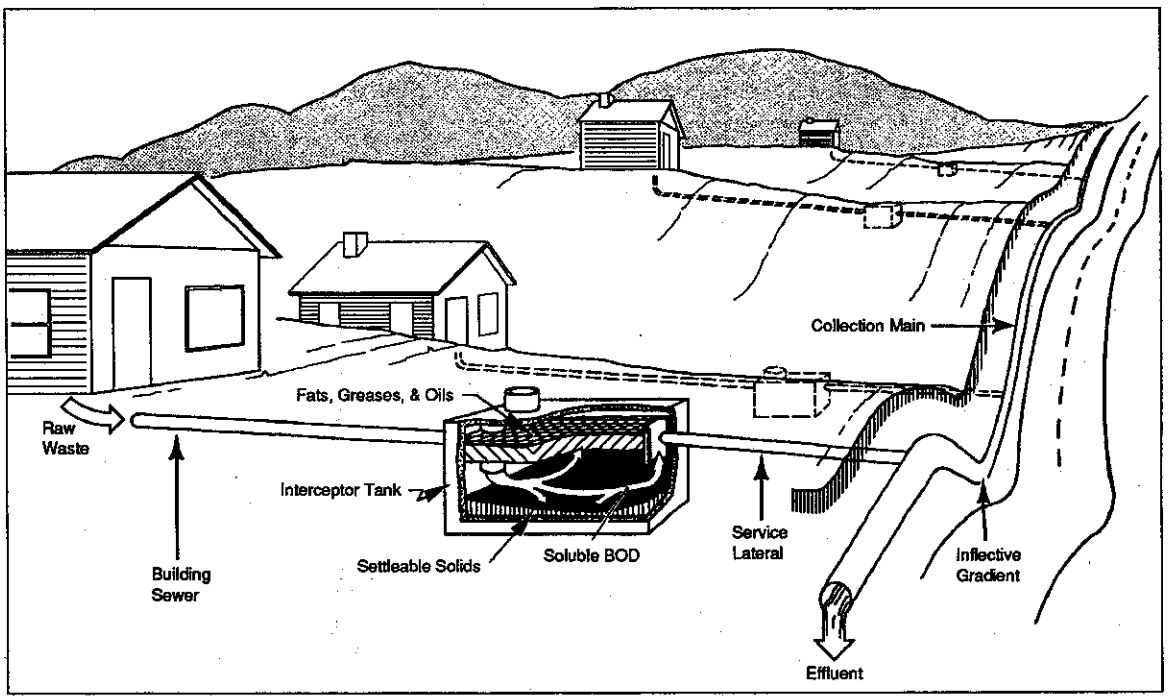
United States Environmental Protection Agency | Office of Research and Development Washington, DC 20460 | Office of International Activities Washington, DC 20460 | Office of Water Washington, DC 20460 | EPA/600/M-91/032 October 1991

EPA

Small Community Wastewater Systems



EPA Technical Information Packages

This brochure is part of a series of information packages prepared by the United States Environmental Protection Agency (EPA). Aimed at the international community, the packages focus on key environmental and public health issues being investigated by EPA. The products highlighted within these packages provide a sound technical basis for decisions regarding the development of environmental policy, abatement activities, and pollution prevention. By pooling expertise in the areas of environmental science and technology, significant progress can be anticipated to ensure a habitable environment for all nations.

Small Community Wastewater Systems discusses the scope of the wastewater problem in small communities, wastewater collection and treatment systems, as well as sludge management. Brochures and associated support material are available on the following topics:

- **Ensuring Safe Drinking Water**....EPA/600/M-91/012
- **Mining Waste Management**.....EPA/600/M-91/027
- **Pesticide Waste Disposal**.....EPA/600/M-91/028
- **Air Quality Management**.....EPA/600/M-91/029
- **Solid Waste Disposal**.....EPA/600/M-91/030
- **Hazardous Waste Management**..EPA/600/M-91/031
- **Small Community Wastewater Systems**.....EPA/600/M-91/032
- **Water Quality**.....EPA/600/M-91/033
- **Risk Assessment**.....EPA/600/M-91/034
- **Pesticide Usage Guidelines**.....EPA/600/M-91/035
- **Pollution Prevention**.....EPA/600/M-91/036
- **Environmental Impact Assessments**.....EPA/600/M-91/037
- **EPA Information Sources**.....EPA/600/M-91/038
- **Environmental Management**...EPA/600/M-91/039

Each complete Technical Information Package (TIP) consists of a cover brochure as well as all of the documents highlighted within the body of the brochure. Generally, the cover brochures contain a section discussing the environmental issue, associated health and environmental effects, guidelines, sampling and analytical methods, as well as treatment and disposal technologies. Following this section, a bibliography is provided to identify other important sources and documents in the field. An attempt has been made to provide references that are readily available in technical libraries. Finally, a number of Office of Research and Development (ORD) technical experts followed by some additional EPA resources are listed to facilitate consultation and technical assistance. Document ordering information is provided on the back inside cover.

Scope of the Wastewater Problem in Small Communities

Fully 25 percent of the homes in the United States (U.S.) are not served by centralized collection and treatment of domestic wastewater. This percentage is relatively stable, and is unlikely to drop below 20 percent since large numbers of unsewered homes still are being constructed each year. A 1975 World Health Organization (WHO) study of developing countries showed, in contrast, that 75 percent of urban dwellers were not served by sewers, and 25 percent had no disposal system of any kind. Only 15 percent of rural dwellers had adequate excreta disposal methods. In the U.S., small communities that are serviced by centralized collection and treatment (of < 1 mgd) constitute more than 80 percent of all wastewater facilities. Sixty-four percent of all treatment facilities serve fewer than 3,500 people. A complete breakdown is given in Table 1.

In terms of environmental impact, 90 percent of the rural communities of the U.S. obtain their drinking water from ground water sources, and a high percentage of these are served by septic tank-soil absorption systems (ST-SAS), which represent a health risk to the quality of that ground water.

The sewered small communities represent the dominant number (estimated well in excess of 90 percent) of non-compliance violations of the National Pollutant Discharge Elimination System (NPDES) permits. Since the majority of these systems discharge to higher quality, lower flow streams, the local impacts of these violations are often disproportionately higher than would be the case if only the population were considered on a comparative national basis.

Despite the intensive wastewater facility public works programs of the last two decades, the number of dwellings served by individual or non-sewered systems has risen steadily, e.g., from 20.2 million in 1970 to 22.6 million in 1980. With the end of the federal construction grants program, the total number of unsewered facilities is likely to increase at a rate greater than the 320,000-per-year rate of the 1970s.

The following products have been developed to maximize the efficiency of these onsite systems and to provide a basis for the optimal use/disposal of resulting residual solids from these onsite treatment devices:

- EPA 625/1-80/012 *"Design Manual: Onsite Wastewater Treatment and Disposal Systems"* - The document deals with a variety of alternative system designs to overcome site

Table 1. U.S. WASTEWATER SYSTEMS BY SIZE DISTRIBUTION

SIZE (POPULATION SERVED)	NO.	% OF TOTAL POTW	POPULATION SERVED (MILLION)	% POPULATION
UNSEWERED	*	0	69	25
<1,000	5,983	38	2	1
1,000-3,500	3,920	26	9	4
3,500-10,000	2,670	17	18	7
10,000-100,000	2,427	16	72	29
>100,000 -	446	3	80	34
NATIONAL TOTAL	15,591	100	250	100

*23 x 10^6 Septic tank/soil absorption systems

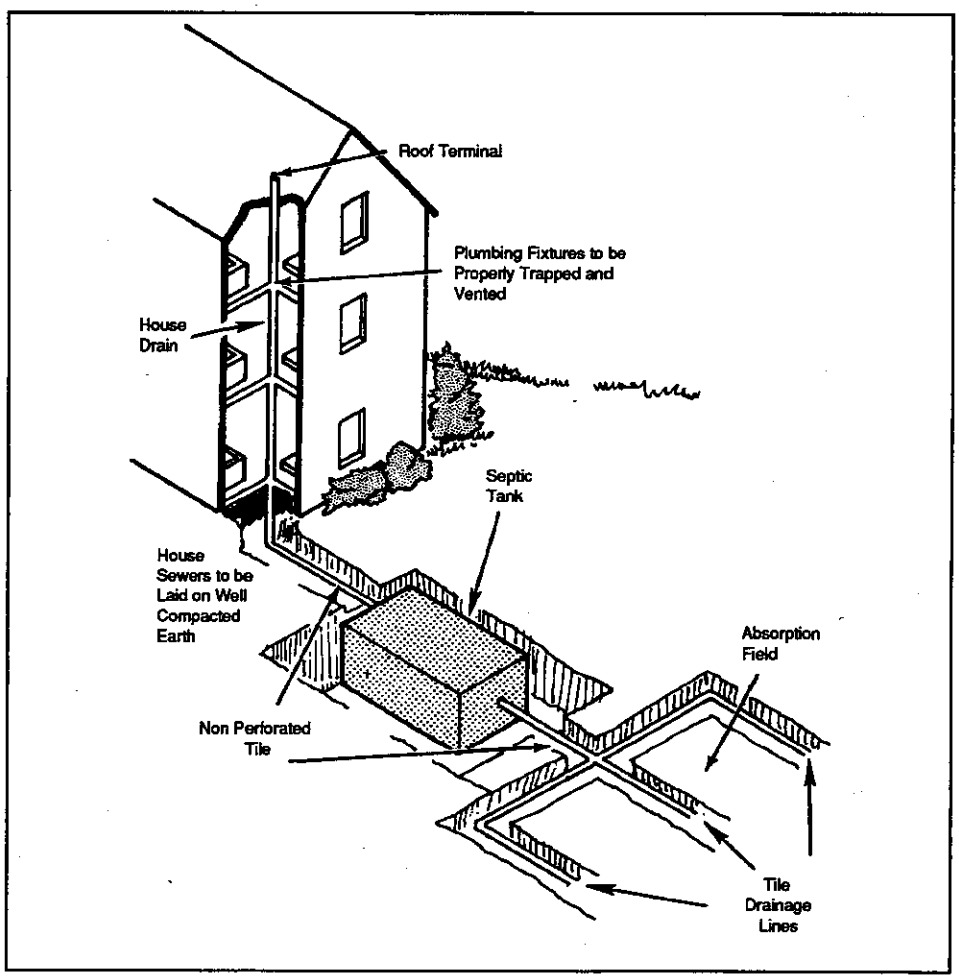


Figure 1. Typical Onsite System

limitations which preclude conventional onsite systems. It describes how to evaluate the site to choose the optimal design and management. The document also presents design and operation requirements, as well as performance and applicability criteria for dozens of alternative subsurface soil disposal and surface disposal alternatives. Detailed wastewater characterization and pollution prevention/recycle concepts are provided to facilitate optimum solutions to onsite disposal problems.

- EPA/625/6-84/009 *"Handbook: Septage Treatment and Disposal"* - This document was prepared by an international team of experts to maximize the technical information provided on each of the alternative means of treatment and disposal. A strategy of septage management options also is provided to assist localities and their engineers in choosing the most advantageous approach for each set of circumstances.

Both of these documents are being updated at this time, but both remain germane to present-day needs for assistance until the new documents are completed.

Appropriate Wastewater Collection Systems

In the late 1960s and early 1970s, a general awakening to the dilemma of wastewater facilities for small communities revealed that conventional gravity sewers constituted the

great majority of the total cost. This spurred interest in alternative collection systems that employ small-diameter, light-weight piping buried at shallow depths to serve economically the rural areas with low population densities. These alternative collection systems are classified as three types in accordance with their predominant motive force: pressure, vacuum and gravity.

Pressure sewers are subdivided into grinder-pump (GP) systems, which macerate sewage solids before pumping, and septic tank effluent pumping (STEP) systems, which use septic (interceptor) tanks to remove grit, grease and settleable solids prior to pumping. Both systems have been widely applied in North America and in several European and Asian countries. Pressure sewers have been the most popular alternative collection systems in the U.S., with more than 200 systems installed through the federal grants program in the 1980s.

Small-diameter gravity (SDG) sewers are nearly as popular as pressure sewers in the U.S., owing to their innate simplicity. These sewers use septic (interceptor) tanks to remove the problem-causing settleable and floatable materials prior to entry into the sewer. This system minimizes concerns of sewer clogging and required self-cleaning velocities, which cause costs of conventional sewers to escalate due to the deep burial and lift stations needed to satisfy these codified requirements. Small-diameter gravity sewers and similar, simplified gravity collection systems also are becoming popular in North and South America, Australia and Asia because of their reduced capital costs and operating requirements when compared with conventional sewers.

Vacuum sewers (VS) date back to the 19th century and utilize a central vacuum source that draws wastewater and air through collection pipes to the central collection point. These systems have been the least popular of the three alternatives, with fewer than 50 installations in the U.S. However, their popularity has been growing in the past few years since they can serve denser developments in rural areas and provide wastewater in a fresher condition.

The following design manual represents the culmination of more than twenty years of experience with alternative collection systems:

- EPA/625/1-91/024 *"Manual: Alternative Wastewater Collection Systems"* - This document outlines the history of non-conventional sewer systems, why and where they may be advantageous as alternatives, their design and performance histories, their operation and maintenance requirements and cost examples. The text carefully documents component features and their impact on performance, provides examples of site conditions that have been serviced effectively by these systems and deals with the myths that are commonly encountered when these systems are proposed as solutions to local problems. The manual presents in detail the materials of construction, sizing and key features of each component part of the various alternative sewer systems. The material provided illustrates the variability of operation and maintenance requirements, as well as system performance due to different design approaches, materials of construction and construction/procurement procedures.

Appropriate Small Community Wastewater Treatment Systems

Recent information from EPA's Office of Water "Needs Survey" indicates that more than 10,000 small communities are in need of some form of wastewater management assistance. The 1988 Survey indicates that more than 10,000 facilities have documented water quality or public health problems. The efforts initiated in the 1970s determined that urban technologies cannot be downsized and successfully used in small communities for a variety of reasons. Conventional gravity sewers become prohibitively expensive in rural areas, where median incomes are significantly lower than in urban/suburban areas. Operation and maintenance (O&M)-intensive treatment systems, commonly employed in urban areas, e.g., conventional activated sludge, have failed to function properly in rural areas. In fact, even the simplified activated sludge concepts, such as oxidation ditches, extended aeration, etc., have exhibited poor performance in plants processing less than 50,000 to 100,000 gallons per day (gpd). Most of these processes require a level of process expertise rarely found in available operating personnel in rural locations, and when it is attained through training and experience, it is

lost to larger cities due to concomitantly increased salaries. Therefore, the high rate of non-compliance in small community activated sludge systems is completely rational.

One advantage of small communities over urban areas is the general availability of land. Wastewater stabilization ponds are the most frequently employed (>7,000) treatment system in the U.S., which trades off simplicity of operation for land. To a lesser degree the trickling filter operation also is a larger space-intensive system, which is far easier to operate than an activated sludge system. The more than 2,000 of these processes that are in operation also verify their applicability in small- to medium-size communities.

Unfortunately, small community systems often are located on high quality streams with low flows. Therefore, many of the ponds and filters in use require upgrading to meet more stringent water quality standards. This goal should be accomplished in a manner which is low in capital cost with minimal O&M demands of the staff. Probably the most popular approach has been use of various forms of land treatment that require large land areas, but minimal operation and maintenance.

Constructed wetlands have recently come to the forefront as a treatment approach that fits a small community's needs, i.e., land intensive and operationally simple. Because of the lack of verified design criteria, these systems are not yet being constructed in an optimal fashion. The number of such systems has already reached 150, and they are being widely touted in the popular press as a panacea to small community treatment problems. These systems potentially may be ideal for small communities in cases where only conventional pollutant removal (secondary treatment) is required or in combination with other simple approaches or even other types of constructed wetlands.

Other natural or simple (less mechanical) systems that show great promise for use in small communities are several forms of intermittent sand filters and recirculating filters. These systems take advantage of additional available land and limited O&M to treat wastewaters from small communities to a more consistently high level than presently employed activated sludge systems. Also promising are some newer, highly automated treatment systems that utilize sequencing or periodic approaches to activated sludge treatment. This approach, which minimizes the need for process (mechanistic, kinetic, etc.) understanding but relies on mechanical aptitude of the O&M staff (easily found in rural settings), has been successfully employed in small European facilities.

The following documents provide detailed information on the above treatment problem assessment, upgrading concepts, and appropriate treatment alternatives:

- EPA 625/6-89/020 *"Handbook: Retrofitting POTWs"* - This document provides the engineering community with two important sets of information. The first is descriptive information on a variety of techniques for retrofitting existing treatment facilities to upgrade their performance without major capital expenditures. The second is the comprehensive performance evaluation/composite correction program technique of assessing existing facilities to determine the critical problems that prevent better performance. The handbook provides experience data and costs on low-capital-intensive treatment plant upgrading/retrofitting. It focuses on the small- to medium-sized facilities and attempts to provide maximization of existing structures through basic improvement.

- EPA 625/1-83/015 *"Design Manual: Municipal Wastewater Stabilization Ponds"* - This document is a comprehensive assessment of stabilization pond technology for small community wastewater treatment. It provides discussion of theory, design, performance, construction, upgrading alternatives, energy requirements, and capital, operation and maintenance costs to ensure that this technology is utilized in the most appropriate manner. The information has applicability for both new and existing stabilization ponds and presents cold and warm climate information, as well as a comprehensive comparison of alternative design methods. It also provides suggestions for maximizing pond performance, based on experience on numerous issues other that normal sizing criteria.

- EPA 625/1-81/013 *"Process Design Manual: Land Treatment of Municipal Wastewater"* - This document provides a comprehensive description of land treatment methods (in-

cluding rapid infiltration, overland flow and slow-rate infiltration). Energy, health and design issues are presented, along with performance and operational data. A supplement (EPA 625/1-81/013a *"Process Design Manual: Supplement for Land Treatment of Municipal Wastewater"*) provides additional data on rapid infiltration and overland flow to improve the sections in the original design manual. The wealth of data provided on climate, soil infiltration rates and various plant uptake rates can guide the engineer through the process of design. These systems require a more skillful design capability. These documents are comprehensive in nature to address the numerous features required for adequate design.

- EPA 625/1-88/022 *"Design Manual: Constructed Wetlands and Aquatic Plant Systems for Municipal Wastewater Treatment"* - This document was developed in 1988 to assemble the state-of-the-art design information on natural wastewater treatment systems. Both free-water-surface and subsurface constructed wetlands are described and assessed, since both have been used in the U.S. for small community wastewater treatment. In the aquaculture section, data on both water hyacinth and duckweed systems are provided. The information presented consolidates early worldwide experience.

Sludge Management in Small Communities

Traditionally, the sludges generated by smaller wastewater treatment facilities and onsite systems have presented difficult problems for small communities, even though the general availability of land should make these simpler to solve than sludge problems in urban areas. The most common scenario for wastewater treatment plant sludge handling is digestion by aerobic or anaerobic means, air drying on sand beds and dried solids burial in landfills or trenches. Aerobic digesters have been shown generally to be unable to meet EPA's proposed sludge regulations regarding pathogen reduction, while anaerobic digesters are costly to build and demand higher employee skill levels to operate. Operator-friendly concepts such as autothermal thermophilic aerobic digestion (ATAD) need to be implemented in the U.S. The process of sand bed drying of sludges has been seriously questioned by several states and foreign countries in recent years, and low-cost

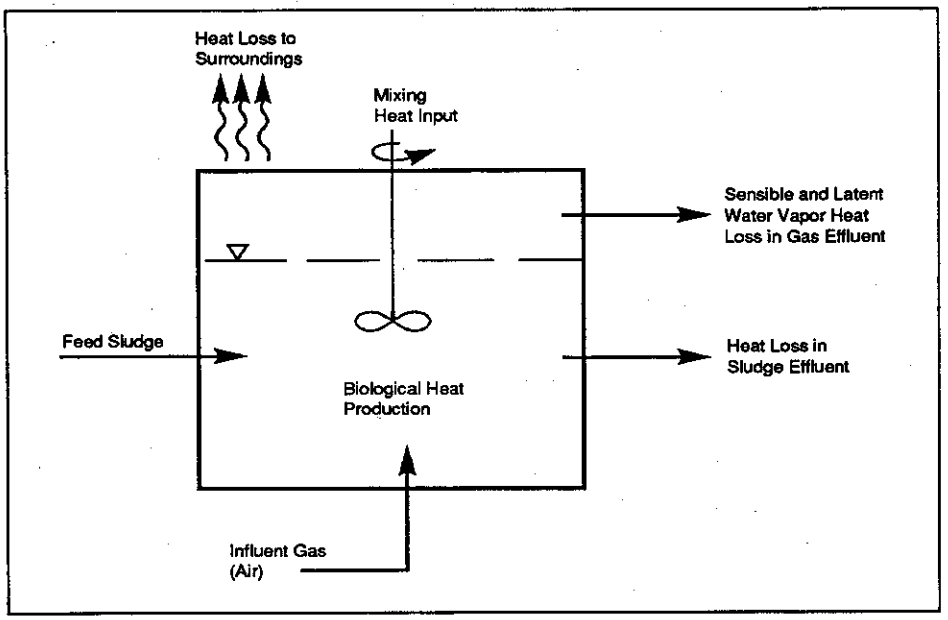


Figure 2. Heat Balance Schematic of a Thermophilic Aerobic Digester

retrofitting concepts, based on comprehensive studies of these systems, and compatible alternative technologies are needed. Landfilling of small community sludges becomes increasingly less acceptable each day. Although land spreading is now widely practiced, only 28% of the small community treatment plant sludges are presently being utilized for this form of beneficial reuse, despite the local availability of land.

The following documents provide engineering design, performance and operating and maintenance information on sludge management systems for small communities:

- EPA 625/10-89/006 *"Environmental Regulations and Technology - Control of Pathogens in Municipal Wastewater Sludge"* - This document describes the need for concern and the U.S. regulations on pathogens in sludge. It also describes the pathogen-removal capability of a variety of sludge processing steps including those incorporated in "processes to significantly reduce pathogens" and "processes to further reduce pathogens" definitions. Finally, it discusses proposed regulatory changes and provides listings of federal and state personnel who can provide assistance.

- EPA 625/10-90/007 *"Environmental Regulations and Technology - Autothermal Thermophilic Aerobic Digestion of Municipal Wastewater Sludge"* - The report summarizes the data from Europe on the Autothermal Thermophilic Aerobic Digestion (ATAD) technology. The principles, design, performance and costs of the ATAD systems are included. The variations in ATAD system design are clearly described and their relative merits are highlighted. A design example is provided, as is a comparison of ATAD system performance versus U.S. regulatory requirements for pathogen reduction and vector attraction. German criteria for agricultural use of sludge are also provided.

- EPA 625/1-87/014 *"Design Manual: Dewatering Municipal Wastewater Sludges"* - This document provides the necessary engineering data for selection of the optimum dewatering system for new installations and for upgrading existing sludge handling schemes. It emphasizes the need for proper conditioning prior to dewatering, and it provides accurate estimates of product quality and its impact on disposal schemes. Many case studies are provided for all types of dewatering discussed under the categorical designations of air drying, belt presses, centrifugation, vacuum filtration and pressure filtration. However, only a few of these are potentially viable for small communities.

- EPA 625/10-84/003 *"Environmental Regulations and Technology - Use and Disposal of Municipal Wastewater Sludge"* - This document provides a review of the various alternative methods of sludge disposal and reuse. Key information is provided to assist municipalities in choosing the optimum method of reuse/disposal. The report features flow diagrams to lead the reader through the required sludge processing steps; additionally, typical chemical and biological constituent information is presented for the various stages of sludge processing. Evaluations and case studies are provided for the following major options: land application, composting/marketing, landfilling, and incineration.

- EPA 625/1-83/016 *"Process Design Manual: Land Application of Municipal Sludge"* - This manual provides the detailed engineering data for the land application of municipal sludges. Extensive information is provided on site evaluation and planning, as well as the key information on design, monitoring and operational requirements for agricultural, forest land, and disturbed land disposal of sludges. It includes cost information, public participation concepts and other concerns of the engineer in considering this most widely applied beneficial reuse of sludge.

- EPA 600/6-90/002a *"Pathogen Risk Assessment for Land Application of Municipal Sludge: Volume I - Methodology and Computer Model and Volume II - User's Manual"* — These document describe a methodology and associated computer model for assessing the risk to humans of pathogens in treated municipal sewage sludge applied to land. Land application of sludge in this methodology refers to the distribution of sludge on or just below the

soil surface where it is employed as a fertilizer or soil conditioner for growing human food-chain and non-food-chain crops. The two categories of land application addressed in this model are (1) agricultural utilization and (2) distribution and marketing (D&M), and the source of microbial pathogens is (1) liquid or (2) dried or composted municipal sewage sludge. Volume I describes the conceptual framework of the risk assessment methodology and the structural organization, including assumptions and components, of the computer model. Volume II contains background information to provide the user with an understanding of the actual functioning of the model. This information includes descriptions of operating variables and their default values, explanations of the various subroutines, and the mathematical basis for process and transfer functions.

• EPA/600/6-88/003 "Pathogen Risk Assessment Feasibility Study" — This report evaluates the practicality of formulating guidelines to assess the risk associated with exposure to pathogens in sludge. Risk assessment may be used to determine the likelihood that an environmental agent may cause human disease (that is, potential to cause human cancer or toxicity). On the assumption that the agent causes a particular disease, given current and projected exposure levels, a quantitative evaluation can be made on the magnitude of the likely impact of the agent on public health. The feasibility of performing a microbiological risk assessment for pathogens in municipal wastewater sludge by various disposal options was also evaluated.

Active sewage treatment lagoon.

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Small Community Wastewater Expertise List

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Small Community Wastewater Collection	James Kreissl	513-569-7566
Small Community Wastewater Treatment Constructed Wetlands	Donald Brown Eric Preston	513-569-7276 503-757-4799
Filtration Systems	James Kreissl	513-569-7566
Land Treatment Systems	Carl Enfield	405-332-2210
Sequencing Batch Reactors and Biological Package Plants	James Heidman	513-569-7276
Small Community Sludge Management	Joseph Farrell James Smith	513-569-7276 513-569-7566
Ground Water Impact	James McNabb	405-332-8800
Health and Environmental Effects	Judith Olsen	513-569-7475
Sludge Risk Assessment Methodology	Norm Kowal	513-569-7475

Note: TELEX number for most of the above research staff is 989-296-(US EPA UD).

Additional Opportunities for Obtaining Technical Information

EPA WORKSHOP: Alternative Collection Systems for Small Communities

Technical management and administrative information are presented to optimize the use of alternative collection systems in rural areas. Detailed discussion of design issues vs. performance, planning concepts for optimal use, capital costs and operation and maintenance requirements will be incorporated.

The sessions are primarily aimed at planning, regulatory and engineering communities to minimize misuse and optimize proper application of alternative collection system technology. For EPA seminar/workshop information, contact: J. F. Kreissl, USEPA, CERI, G-75, Cincinnati, OH 45268. FAX: 513-569-7566.

EPA National Small Flows Clearinghouse at the University of West Virginia. This EPA-supported service maintains a small community technology bibliography service and other small community assistance activities. For additional information and assistance, call 800-624-8301 or 304-293-4191, or write to: USEPA Small Flows Clearinghouse, P.O. Box 6064, Morgantown, WV 26506.

ORD TECHNOLOGY TRANSFER NEWSLETTER

An ORD newsletter that provides a current listing of scheduled workshops, conferences, and seminars. It also announces the availability of new publications, reports, databases, and expert systems. A publication order sheet is included. To receive the Technology Transfer Newsletter, write to: CERI, Technology Transfer, U.S. Environmental Protection Agency, P.O. Box 19963, Cincinnati, OH 45219-0963.

DATABASES

ATTIC - The Alternative Treatment Technology Information Center database is an information retrieval network that provides up-to-date technical information on innovative treatment methods for hazardous wastes. It facilitates access to innovative technology demonstration studies, remediation ideas and experiences, vendor identification, and expert assistance. This on-line system contains literature search databases, treatability databases, a message center, a calendar of events, and a publication listing. Call 301-816-9153 for information or assistance.

ORD-BBS - The ORD Electronic Bulletin Board System, in addition to fostering communication among officials, researchers and the private sector, facilitates the exchange of technical information and ORD products in the form of electronic messages, brief bulletins about ORD products and activities, files for downloading, participation in conferences, and on-line databases for identifying ORD publications. For additional information and assistance in using the BBS, call 513-569-7272 or write to: CERI, U.S. Environmental Protection Agency, ORD-BBS, G-76, Cincinnati, OH 45268.

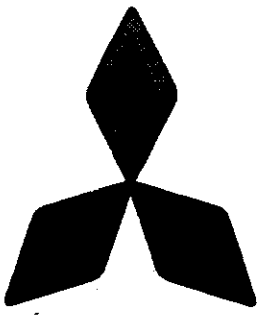
Ordering Technical Documents

The EPA documents mentioned in the Technical Information Package brochures can be ordered at no charge (while supplies are available) from the Center for Environmental Research Information (CERI). Once the CERI inventory is exhausted, clients will be directed to the National Technical Information Service (NTIS) where documents may be purchased. Orders can be placed by mail, phone, or FAX. To order documents, have the document number or the EXACT title ready. The journal articles listed in the *Additional References* section may be ordered from the U.S. National Focal Point of INFOTERRA.

CENTER FOR ENVIRONMENTAL RESEARCH INFORMATION (CERI)
U.S. EPA, P. O. BOX 19963
CINCINNATI, OH 45219-0963
513-569-7562 PHONE 989-296-(US EPA UD) TELEX
513-569-7566 FAX
NEEDED TO ORDER: EPA document number or the EXACT title.

NATIONAL TECHNICAL INFORMATION SERVICE (NTIS)
5285 PORT ROYAL ROAD
SPRINGFIELD, VA 22161
703-487-4650 PHONE
703-321-8547 FAX
NEEDED TO ORDER: EPA document number, NTIS number, or EXACT title.

INFOTERRA U.S. NATIONAL FOCAL POINT
U.S. EPA
401 M ST., S.W., PM 211A
WASHINGTON, D.C. 20460
202-260-5917 PHONE (23) 4979995 TELEX
202-260-3923 FAX
NEEDED TO ORDER: Name of journal, volume number, and page numbers.



EPA TIPs

Technical Information Packages