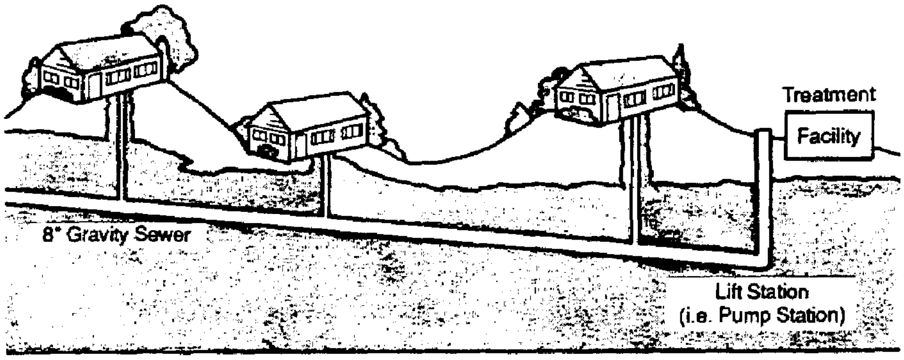
Sludge collects at the bottom of the lagoon and may have to be removed and properly disposed of every 5 to 10 years.

Source: It's Your Choice.

Alternative Wastewater Collection Systems

Centralized treatment, which requires a collection system, may be necessary for areas where on-site systems will not work. Selecting the appropriate collection system is important because conventional gravity sewers can account for 70 to 90 percent of the construction costs of a conventional wastewater treatment system. Although conventional gravity sewers are costly, they may be advantageous where homes are close together and where many households can share the cost. Figure 2.7 illustrates a conventional gravity sewer.

Figure 2.7: Conventional Gravity Sewer



Notes:

This system is appropriate in densely developed areas (100 or more homes per mile of sewer, lots of 1/2 acre or less).

Untreated wastewater travels mainly by gravity through a system of sewers and pumping stations.

The system is difficult and expensive to install; it must always slope downhill.

Costly manholes are required for maintenance.

Infiltration and inflow (leaky sewers) may be significant.

The system can be used alone or combined with other collection systems.

Source: It's Your Choice.

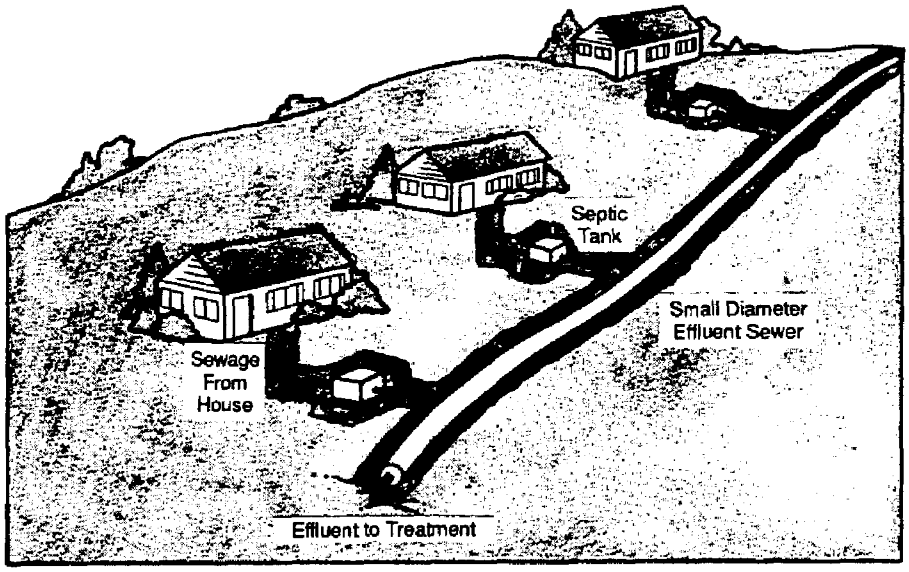
Alternative collection systems are appropriate where 50 to 100 households will be connected to each mile of sewer, according to EPA. The savings associated with alternative collection systems for appropriate small communities generally range from 25 percent to as high as 90 percent of the cost of conventional gravity sewers, according to an environmental engineer who was responsible for EPA's I&A research program at its Risk Reduction Engineering Laboratory for many years. Alternative collection systems use pipes that are smaller in diameter than conventional sewer pipes and cost less to purchase. In addition, the excavation costs for installing the pipes are reduced because small-diameter pipes can be installed at shallower depths. The pipes can follow land contours and can be laid with curving and variable gradients to avoid buildings and other large objects. In contrast, conventional gravity sewers must be installed at a specific minimum slope that may require fairly deep cuts in the terrain and expensive pump or lift stations to pump the sewage to the desired elevation.

Three main classes of alternative sewers are small-diameter effluent sewers, pressure sewers, and vacuum sewers. These alternatives can be used with conventional sewers or with other alternative sewers, as discussed below.

Small-Diameter Effluent Sewers

Small-diameter effluent (or gravity) sewers use small-diameter pipes and a septic tank at each home for primary treatment. Although flow in the pipes is accomplished by gravity, lines can be installed at a lesser gradient than in conventional gravity sewers; therefore, less excavation is required. Figure 2.8 illustrates a small-diameter effluent sewer. According to EPA, 167 communities have received I&A program grants to construct small-diameter effluent sewers. One of the communities, located in the Maysville area of Muskingum County, Ohio, has some 770 households. This area had many existing septic tanks and drain fields that failed or were near failing. A conventional gravity sewer system was found to be too expensive because of the low-density development. A small-diameter effluent sewer system was estimated by a National Small Flows Clearinghouse study to cost about 35 percent less than the conventional gravity sewer system.

Figure 2.8: Small-Diameter Effluent Sewer



Notes:

This system is appropriate in less densely developed areas (fewer than 50 to 100 homes per mile of sewer, lots of 1/2 to 2 acres).

Septic tank effluent (water flowing out of septic tanks) travels through a small-diameter plastic pipe. Some homes may require a pump to move the effluent.

The system can be installed at shallow depths and may follow the land's contours; it can be "woven" around trees and buildings.

Septic tanks remove the solids; sewer clogging is generally not a problem even in low spots.

Less costly cleanouts may be used in place of manholes.

A smaller and simpler treatment facility can be used.

Septic tanks should be pumped out every 3 to 5 years.

The system presents less possibility of infiltration and inflow.

The system can be used alone or combined with other collection systems.

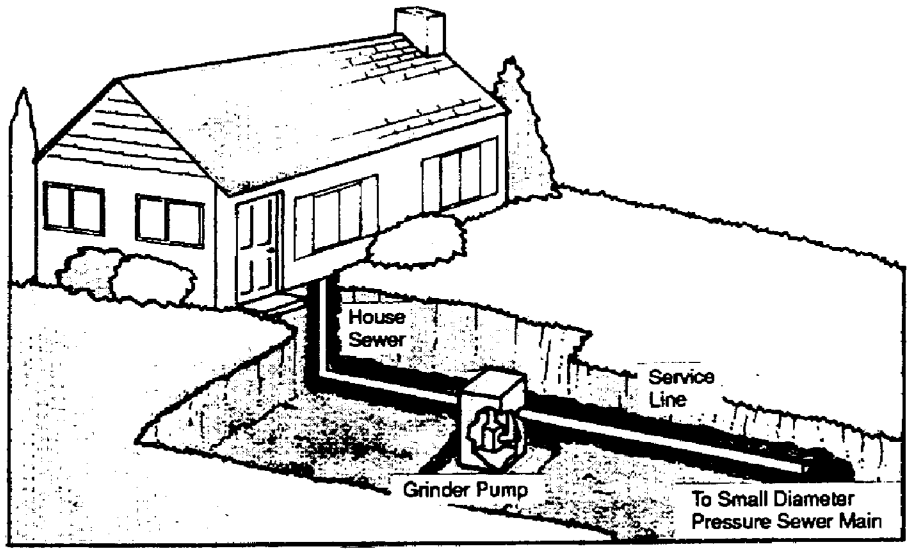
Source: It's Your Choice.

Pressure Sewers

Pressure sewers could consist of either (1) a grinder pump that grinds the solids present in wastewater into a slurry, much as a garbage disposal unit grinds waste in a kitchen sink, or (2) a septic tank and effluent pump

(STEP) system. Figure 2.9 illustrates a grinder pump pressure sewer. A grinder pump system may require more sewer line cleaning and pump maintenance than a STEP system. In a STEP system, the septic tank holds the solids, grit, grease, and other waste that could clog a pipeline. Because wastewater is treated in a septic tank, the treatment facility can be smaller and simpler than would otherwise be needed. Under the I&A program, EPA has provided grants to 87 communities for constructing STEP systems and 163 communities for constructing pressure sewers with grinder pumps.

Figure 2.9: Grinder Pump



Notes:

This system is appropriate in the same areas as a septic tank effluent sewer system.

The system is similar to a septic tank effluent sewer system except that a grinder pump is used in place of a septic tank.

Grinder pumps have built-in cutter mechanisms that grind solids so they do not clog sewers.

Operation and maintenance requirements are slightly higher than for a septic tank effluent sewer system.

Power costs $10 to $20 per year.

The system can be used alone or combined with other collection systems.

Source: It's Your Choice.

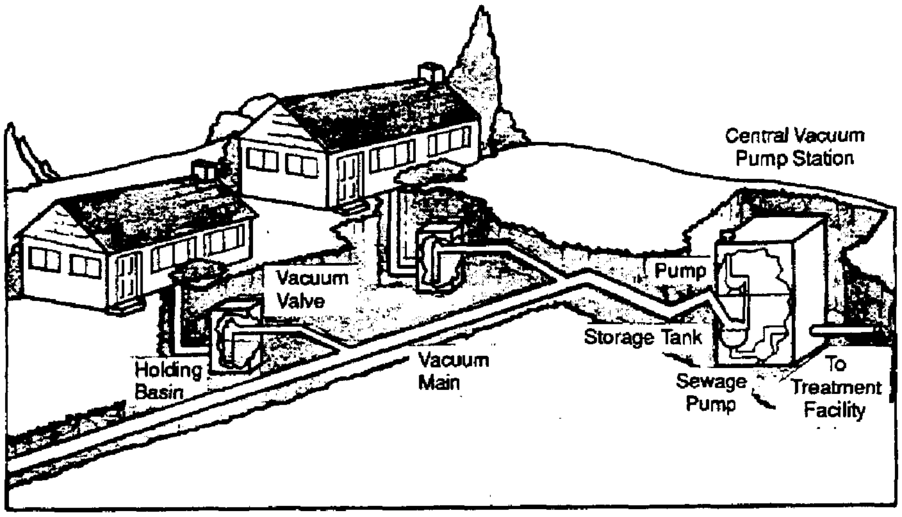
One state is attempting to demonstrate that using the STEP system could save costs for some of its small communities. Illinois has established a federal and state interagency coordinating committee to find solutions to the problems of small rural communities with failing private septic systems or deteriorating wastewater treatment systems. According to officials from the Illinois Environmental Protection Agency, it is extremely difficult for a community with a population of under 300 to afford a conventional wastewater collection and treatment system because per-capita costs are too high. The Governor's Rural Affairs Council of Illinois estimated that small communities could save about 25 to 40 percent in construction costs by using an alternative collection system and that savings would allow many of these small communities to correct their wastewater problems.

To demonstrate that alternative collection systems will work and will lower costs, Illinois has selected a number of small communities that have serious problems with their on-site septic systems and cannot afford the conventional gravity sewers selected by consulting engineers and identified in their facility plans. For example, the Village of Browns, Illinois, with a population of about 200, has septic systems that are failing because of seasonally high groundwater. Consulting engineers for Browns have estimated that a conventional sewer and lagoon treatment system would cost $1.3 million, whereas a STEP system with a comparable treatment system would cost $965,000.

Vacuum Sewers

Vacuum sewer systems move sewage by creating within the sewer lines a vacuum or negative pressure that draws the waste to a common collection tank. Once in the collection tank, the wastewater is pumped to a treatment facility. Figure 2.10 illustrates a vacuum sewer.

Figure 2.10: Vacuum Sewer



Notes:

This system is an option in areas that are flat.

The system conveys untreated wastewater by vacuum through a small plastic pipe to a central station. There, it is pumped to a treatment facility.

Each home or group of homes is equipped with a vacuum valve rather than a septic tank or grinder pump.

The system requires careful installation and skilled maintenance.

The system can be used alone or combined with other collection systems.

Source: It's Your Choice.

One vacuum collection system financed partially with grant funds from EPA is in Cedar Rocks, West Virginia. Before the vacuum collection system was considered, a gravity collection system was designed. The lowest bid received for this system was $2.15 million in 1978. A vacuum collection system was then designed and constructed at an actual cost of $1.23 million. Under the I&A program, EPA awarded grants to 41 communities for vacuum sewers.

Variety of Systems in Garrett County, Maryland

Various treatment and collection systems—alternative and conventional—can be mixed with each other to take advantage of each system's positive features. Garrett County, Maryland, is a rural area where 60 percent of the people use individual septic systems; the other 40 percent use a variety of systems managed by a sanitary district for the county or a local town government. For example, variable-grade, small-diameter sewers with on-site septic tanks and recirculating sand filters are used in the small communities of Gorman and Crellin. At Deep Creek Lake, the largest system uses small-diameter pressure sewers with grinder pumps in combination with larger gravity pipes and a conventional treatment plant. The Administrator of the sanitary district noted that communities in Deep Creek Lake could not afford a conventional gravity system because of the topography.

Conclusions

Many small communities may not be able to afford the conventional wastewater collection and treatment systems typical of large metropolitan areas. Fortunately, many alternative wastewater collection and treatment systems are available and may be more affordable. A number of small communities have used these technologies, and some have reported substantial cost savings over conventional technology.

Barriers to the Use of Alternative Systems Can Be Reduced

A number of barriers impede the use of alternative wastewater treatment and collection systems including

- a lack of knowledge about the alternatives' applicability, performance, and cost;
- financial disincentives within the private sector to design and/or construct facilities employing alternative systems; and
- restrictive state and local codes and regulations.

EPA has an important role to play in addressing these barriers and helping communities achieve the cost savings that are possible with the use of the alternative systems.

EPA's Role in Promoting Alternatives Has Changed

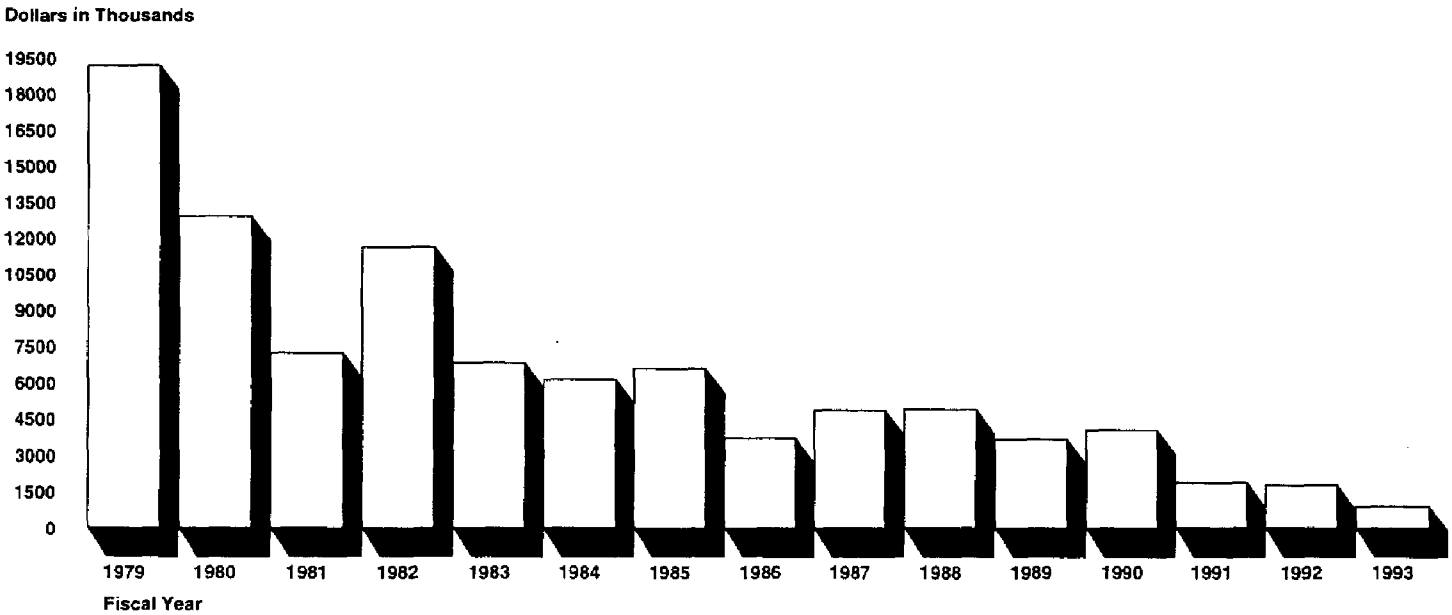
In the 1970s and 1980s, EPA vigorously promoted the wider use of alternative systems. These activities occurred primarily through the innovative and alternative wastewater treatment technology program and the technical transfer activities authorized under the Clean Water Act. However, these activities largely ceased when funds for evaluating and disseminating the results of projects using these systems were virtually eliminated with the termination of EPA's Construction Grants Program. As a result, information that is critical to the use of alternative wastewater systems has not been developed or disseminated to those who could use it.

In its 1989 report to the Congress on the effectiveness of its I&A program, EPA concluded that the program "has been tremendously successful at promoting the development and application of more cost-effective, environmentally sound wastewater treatment technologies, especially in small communities."[1] However, the report also acknowledged concerns about whether innovative and alternative technologies would continue to be used once the I&A program ceased in 1990. Specifically, the report cited concerns about the continuation of (1) technology transfer activities, (2) guarantees to modify or replace failing systems, and (3) the testing and demonstration of promising new technologies. To address some of these concerns, the report recommended that EPA continue to (1) conduct, publish, and distribute evaluations of the performance of innovative and alternative wastewater technologies and (2) conduct technology transfer and training seminars.

[1] Effectiveness of the Innovative and Alternative Wastewater Treatment Technology Program: Report to Congress, EPA (Washington, D.C.: Sept. 1989).

While EPA has continued a limited number of these technology transfer efforts, EPA's research and development funding for wastewater treatment engineering has been severely reduced from about $19 million in fiscal year 1979 to $880,000 in fiscal year 1993. (See fig. 3.1.) As a result, virtually no evaluation work has been done, most of EPA's technical manuals are outdated (many are based on research done in the 1970s), and few technology transfer and training seminars have been held. Furthermore, officials of EPA's Office of Research and Development (ORD) told us that the virtual elimination of ORD's wastewater treatment budget has caused the agency to lose much of its expertise in innovative and alternative technologies. According to these officials, the agency may no longer be able to keep abreast of new developments, much less evaluate them and disseminate information about them.

Figure 3.1: Funding for Municipal Wastewater Engineering Research



Note: The amount for 1982 includes $3.8 million carried over from the prior year. Figures for all years do not include research on the land application of watewater performed by EPA's laboratory in Ada, Oklahoma, during the 1970s and ending in the 1980s.

Source: ORD's Risk Reduction Engineering Laboratory.

Although ORD officials maintain that their wastewater budget need not be restored to the 1970s' levels, they believe that some restoration is needed if the agency wishes to retain minimal expertise in current treatment technologies. Some of the officials we spoke to from EPA, from state and local entities, and from wastewater treatment, engineering, and rural and environmental associations—including both advocates and skeptics—agree that the loss of EPA's technology transfer activities hinders the wider use of alternative technologies. A critical component of these activities was EPA's independent evaluation of alternative technologies, publication of technical manuals reflecting these evaluations, and dissemination of this information through workshops and training seminars.

In 1993, action was taken that may reverse the declining level of attention that EPA has been able to give to these alternative technologies. The Congress funded the administration's "Environmental Technology Initiative" for EPA to accelerate the development and use of innovative environmental technologies. EPA plans to focus, in part, on reducing barriers to innovation and the use of new technologies and on creating incentives in federal and state regulations for the development and use of innovative technologies.[2] The initiative is being funded at $36 million for fiscal year 1994. As discussed later in this chapter, EPA staff have developed proposals to use a portion of these funds to address barriers to the use of alternative wastewater technology.

Information Is Needed on the Alternatives' Applicability, Performance, and Cost

The absence of comprehensive and current information on alternative wastewater systems' applicability, performance, and cost is a primary barrier to the greater use of these systems. Engineers remain largely unfamiliar with the treatment alternatives, according to officials from the Water Environment Federation, in part because these alternatives were given little or no attention in engineering school courses until recently. Also, according to the Chief of EPA's Municipal Technology Branch, state regulators who are unfamiliar with alternative technologies are less likely to approve their use.

Even when engineers, municipal officials, and regulators have a basic familiarity with alternative technologies, they may have reservations and/or questions about their applicability, performance, or costs. Although EPA's former I&A program was successful in expanding the use of these technologies, it also funded a number of systems that did not perform up

[2] Chapter 4 contains a discussion of this initiative.

to expectations or realize anticipated savings. As a result, some state and local officials and engineers continue to have reservations about choosing alternative technologies. Even though EPA attempted to address these concerns by issuing informational manuals and conducting workshops, most of these activities ended. If such questions are left unresolved, it is unlikely that systems using alternative technologies will be selected.

For example, a Gloucester, Massachusetts, citizens' group advocates the use of on-site treatment alternatives for the city. The group maintains that despite some siting difficulties, a variety of alternative treatment technologies can be used in lieu of connecting the city's entire population to the city's treatment plant. The group argues that the level of treatment would be superior to, and significantly less expensive than, that provided by the city's treatment plant, which provides only primary treatment. The group supports its position by pointing to an engineering firm's revised facility plan that examined alternatives and concluded that they are feasible. The engineering firm estimated the capital cost of alternative technologies for different areas of the city at about $13.6 million compared with the capital costs of conventional sewers estimated at about $25.2 million. The group also invited a National Small Flows Clearinghouse engineer to assess the situation; the engineer concluded that a mix of on-site and other alternative technologies could meet the city's wastewater treatment needs.

In contrast, the city's former mayor, the city's project engineer, and the state's Director of the Division of Water Pollution Control, Department of Environmental Protection, maintain that Gloucester's soil conditions preclude the widespread use of on-site alternatives. Specifically, these officials cite the city's high water table and underlying rock formations as factors precluding on-site treatment alternatives.

In February 1993, Gloucester agreed to a compromise and signed an agreement with the state under which the city will install either conventional sewers or alternative collection systems with connecting septic tanks for various areas of North Gloucester by specific dates (the latest date being Feb. 1, 1997) and assess the feasibility of using alternative on-site systems for the remaining unsewered areas of the city. According to the city's former mayor and project engineer, this assessment will consist of experimenting with four pilot on-site alternatives to obtain data on their applicability and performance. Under the agreement, Gloucester must have finished constructing wastewater treatment system(s) in the areas that could use on-site systems by December 31, 1998.

Questions about alternative treatment systems' applicability and performance also surfaced in our discussions with other state regulators. In Virginia, for example, state Health Department and Water Control Board officials questioned the natural treatment systems' ability to satisfactorily meet new, increasingly stringent discharge limits for some pollutants, such as nitrogen and ammonia. An Illinois Department of Public Health official told us that soil conditions and/or population density in much of the state precludes the use of on-site treatment alternatives. Some advocates of alternatives maintain, however, that if the proper site and technology are selected, alternatives can be used in most circumstances where poor soil conditions are a concern.

Questions have also arisen about how much money can be saved by using alternative wastewater technologies. Even some who believe that alternatives can perform in a wide variety of circumstances question whether the alternatives will produce significant savings or any savings under certain circumstances. For example, Virginia Health Department and Water Control Board officials said that because these systems require extensive land, they may not save costs where land is expensive. An Illinois Environmental Protection Agency official said that cost savings of 30 to 40 percent, estimated by others as achievable by using alternative collection systems, were too high for many communities in Illinois because of its flat terrain. Nevertheless, he noted that a community located in hilly terrain had constructed an alternative collection system that saved about 50 percent of the cost of a conventional system. He acknowledged that, if realized, savings of 30 to 40 percent could make wastewater treatment affordable for many small communities not serviced by sewers.

Sometimes, the examples cited in the debate are from projects that were designed and constructed years ago and do not reflect technological advances that have improved the alternatives' performance and cost savings. For example, pumps used in early STEP systems were prone to corrosion and failure and were difficult and expensive to operate and repair. Nevertheless, advances in pump design and manufacturing have resulted in a reliable, energy-efficient pump that is easy to maintain and repair, according to EPA officials in ORD and the Office of Water.

The debate over alternatives' applicability, performance, and cost stems from a lack of comprehensive and up-to-date information on the alternatives. Those advocating the wider use of alternatives support their position by citing specific examples where alternatives are performing well and saved significant costs. Skeptics, however, point to cases where the technologies failed to realize performance and/or cost-savings expectations.

Advocates of alternative wastewater treatment technologies and skeptics agree that more comprehensive and current performance and cost data are needed to resolve questions about these technologies. Most of the officials from EPA, state and local governments, and engineering firms we spoke with agreed that an independent third party should examine existing systems that use alternative technologies, analyze how well they perform under varied circumstances, and verify their actual design, construction, and operation and maintenance costs. Some said that this analysis should include a study of the lessons learned from alternative systems that did not meet expectations.

Concerns About Liability and Engineering Fees Pose Barriers

As we have reported in the past, consulting engineers, state regulators, and local officials wish to minimize the possibility that a system could fail to meet expected performance and/or cost parameters. Engineers wish to avoid potential damage to their professional reputations and/or possible financial liability for designing such a system; regulators are reluctant to approve a system that may not be able to perform reliably; and local officials wish to avoid the fiscal and political ramifications of selecting such a system. These concerns, we believe, are also mutually reinforcing. Local officials and engineers are reluctant to select an alternative if they believe it will not be approved by regulators. Regulators are reluctant to approve a system if it is not clear who will be liable or if resources will not be available to modify or replace a system that fails to meet the parameters of its design.

The I&A program had a “modification and replacement” provision designed to allay these types of concerns. The program did so by providing grants for up to 100 percent of the cost to modify or replace innovative and alternative wastewater systems that failed to perform according to the parameters of their design. There is no similar mechanism in the current state revolving fund program that supports communities’ wastewater projects.

Because of concerns about these issues, the Associated General Contractors of America and the American Consulting Engineers Council established a task force to examine innovative steps to assign construction risks. The task force’s report concluded that the traditional approach of resolving liability issues after unforeseen conditions are found or unexpected events occur is costly and dispute-prone.[3] When these disputes occur, relationships between parties can become adversarial and result in costly delays to projects, especially when the courts are asked to resolve liability issues. In contrast, the task force noted that allocating and managing risks up front with all the involved parties can reduce both costly delays and disputes. The report also stated that although some aspects of risk-sharing have been around for years, they are just now becoming more widely used.

Besides concerns about liability, engineers also face financial disincentives in designing lower-cost alternative systems, according to several sources, including the American Consulting Engineers Council. Design fees are usually derived from "cost-curves" developed by EPA and the American Society of Civil Engineers.[4] Under these cost curves, engineers' fees are calculated as a percentage of net construction costs, and lower-cost construction projects carry a higher-percentage award. Using the society's cost curves, an engineer's fee would be about 7.5 percent of the construction costs for a $1 million plant and about 6.4 percent of the construction costs for a $5 million plant. However, even with the higher-percentage fee for the lower-cost project, the engineers' actual compensation is higher for the high-cost project. Design fees would be about $320,000 for the $5 million facility compared with about $75,000 for the $1 million facility. This problem is exacerbated because alternative plants frequently require more time to design than traditional systems because site-specific considerations must be taken into account.

Despite the prevailing fee structure, some engineers may be motivated to take on lower-cost design projects. However, communities may not be able to readily identify these engineers. To increase the opportunity for communities to hire engineers who are qualified and motivated to design lower-cost systems, the American Consulting Engineers Council generally favors the use of qualification-based selection (QBS). Under QBS, communities do not initially select engineers on the basis of fees but instead screen consulting engineers' bids on the basis of predetermined qualification factors, such as experience with similar projects, and of engineers' ability to work within time constraints. The engineers meeting these qualifications are then interviewed and ranked against the factors. At

[3]This 1990 report is entitled Owner's Guide to Saving Money by Risk Allocation.

[4]Although consulting engineers are not required to use a fee structure based on a project's total costs, EPA's cost curves were used under the agency's Construction Grants Program to derive allowable design costs, and their use remains widespread.

this point, the highest-ranked engineer is invited to further discuss the scope of work, and only then are fees negotiated. If the negotiation process fails to yield satisfactorily mutual agreements, the second-highest-ranked engineer is invited to negotiations, and so on. Wisconsin and New Mexico—two states that encourage or require QBS—report great satisfaction with the process, as do consulting engineers and municipalities.

State and Local Codes and Regulations Are Restrictive

State and local codes and regulations can restrict or actually prohibit the use of alternative technologies because many codes contain specifications that apply to conventional technologies. For example, several states' codes and regulations require sewers to have manholes spaced at a set number of feet and require pipes to be buried at a given depth. However, alternative sewers do not need manholes or deep burial, and constructing them to meet these specifications would negate much of their cost-effectiveness. Similarly, Illinois's code requires basement drains to flow into sewer lines, but compliance with this requirement could overwhelm proposed small-diameter sewer systems.

Some states have recognized that their codes were written with conventional technologies in mind and are addressing the issue. Several states are updating codes to allow greater flexibility in the use of alternative technologies. The following are illustrations:

- Wisconsin's on-site domestic wastewater regulatory agency is currently revising the state's code for privately owned sewage systems and making it a performance-based code that will promote flexibility and innovation in the design of alternative technologies.
- Massachusetts is also drafting new codes for on-site systems, in part to allow for more flexibility in the use of alternative technologies. These new codes are intended to clarify the process for approving and using alternative technologies, ensure that on-site systems are properly operated and maintained, and provide information to municipal officials to help them determine which alternative systems are appropriate for their community.

In addition, Washington State has established guidelines for the use of a number of alternative on-site systems through the state's On-Site Sewage Technical Review Committee. This committee develops guidelines for the use of new on-site technologies, which local health agencies then use in issuing permits for the new technologies. In addition, the National On-Site

Wastewater Recycling Association is currently working with the Water Environment Federation to develop a model national on-site wastewater treatment code that will encourage the use of alternative technologies by moving from prescriptive, technology-based standards to performance-based standards.

EPA's requirements can also discourage the use of alternative technologies. EPA's Chief of the Municipal Technology Branch stated that when EPA (or a state) directs a community to build a treatment facility within a tight time frame, the community and the consulting engineer may select a conventional system to avoid the additional time that may be required to design and receive approval for an alternative system.

EPA May Address Barriers

Although the Director of EPA's Office of Wastewater Management acknowledged the value of (1) evaluating the applicability, performance, and cost of projects employing alternative technologies and (2) publishing and updating technical manuals reflecting the results of these evaluations, he was concerned that limited resources would preclude the Office from undertaking activities that were not mandated by the Clean Water Act. Subsequently, EPA's Office of Water proposed three limited projects to address barriers to the use of innovative and alternative wastewater treatment technologies. According to the Chief of the Municipal Technology Branch, EPA may decide to propose funding these projects with the agency's fiscal year 1995 appropriation for its Environmental Technology Initiative, which EPA expects to be somewhat higher than the $36 million appropriated for the initiative in fiscal year 1994.

Two of the three projects would develop and publish information on the applicability, performance, and cost of alternative wastewater treatment technologies. One project would gather information on technologies that have had "technology assessments" or evaluations completed but not disseminated. Under this project, EPA would determine the proper methods to package and disseminate this information. The second project would analyze the performance of technologies from the I&A program that have not yet been seriously reviewed. EPA estimates the cost of completing these two projects at $650,000.

The goal of the third project would be to recommend approaches to reduce or eliminate impediments to the use of innovative and alternative wastewater treatment technologies that communities finance through the state revolving funds program. The Chief of EPA's Municipal Technology

Branch said that EPA could take actions on the basis of this project's recommendations to address such barriers as liability, engineering fees, and restrictive codes. The recommendations would be based on an assessment of barriers to the selection of these technologies. EPA estimated the cost of this project at $500,000.

Conclusions

Alternative wastewater collection and treatment systems may cost less than conventional systems and may present some communities with affordable options for adequate wastewater treatment. Nevertheless, barriers to the full use of these systems need to be addressed if the systems are to be used as frequently as may be warranted by site conditions and cost-saving considerations.

The projects that EPA is considering funding would be a helpful start in addressing these barriers and could be initiated for a very small portion of the total investment that EPA anticipates it will be making in the development of environmental technology. Most importantly, the proposed projects would begin to address the need for credible, current performance and cost data. This is an area that EPA is well situated to address, given its past and current involvement with wastewater treatment systems.

Obstacles Hinder the Development of New Technologies

Technological advancements are needed to cut the cost of achieving environmental goals. However, many believe research and development on advanced technology to be inadequate. The private sector can be understandably hesitant to invest in developing unproven technologies, given the reluctance of many in the engineering, regulated, and regulatory communities to accept alternative technologies. Uncertainties about future regulatory requirements have discouraged long-term investments in new technologies. Federal budget constraints have also limited investments, as the curtailment of EPA's research on wastewater treatment technology has shown. Nevertheless, additional federal investment is now planned through EPA's Environmental Technology Initiative.

Development of Technology Could Reduce Future Costs of Wastewater Treatment

The market opportunities for lower-cost wastewater collection and treatment technologies are significant. EPA estimated the nation's wastewater treatment needs at $108 billion in 1992; of this sum, $95 billion is needed by medium-sized and large communities. These needs include upgrading facilities to meet current secondary or advanced treatment requirements, addressing combined sewer overflow problems, and repairing and replacing aging sewers.

Water quality professionals believe that research and development could reduce these costs. They pointed out that large-scale wastewater treatment technology has not fundamentally changed over the past several decades and speculated that new technologies could help the nation meet its wastewater treatment needs more cost-effectively. Other professionals cited a growing consensus about the merits of reducing or preventing pollution at its source rather than treating it at "the end of the pipe" and suggested that research and development investments should be concentrated in technologies for preventing rather than treating pollution. Both of these areas would appear to be fruitful to pursue because each presents a set of opportunities with market potential.

Current Levels of Research and Development Are Considered Inadequate

Although projects are currently being funded by EPA, other federal agencies,[1] equipment manufacturers, foundations, and academia, EPA and water quality organizations said that current research and development activities are inadequate to meet the future needs of both large and small communities. They also said that these efforts are not well coordinated

[1]Other federal agencies, including the National Aeronautics and Space Administration, Tennessee Valley Authority, Department of Energy, and National Science Foundation, also support a limited number of wastewater treatment research and development projects.

and, therefore, may not be targeted to meet the nation's most pressing or long-term needs.

The Director of the Water Environment Research Foundation[2]—the organization that currently conducts a large share of the research and development on wastewater treatment—noted that the foundation's annual survey of subscribers' needs identifies a yearly need of $20 million for research on wastewater treatment but that the foundation's current funding totals about $5 million annually. Although the President of the Water and Wastewater Equipment Manufacturers' Association stated that the industry spends 3 to 4 percent of about $1 billion in sales on research and development, the primary focus of these efforts is to refine existing technologies to meet customers' short-term needs rather than to pursue significant technological advancements. According to the Deputy Director of the Office of Research and Development's (ORD) Risk Reduction Engineering Laboratory in Cincinnati, Ohio, EPA's current funding levels are not adequate even to keep EPA's staff abreast of emerging technologies, much less to support or conduct basic research and development on more cost-effective wastewater treatment technologies.

Disincentives Limit Investment by Private Sector

Equipment manufacturers are understandably hesitant to make significant investments in research and development for higher-risk, cutting-edge technologies because many within the engineering, regulated, and regulatory communities are reluctant to accept new technologies. Several of the National Advisory Council for Environmental Policy and Technology's (NACEPT)[3] findings support these concerns. For example, (1) regulators and the permitting process often create barriers to the use of innovative technologies, (2) regulatory uncertainties inhibit the development of innovative environmental technologies, and (3) venture capitalists are reluctant to invest in environmental technology demonstration projects without knowing if regulators will approve or permit new technologies.[4]

[2]This foundation is funded primarily through voluntary subscriptions from publicly owned treatment plants and, to a lesser extent, corporate subscribers. It also receives about $500,000 annually from EPA. The foundation's parent organization is the Water Environment Federation—a nonprofit entity that represents a wide range of water quality professionals.

[3]NACEPT is a public advisory committee providing extramural policy information and advice to EPA.

[4]Improving Technology Diffusion for Environmental Protection: Report and Recommendations of the Technology Innovation and Economics Committee, NACEPT (Oct. 1992).

Private-sector funding for researching and developing wastewater treatment technologies is also limited by financial constraints because most of the industry's firms are small corporations that cannot sustain the long-term investments required to develop new technologies. Furthermore, manufacturers fear that if a technology they develop fails, they will be held liable, their firms' reputations will be damaged, and they will lose future business opportunities.

EPA Gives Low Priority to Wastewater Treatment Research and Development

EPA's funding for engineering research on wastewater treatment dropped considerably from the late 1970s (as discussed in ch. 3). ORD officials stated that the budget reductions reflected a change in the agency's research priorities. Nearly half of ORD's funding in fiscal year 1992 ($315 million) was directed toward multimedia efforts—primarily research on ecological effects—and nearly a third of the funding was set aside for the Air and Radiation Program. ORD also targeted pollution prevention as a high priority. As noted in ORD's April 1993 Strategic Issue Plan for Wastewater and Sludge, funding for this area would not allow EPA to conduct research on new cost-effective wastewater technologies for small communities. Also, research on new cost-effective wastewater treatment technologies for larger municipalities was not a priority.

The decline in EPA's wastewater research reflects a trend. Over the last decade, EPA's overall research and development budget has been reduced substantially. For example, in fiscal year 1983, research represented over 15 percent of EPA's total budget; in fiscal year 1994, this level has dropped to about 5 percent.

Barriers to Developing Technologies Extend Across Media Programs

The barriers to research and development discussed above have limited the development not only of wastewater treatment technologies but also of innovative technologies in other media programs, as EPA and others have noted. EPA has acknowledged these barriers within specific programs and has developed initiatives to address them within individual media programs.

For example, in response to the need for technologies to clean up hazardous waste, EPA was mandated by the Congress to establish the Superfund Innovative Technology Evaluation Program. In addition, EPA created the Technology Innovation Office to support the commercialization of innovative Superfund technologies. Similarly, as we recently reported, EPA has taken some action to address barriers to developing new technologies for treating drinking water.[5]

Initiatives Are Under Way to Address Barriers to Innovation in Technology

Rather than addressing these barriers on a program-by-program basis, EPA has received suggestions for a comprehensive, agencywide approach. For example, because the barriers to developing environmental technology cut across programs for different media, NACEPT concluded that EPA should address these barriers systematically through a comprehensive agencywide effort. Among other things, NACEPT recommended that EPA involve the providers, regulators, and users of environmental technology to help EPA (1) identify the most critical technology development needs and (2) identify and reduce the barriers to the wider use of innovative technologies. The administration's recent National Performance Review report also recommended that EPA increase private sector partnerships to accelerate the development of innovative technologies through improvements in the regulatory and statutory climate.[6]

EPA has acknowledged the need to play an expanded role in reducing these barriers and has some efforts under way. In 1992, EPA created an Innovative Technology Council to serve as an in-house advisory and advocacy group to coordinate the agency's fragmented activities for developing innovative technologies. The Council is currently drafting a strategic plan that centers on the four following objectives: (1) adapting EPA's policy, regulatory, and compliance framework to promote innovation; (2) strengthening the capacity of technology developers and users to succeed in environmental technology innovation; (3) strategically investing EPA's funds in the development and commercialization of promising new technologies; and (4) accelerating the diffusion of innovative technologies at home and abroad.

To meet these objectives, the Council has developed the five following basic operating principles for the agency to pursue: (1) maximum consultation with stakeholders; (2) coordination with federal, state, and local agencies; (3) partnership and collaboration with the private sector and academia to reduce the risk to innovators in the market for environmental technologies (through public-private partnerships, collaborative and cofunded research, and support for testing and

[5]See Drinking Water: Stronger Efforts Essential for Small Communities to Comply With Standards (GAO/RCED-94-40, Mar. 9, 1994).

[6]From Red Tape to Results: Creating A Government That Works Better and Costs Less, Report of the National Performance Review (Sept. 7, 1993).

demonstrating innovative technologies to provide credible documentation of their performance); (4) cleaner technology (focusing on reducing pollution before it is generated), not just control technology; and (5) measurement of progress in bringing innovative technologies to bear in solving the nation's pressing environmental problems.

In addition, the administration proposed the "Environmental Technology Initiative." In his State of the Union address in February 1993, the President stated that the purpose of the initiative is to develop and deploy environmental technologies to improve the quality of the environment and to enhance the economic standing of the United States in the world marketplace. The Congress responded by providing EPA with $36 million in fiscal year 1994 (with a further increase anticipated by EPA for fiscal year 1995) to fund the Environmental Technology Initiative. EPA has made its Innovative Technology Council responsible for recommending specific uses for these funds.

The Senate Appropriations Committee supported this funding, in part, out of concern that the United States may lose its ability to compete effectively in the growing international market for environmental technologies.[7] The Committee supported funding of the initiative to (1) recommend effective public and private partnership arrangements for the development of environmental technology, (2) develop approaches for the commercialization and diffusion of environmental technologies developed with federal funds, and (3) identify economic and regulatory barriers and incentives to the development, deployment, and trade in environmental technologies. However, the Senate Appropriations Committee expressed concern about EPA's plans for accomplishing these objectives and directed EPA not to expend funds on the initiative until it submits a strategy and detailed spending plan, subject to approval by the House and Senate Committees on Appropriations. Similarly, the House Appropriations Committee, concerned because EPA did not have clearly defined plans for the initiative, directed EPA to submit quarterly status reports. EPA was further directed to inform the Committee of all expenditures for the initiative.

[7]According to a 1992 Organization for Economic Cooperation and Development report, by 2000, the international market for environmental technologies is expected to approach $300 billion. The report also stated that the United States invests only 0.5 percent of its government research and development funds in environmental objectives, whereas many European nations spend four or more times this percentage.

As of September 1994, the Committees had approved all projects in EPA's spending plan for fiscal year 1994, and EPA was soliciting proposals for the initiative for fiscal year 1995.

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