



Planning Decentralized Wastewater Systems

An Online Continuing Education Course for Engineers

Course Number: EN-6003

Credit: 6 Hours / 6 PDH / 6 CPD

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Course Summary

Development of sound decentralized wastewater systems designs centers around a detailed physical site and soils evaluation, along with other critical information such as flows and waste characteristics, and applicable regulatory requirements. The results of the site evaluation, along with applicable regulatory requirements, will serve to identify limiting design parameters (LDPs) and viable system approaches that can be compared on the basis of near and long-term costs, energy consumption, operation and maintenance (management) needs, etc. Along with soil textural analyses, soil structures and other site characteristics should be evaluated for conditions such as preferential flow patterns that may impact the site's natural treatment capabilities.

All decentralized systems require some means of providing adequate primary treatment. Section 5 of the course described how minimal sizing needs can be determined, based on observed performance for these systems. If the results of a physical site evaluation reveal that required or targeted levels of treatment can't be achieved through natural soil treatment processes following primary treatment, some method(s) of further treatment will be needed prior to final effluent dispersal to soils. Section 6 described the methods of pre-dispersal treatment most commonly used for decentralized systems, including some of the benefits and limitations as related to performance.

Unlike centralized systems, for which treatment prior to discharge constitutes essentially all of the treatment system, for decentralized wastewater systems using soil-based dispersal systems, overall treatment includes both pre-dispersal and post-dispersal processes. Developing the most sound and cost-effective decentralized wastewater systems involves optimizing use of the soil/land's natural ability to attenuate pollutants, and supplementing that as needed. While in some cases regulatory requirements may limit the designer's ability to take maximum advantage of that opportunity, not doing so whenever possible can result in excessive land usage and/or systems costs. Likewise, not accounting for limitations in a soil's natural treatment capacity in designs can result in costs to water quality and public health by not providing for adequate overall treatment.

As with centralized wastewater systems, sound decentralized systems must not only be compatible with the geophysical setting and site conditions, but also with the level of management afforded by local labor and material resources for their use in the long-term. The importance of providing sufficient long-term management and care of decentralized systems cannot be overstated. Even the simplest systems, such as a septic tank and gravity fed subsurface bed or trenches, require periodic checks and long-term care. Varying levels of operation and maintenance are needed for different types of treatment and dispersal methods, and should be considered when planning designs.

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Section 1 Introduction

Decentralized, or “onsite” wastewater systems make up a large and critical portion of the world’s wastewater service. The U.S. EPA estimates that approximately 25% of U.S. households are not connected to centralized collection and treatment systems, and instead rely on onsite, or decentralized systems for their wastewater service. Those include both new installations and existing homes that may at some point need repairs or replacement.

Although the terms “onsite” and “decentralized” are sometimes used interchangeably for wastewater systems not connected to centralized collection and treatment systems, “onsite” actually refers to decentralized systems for which the final disposition of the wastewater effluent occurs on the property where the wastewater is generated. “Decentralized wastewater systems” is a broader category of systems serving either individual or multiple properties (e.g. “cluster” or “collective” systems). For clustered systems, effluent from multiple properties is collected and a common location(s) used for treatment and final effluent disposition. “Onsite systems” is therefore a subset of “decentralized systems”.

Onsite, or decentralized wastewater systems play a critical role in the world’s water services infrastructure. Centralized wastewater services aren’t available in much of the U.S. and elsewhere around the world. In areas outlying communities or larger cities having centralized wastewater service grids, it is often much less cost-effective and more environmentally disruptive to continue extending larger centralized sewer lines further into low density areas. Those larger lines must also be built prior to the construction of development that it serves, in contrast to decentralized systems that can be staged in simultaneously with residential and/or commercial building projects. Due to the higher initial capital costs often associated with expansion of centralized wastewater service grids, there are in many cases pressures to overdevelop lands in sensitive environmental settings to increase numbers of users paying for that centralized system. Decentralized wastewater systems are very compatible with less densely populated areas having lower impervious cover, and low impact development (LID) concepts in general.

Decentralized wastewater systems sometimes confront the same types of economic challenges as off-the-grid solar/photovoltaic electric systems serving single or limited numbers of dwellings or businesses. Due to lower economies-of-scale benefits, initial costs of installing decentralized systems tend to be higher as compared with systems serving larger numbers of users, given the ability to spread costs out among more users of centralized systems. However, for systems serving individual homes or business, there are no monthly user charges unless the system is managed by an outside entity, unlike centralized wastewater systems for which users are typically charged monthly service fees. Long-term net present worth analyses may therefore show decentralized wastewater systems to be more cost-effective for lower density areas around communities.

Because of typically higher initial capital investments for decentralized systems per user, it’s especially important to select overall approaches, methods and materials that will result in the least long-term costs with the longest useful service lives, while meeting water quality and public health goals and any applicable regulatory requirements.

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Recurring expenses that can add up quickly over the life of a system include routine operation and maintenance, periodic replacement or repair of components and power usage. As well as reducing long-term costs, systems that use less electric power and which generate less waste sludge needing to be hauled and treated off-site contribute to much more sustainable wastewater service approaches overall.

There are many technical publications and texts available to help engineers and planners with the conceptual planning, theory and detailed calculations associated with a wide variety of decentralized treatment systems. Examples include References 1 through 9 listed at the end of this course. Information presented here is intended provide engineers with an overview of planning considerations in the selection of the most appropriate and cost-effective decentralized wastewater system options, along with general guidance on developing designs.

Essentially all of the information presented here pertains to “domestic” wastewaters, and not to those waste streams considered to be industrial or hazardous. Industrial wastewaters are those contaminated in some way by industrial or commercial activities prior to treatment and release into the environment (or the reuse of that treated water). Examples of industrial waste flows would include waters contaminated from manufacturing processes (e.g., semiconductors), commercial food processing (e.g., meat packing facility), and other processes and activities producing non-human wastes. Hazardous wastes make up a very diverse range of materials, and can be solid, liquid, sludges or contained gases. Examples of hazardous wastes include oil-based paints and thinners, pesticides, cleaning fluids, etc.

Domestic wastewaters are human-generated sewage from homes and businesses. They are wastes produced from sanitary facilities serving residences, cities, mobile home parks, subdivisions, restaurants, rest homes, resorts, etc. Systems handling that category of waste, and which use some method of soil/land-based final disposition of effluent, are the focus of this course.

Current Decentralized Wastewater Industry in the US

In recent decades, and following passage of the Clean Water Act in 1972, greater funding has tended to be directed toward wastewater treatment plant upgrades and scientific investigations associated with larger centralized systems, as compared with smaller decentralized systems. However, the U.S. EPA has begun to focus greater attention on decentralized and smaller scale systems, recognizing their role and importance for achieving sustainable and cost-effective wastewater service. In a January 2005 EPA document (EPA 832-R-05-002) entitled “Decentralized Wastewater Treatment Systems: A Program Strategy”, EPA stated that their vision was that “Decentralized wastewater treatment systems are appropriately managed, perform effectively, protect human health and the environment, and are a key component of our nation’s wastewater infrastructure”. EPA followed by stating it was their mission to “provide national direction and support to improve the performance of decentralized systems by promoting the concept of continuous management and facilitating upgraded professional standards of practice.”

As with the history of so many technical industries, the development of practices, materials and processes used for decentralized and small scale onsite systems has gone through many changes during the past few decades. Prior to the second half of the 20th

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century, the vast majority of systems consisted of very basic approaches that relied less on science and more on successes or failures with “out of sight out of mind” practices. Many such systems and practices still exist today, and especially in developing countries. As more research and development has occurred with onsite systems’ methods, materials and technologies since the 1970’s, accepted practices have changed dramatically in most U.S. states. As more data and observations have been reported on the performance of systems using those various technologies, the industry has continued to change.

Regulatory compliance programs responsible for permitting domestic wastewater treatment systems may vary significantly from state to state. The EPA’s National Pollutant Discharge Elimination System (NPDES) permit program regulates “point source” discharges of pollutants into waters of the United States. Point sources include discharges from pipes or man-made ditches, such as outfalls from centralized municipal wastewater treatment plants discharging to lakes or rivers. The EPA has delegated the authority to administer the NPDES program to most states and territories. The details of how the NPDES permit program is administered may vary however from state to state. For example: Some states currently require entities employing surface irrigation of treated effluent to obtain the state’s equivalent of an NPDES permit (e.g. Maryland), while other states do not (e.g. Texas, which issues land application permits to clustered or larger surface or subsurface soil application systems).

In contrast, individual homes and businesses relying on decentralized wastewater systems using subsurface application of effluent are typically not permitted under the EPA’s NPDES program, with states responsible for developing and implementing design criteria and regulatory requirements for these systems. The EPA has published design and planning recommendations, and voluntary guidelines for the management of onsite/decentralized systems, but those are not mandated as with the NPDES program (See Reference 17).

All wastewater effluent applied to the soil / land must be pre-treated to certain minimal standards prior to surface or subsurface dispersal. For subsurface soil dispersal systems, and depending on state/local regulatory requirements and applicable geophysical conditions where a project is located, pre-dispersal treatment may consist only of “primary” treatment via a septic tank. In other cases it may be necessary to provide higher levels of treatment prior to surface or subsurface soil / land dispersal of effluent. State and local permitting authorities vary for these types of requirements, and should always be referred to when planning projects.

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Section 2

Planning Decentralized Wastewater Systems Projects

Criteria used for selecting the most cost-effective and appropriate wastewater system to serve residences or businesses have long included such factors as initial capital costs and water quality protection. However, there is increasing attention placed on long-term impacts and more “hidden” costs related to sustainability. Energy consumption and reliability of power supplies are increasingly important factors in assessing long-term costs and sustainability. “Residuals” such as energy for lift station pumping and hauling for decentralized systems are also important. Long-term maintenance costs should be considered. The most cost-effective system should be selected based on these factors.

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Preliminary/conceptual planning;

In this earliest phase of the planning, site and soils evaluations are conducted; design flows are determined based on available data or guidelines; applicable rules and requirements are identified; viable alternatives are identified and evaluated, including pre-dispersal treatment needs based on limiting design parameter (LDP) principles discussed in the following section; preferred options are selected based on the project needs and goals (including sustainability considerations), and site conditions; conceptual