EPA/625/R-00/008
February 2002

Onsite Wastewater Treatment Systems Manual

Office of Water
Office of Research and Development
U.S. Environmental Protection Agency

Notice

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Foreword

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory is the Agency's center for investigation of technological and management approaches for preventing and reducing risks from pollution that threatens human health and the environment. The focus of the Laboratory's research program is on methods and their cost-effectiveness for prevention and control of pollution to air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites, sediments and ground water; prevention and control of indoor air pollution; and restoration of ecosystems. NRMRL collaborates with both public and private sector partners to foster technologies that reduce the cost of compliance and to anticipate emerging problems. NRMRL's research provides solutions to environmental problems by: developing and promoting technologies that protect and improve the environment; advancing scientific and engineering information to support regulatory and policy decisions; and providing the technical support and information transfer to ensure implementation of environmental regulations and strategies at the national, state, and community levels.

This publication has been produced as part of the Laboratory's strategic long-term research plan. It is published and made available by EPA's Office of Research and Development to assist the user community and to link researchers with their clients.

E. Timothy Oppelt, Director
National Risk Management Research Laboratory

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Acknowledgments

This update of the 1980 *Design Manual: Onsite Wastewater Treatment and Disposal Systems* (see **http://www.epa.gov/ncepihom/nepishom/tips.html**) was developed to provide supplemental and new information for wastewater treatment professionals in both the public and private sectors. This manual is not intended to replace the previous manual, but rather to further explore and discuss recent developments in treatment technologies, system design, and long-term system management.

The information in the chapters that follow is provided in response to several calls for a more focused approach to onsite wastewater treatment and onsite system management. Congress has expressed interest in the status of site-level approaches for treating wastewater, and the Executive Branch has issued directives for moving forward with improving both the application of treatment technologies and management of the systems installed.

The U.S. Environmental Protection Agency (USEPA) responded to this interest by convening a team of subject matter experts from public agencies, private organizations, professional associations, and the academic community. Two representatives from the USEPA Office of Water and a representative from the Office of Research and Development coordinated the project team for this document. Close coordination with the USEPA Office of Wastewater Management and other partners at the federal, state, and local levels helped to ensure that the information in this manual supports and complements other efforts to improve onsite wastewater management across the nation.

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Introduction

Background and Purpose

The U.S. Environmental Protection Agency (USEPA) first issued detailed guidance on the design, construction, and operation of onsite wastewater treatment systems (OWTSs) in 1980. *Design Manual: Onsite Wastewater Treatment and Disposal Systems* (USEPA, 1980) was the most comprehensive summary of onsite wastewater management since the U.S. Public Health Service had published a guidance on septic tank practice in 1967 (USPHS, 1967). The 1980 manual focused on both treatment and "disposal" of wastewater in general accordance with the approach and terminology in use at the time. The 1980 design manual stressed the importance of site-specific soil, landscape, ground water, and effluent characterization and included soil percolation tests as one of several site evaluation tools to be used in system design and placement. The manual's discussion of water conservation to reduce hydraulic flows, pollutant reduction to minimize contaminant loading, and management programs to oversee the full range of treatment activities was especially important to the developing field of onsite wastewater treatment in the United States and other countries.

Technologies explored in the 1980 manual include the conventional system (a septic tank with a subsurface wastewater infiltration system), alternating leach fields, uniform distribution systems, intermittent sand filters, aerobic units, disinfection technologies, and evapotranspiration systems. The original manual also contains guidance on dosing chambers, flow diversion methods for alternating beds, nutrient removal, and disposal of residuals. Although much of that information is still useful, advances in regional planning, improvements in ground water and surface water protection, and new technologies and management concepts necessitate further guidance for public health districts, water quality agencies, planning boards, and other audiences. In addition, the growing national emphasis on management programs that establish performance requirements rather than prescriptive codes for the design, siting, installation, operation, and maintenance of onsite systems underscores the importance of revising the manual to address these emerging issues in public health and water resource protection.

USEPA is committed to elevating the standards for onsite wastewater management practice and removing barriers that preclude widespread acceptance of onsite treatment technologies. The purpose of this update of the 1980 manual is to provide more comprehensive information on management approaches, update information on treatment technologies, and describe the benefits of performance-based approaches to system design. The management approaches suggested in this manual involve coordinating onsite system planning and management activities with land use planning and watershed protection efforts to ensure that the impacts of onsite wastewater systems are considered and controlled at the appropriate scale. The management approaches described in this manual support and are consistent with USEPA's draft *Guidelines for Management of Onsite/Decentralized Wastewater Systems* (USEPA, 2000). The incorporation of performance standards for management programs and for system design and operation can help ensure that no onsite system alternative presents an unacceptable risk to public health or water resources.

This manual contains overview information on treatment technologies, installation practices, and past performance. It does not, however, provide detailed design information and is not intended as a substitute for region- and site-specific program criteria and standards that address conditions, technologies, and practices appropriate to each individual management jurisdiction. The information in the following chapters provides an operational framework for developing and improving OWTS program structure, criteria, alternative designs, and performance requirements. The chapters describe the importance of planning to ensure that system densities are appropriate for prevailing hydrologic and geologic conditions, performance requirements to guide system design, wastewater characterization to accurately predict waste strength and flows, site evaluations that identify appropriate design and performance boundaries, technology selection to ensure that performance requirements are met, and management activities that govern installation, operation, maintenance, and remediation of failed systems.

This manual is intended to serve as a technical guidance for those involved in the design, construction, operation, maintenance, and regulation of onsite systems. It is also

intended to provide information to policy makers and regulators at the state, tribal, and local levels who are charged with responsibility for developing, administering, and enforcing wastewater treatment and management program codes. The activities and functions described herein might also be useful to other public health and natural resource protection programs. For example, properly planned, designed, installed, operated, and maintained onsite systems protect wellhead recharge areas, drinking water sources, watershed, estuaries, coastal zones, aquatic habitat, and wetlands.

Finally, this manual is intended to emphasize the need to improve cooperation and coordination among the various health, planning, zoning, development, utility, and resource protection programs operated by public and private organizations. A watershed approach to protecting public health and environmental resources requires an integrated operational framework that encourages independent partners to function cooperatively while each retains the ability to satisfy internal programmatic and management objectives. Integrating onsite wastewater management processes with other activities conducted by public and private entities can improve both the effectiveness and the efficiency of efforts to minimize the risk onsite systems might present to health and ecological resources.

Overview

Onsite wastewater treatment systems collect, treat, and release about 4 billion gallons of treated effluent per day from an estimated 26 million homes, businesses, and recreational facilities nationwide (U.S. Census Bureau, 1997). These systems, defined in this manual as those serving fewer than 20 people, include treatment units for both individual buildings and small clusters of buildings connected to a common treatment system. Recognition of the impacts of onsite systems on ground water and surface water quality (e.g., nitrate and bacteria contamination, nutrient inputs to surface waters) has increased interest in optimizing the systems' performance. Public health and environmental protection officials now acknowledge that onsite systems are not just temporary installations that will be replaced eventually by centralized sewage treatment services, but permanent approaches to treating wastewater for release and reuse in the environment. Onsite systems are recognized as potentially viable, low-cost, long-term, decentralized approaches to wastewater treatment if they are planned, designed, installed, operated, and maintained properly (USEPA, 1997). NOTE: In addition to existing state and local oversight, decentralized wastewater treatment systems that serve more than 20 people might become subject to regulation under the USEPA's Underground Injection Control Program, although EPA has proposed not to include them (64FR22971:5/7/01).

Although some onsite wastewater management programs have functioned successfully in the past, problems persist. Most current onsite regulatory programs focus on permitting and installation.

Few programs address onsite system operation and maintenance, resulting in failures that lead to un-necessary costs and risks to public health and water resources. Moreover, the lack of coordination among agencies that oversee land use planning, zoning, development, water resource protection, public health initiatives, and onsite systems causes problems that could be prevented through a more cooperative approach. Effective management of onsite systems requires rigorous planning, design, installation, operation, maintenance, monitoring, and controls.

Public health and water resource impacts

State and tribal agencies report that onsite septic systems currently constitute the third most common source of ground water contamination and that these systems have failed because of inappropriate siting or design or inadequate long-term maintenance (USEPA, 1996a). In the 1996 Clean Water Needs Survey (USEPA, 1996b), states and tribes also identified more than 500 communities as having failed septic systems that have caused public health problems. The discharge of partially treated sewage from malfunctioning onsite systems was identified as a principal or contributing source of degradation in 32 percent of all harvest-limited shellfish growing areas. Onsite wastewater treatment systems have also contributed to an overabundance of nutrients in ponds, lakes, and coastal estuaries, leading to the excessive growth of algae and other nuisance aquatic plants (USEPA, 1996b). In addition, onsite systems contribute to contamination of drinking water sources. USEPA estimates that 168,000 viral illnesses and 34,000 bacterial illnesses occur each year as a result of consumption of drinking water from systems that rely on improperly treated ground water. Malfunctioning septic systems have been identified as one potential source of ground water contamination (USEPA, 2000).

Improving treatment through performance requirements

Most onsite wastewater treatment systems are of the conventional type, consisting of a septic tank and a subsurface

wastewater infiltration system (SWIS). Site limitations and more stringent performance requirements have led to significant improvements in the design of wastewater treatment systems and how they are managed. Over the past 20 years the OWTS industry has developed many new treatment technologies that can achieve high performance levels on sites with size, soil, ground water, and landscape limitations that might preclude installing conventional systems. New technologies and improvements to existing technologies are based on defining the performance requirements of the system, characterizing wastewater flow and pollutant loads, evaluating site conditions, defining performance and design boundaries, and selecting a system design that addresses these factors.

Performance requirements can be expressed as numeric criteria (e.g., pollutant concentration or mass loading limits) or narrative criteria (e.g., no odors or visible sheen) and are based on the assimilative capacity of regional ground water or surface waters, water quality objectives, and public health goals. Wastewater flow and pollutant content help define system design and size and can be estimated by comparing the size and type of facility with measured effluent outputs from similar, existing facilities. Site evaluations integrate detailed analyses of regional hydrology, geology, and water resources with site-specific characterization of soils, slopes, structures, property lines, and other site features to further define system design requirements and determine the physical placement of system components.

Most of the alternative treatment technologies applied today treat wastes after they exit the septic tank; the tank retains settleable solids, grease, and oils and provides an environment for partial digestion of settled organic wastes. Post-tank treatment can include aerobic (with oxygen) or anaerobic (with no or low oxygen) biological treatment in suspended or fixed-film reactors, physical/chemical treatment, soil infiltration, fixed-media filtration, and/or disinfection. The application and sizing of treatment units based on these technologies are defined by performance requirements, wastewater characteristics, and site conditions.

Toward a more comprehensive approach

The principles of the 1980 onsite system design manual have withstood the test of time, but much has changed over the past 20 years. This manual incorporates much of the earlier guide but includes new information on treatment technologies, site evaluation, design boundary characterization, and especially management program functions. The manual is organized by functional topics and is intended to be a comprehensive reference. Users can proceed directly to relevant sections or review background or other information (see Contents).

Although this manual focuses on individual and small, clustered onsite systems, state and tribal governments and other management entities can use the information in it to construct a framework for managing new and existing large-capacity decentralized systems (those serving more than 20 people), subject to regulation under state or local Underground Injection Control (UIC) programs. The UIC program was established by the Safe Drinking Water Act to protect underground sources of drinking water from contamination caused by the underground injection of wastes. In most parts of the nation, the UIC program, which also deals with motor vehicle waste disposal wells, large-capacity cesspools, and storm water drainage wells, is managed by state or tribal water or waste agencies with authority delegated by USEPA.

The Class V UIC program and the Source Water Protection Program established by the 1996 amendments to the federal Safe Drinking Water Act are bringing federal and state drinking water agencies into the field of onsite wastewater treatment and management. Both programs will likely require more interagency involvement and cooperation to characterize wastewater impacts on ground water resources and to develop approaches to deal with real or potential problems. States currently have permit-by-rule provisions for large-capacity septic systems.

Overview of the revised manual

The first two chapters of this manual present overview and management information of special interest to program administrators. Chapters 3, 4, and 5 contain technical information on wastewater characterization, site evaluation and selection, and treatment technologies and how to use them in developing a system design. Those three chapters are intended primarily for engineers, soil scientists, permit writers, environmental health specialists, site evaluators, and field staff. Summaries of all the chapters appear below. The level of detail provided in this manual is adequate for preliminary system design and development of a management program. References are provided for additional research and information on how to incorporate local characteristics into an optimal onsite management program.

Overview of the Onsite Wastewater Treatment Systems Manual

Chapter 1, Background and use of onsite wastewater treatment systems	Review of the history and current use of onsite treatment systems, introduction of management concepts, and brief discussion of alternative technologies.
Chapter 2, Management and regulation of onsite wastewater treatment systems	Discussion of methods to plan, institutionalize, and manage OWTS programs, including both prescriptive and performance-based approaches. If prescriptive-based management programs are used, parts of this chapter will not apply because the basic functions of prescriptive-based management are more simplified.
Chapter 3, Establishing treatment system performance requirements	Discussion of methods for estimating wastewater flow and composition, identifying pollutants of concern and their transport and fate in the environment, establishing performance requirements, and estimating watershed-scale impacts.
Chapter 4, Treatment processes and systems	Identification of conventional and alternative OWTS technologies, pollutant removal effectiveness, design parameters, operation and maintenance requirements, costs, and special issues.
Chapter 5, Treatment system selection	Discussion of strategies for establishing site-specific performance requirements and performance boundaries based on wastewater flow and composition and site characteristics, selection of treatment alternatives, and analysis of system failure and repair or replacement alternatives.
Glossary	Definitions of terms used in the manual.
Resources	Selected reference documents and Internet resources.