Chapter 4

Management of Onsite Wastewater Treatment Systems

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Introduction and Purpose

Onsite wastewater treatment systems are a significant issue for water quality management planning in Butler, Clermont, Hamilton and Warren counties. Individually, onsite systems prevent raw sewage discharges and increase property values without large-scale infrastructure. Cumulatively, they can degrade water quality, especially in areas where natural conditions are prohibitive to their effective operation, vigilance is lacking, or development density intensifies unabated. For onsite wastewater treatment systems to be effective, they must be maintained and inspected, and sometimes upgraded or replaced. The purpose of this chapter is to summarize onsite system impacts, management, regulation and alternatives. Potential onsite problem areas in Butler, Clermont, Hamilton, and Warren counties are discussed in text and shown on maps. The chapter ends with recommendations, by others and by OKI.

A clarification of terms is useful here. In this text, the term *onsite wastewater treatment system* is synonymous with *household sewage treatment system*, which has the following definition in the Ohio Revised Code (Chapter 3718.01): "any sewage treatment system or part of such a system that receives sewage from a single-family, two-family or three-family dwelling." State health officials consider treatment preferable to mere disposal.) In this text, o*nsite wastewater treatment system* refers most frequently to a septic tank-leach field system. The term *septic tank* is defined by Section 3701 of the Ohio Sanitary Code as "means a water-tight, covered receptacle for treatment of sewage that receives the discharge of sewage from a building, separates settling and floating solids from the liquid, digests organic matter by anaerobic bacterial action, stores digested solids through a period of detention, allows clarified liquids to discharge for additional treatment and final dispersal, and attenuates flows.."

Beyond the legal definitions, onsite wastewater treatment system typically refers to an underground settling tank and leach field that serve a single property parcel or subdivision lot. A broader, more descriptive definition is offered by the California Planning Roundtable, which defines a *septic system* as "a sewage-treatment system that includes a settling tank through which liquid sewage flows and in which solid sewage settles and is decomposed by bacteria in the absence of oxygen. Septic systems are often used for individual home waste disposal where an urban sewer system is not available. (*A Planners Dictionary*, American Planning Association, 2004) The U.S. EPA definition of an onsite system is more process-oriented, saying they "treat wastewater from household plumbing fixtures (toilet, shower, laundry, etc.) through both natural and technological processes, typically beginning with solids settling in a septic tank, and ending with wastewater treatment in the soil via the drain field." (*Septic Systems Overview*, U.S. EPA, 2019)

The Toledo Metropolitan Area Council of Governments (TMACOG) aptly describes the proper use of onsite systems: "On-site sewage treatment includes the treatment and disposal of sewage on the same property as a household or commercial structure, rather than at a centralized (off-site) treatment plant. On-site treatment uses individual sewage treatment systems (STS); these systems should provide adequate and cost-effective removal of pollutants and pathogens from wastewater before sewage effluent enters ground or surface waters. On-site sewage treatment should do this in a way that avoids odor and other nuisance conditions"

In areas with low density development, the use of onsite wastewater treatment systems is both appropriate and efficient— appropriate because centralized sewage service is typically unavailable in sparsely developed areas, and efficient because onsite systems are less expensive than the costly infrastructure expenditures and tap-in fees associated with sewer line extensions to places with fewer customers per mile. Provided they are properly located, designed, installed, operated and maintained, onsite wastewater treatment systems are preferable to the simpler alternatives, which are cesspools, privies (i.e., outhouses), drywells, straight pipe discharges, or other rudimentary means of sewage disposal with little or no treatment.

Butler, Clermont, Hamilton and Warren counties all have low-density development areas that use onsite systems. In 1978, OKI calculated that about 19 percent of the population in the entire OKI region used onsite systems. (*On-Site Wastewater Treatment Systems*, OKI, 1978). In the late 1980s, OKI compiled a series of reports mapping concentrations of septic tanks in Butler, Clermont, Hamilton and Warren counties. The numbers and concentrations of onsite systems remain significant in all four counties, but progress has been achieved. The 1977 *Regional Water Quality Management Plan* named Morrow, Loveland, Milford and New Miami as communities that "are fairly concentrated with septic tanks." Centralized sewage service has since been provided to all four municipalities. In the meantime, however, additional onsite system concentrations have arisen elsewhere in all four counties.

In 2018 and 2019 OKI completed a prioritization analysis for Clermont, Hamilton, and Butler Counties in an effort to identify concentrations of onsite systems most likely to contribute to water quality impairments. OKI will be completing this analysis for Warren County in 2020-21. OKI consulted with each county's health department throughout the process. Maps showing the results of this analysis can be found at the end of the chapter.

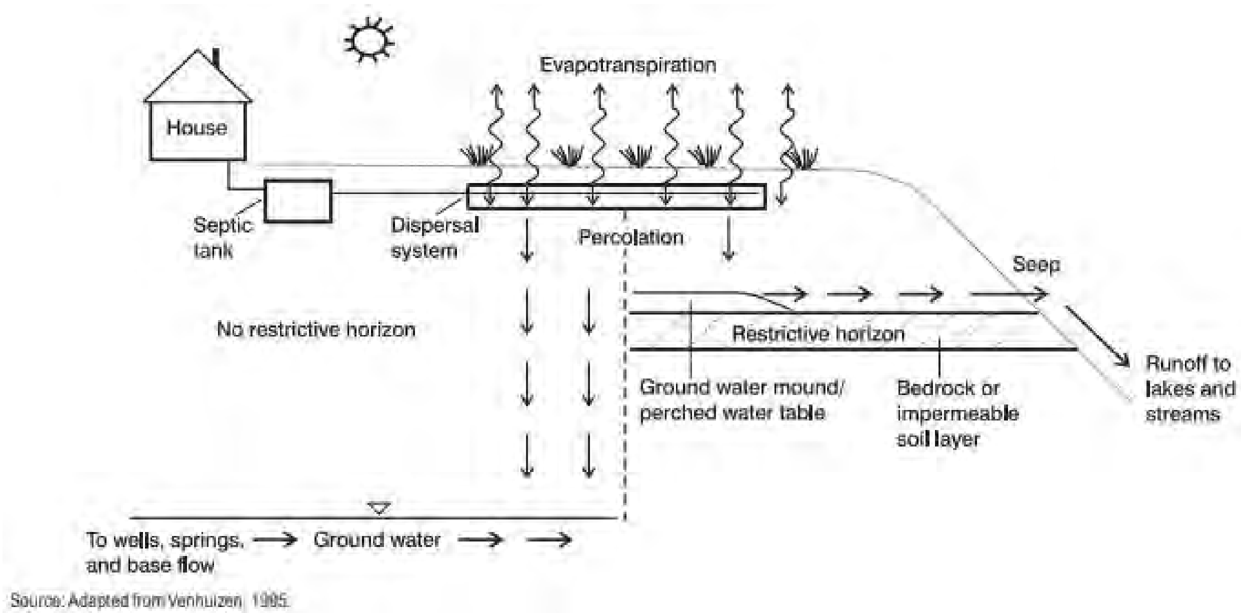
The cumulative effect of many onsite systems in a relatively small area has gained statewide attention. In its *Report to the Household Sewage and Small Flow Onsite Sewage Treatment System Study Commission* (January 1, 2008), the Ohio Department of Health wrote: "The most commonly identified impact from failing systems in Ohio has been contamination of surface water, particularly in areas with large numbers of discharging sewage systems. Several counties, including Hamilton, Cuyahoga and Trumbull have experienced widespread contamination, and subsequent enforcement actions resulting in millions of dollars spent on extending public sewers to many areas or direct replacements of failing systems."

The Ohio EPA more recently reported how onsite systems contaminate ground water. In the *2018 Ohio Integrated Water Quality Monitoring and Assessment Report*, the Ohio EPA stated: More than 1,000,000 household wastewater systems, primarily septic tanks and leach fields, or in some cases injection wells, are present throughout the rural and unsewered suburban areas of Ohio. A number of these systems are improperly located, poorly constructed or inadequately maintained and may cause bacterial and chemical contamination of ground water which may supply water to nearby wells. Improperly operated and maintained septic systems are considered significant contributors to elevated nitrate levels in ground water in vulnerable geologic settings (for example, shallow fractured bedrock and sand and gravel deposits).

As noted by the Ohio Department of Health (ODH), "Very porous sand and gravel deposits can allow the rapid transport of sewage into the groundwater aquifer." (*2008 report to the Household Sewage and Small Flow Onsite Sewage Treatment System Study Commission*). Sand and gravel deposits are the major components of the buried valley aquifers found to a great extent in Butler, Hamilton and Warren counties, and to a lesser but still significant extent in Clermont County.

Figure 4-1 below shows how onsite system discharges will eventually reach either surface water or groundwater. The drawing originates from the *Onsite Wastewater Treatment Systems Manual* (U.S. EPA, 2002).

Figure 4-1: The Fate of Wastewater Discharged into Septic Systems



As indicated by the figure above, onsite effluents have many pathways. The ODH's commission report stated, "Contamination from sewage systems has occurred through the direct discharge into ditches, farm tiles, collector tiles, streams, rivers and lakes. Where shallow perched or seasonal water is present in the soil, sewage effluent moves downward until the limiting zone or condition is reached, it then travels horizontally and may reach ditches or streams. In areas where sewage systems are installed in shallow perched seasonal water tables, sewage can also be captured by curtain or perimeter drains and transported to nearby ditches and streams. Failing discharging sewage systems have impacted or impaired the recreational uses of water in Ohio, including wading, swimming, fishing and boating."

ODH's Bureau of Environmental Health described the dual threat from onsite systems as such: "Improperly designed systems in very permeable soils allow both pathogens and nutrients to enter our ground water. Improperly designed systems in shallow soils, very slowly permeable soils and saturated soils threaten our surface waters and in many cases create public health nuisance conditions." (*Sewage Treatment Systems: Ohio's Decentralized Wastewater Infrastructure*, ODH fact sheet, 2007)

Surface water pollution by inadequately treated onsite system effluents can occur by three routes: (1) direct discharge, (2) surface ponding accompanied by runoff, and (3) movement over an impervious layer until reaching surface waters. (*Assessment of Onsite Wastewater Treatment Systems in Clermont County, Ohio*, OKI, 1987) Groundwater pollution by onsite effluents also has several pathways. In the OKI region, the predominant soils are fine textured, with coarse soils generally occurring only in or near floodplains. As a result, most groundwater contamination occurs by overland flow to an inadequately protected well. In isolated places, onsite contaminants degrade the groundwater by entry through a high groundwater table. Next to lakes and streams, where pervious sandy soils and high groundwater table both exist, problems of nitrate infusion have been detected. (*Assessment of Onsite Wastewater Treatment Systems in Clermont County, Ohio*, OKI, 1987)

Very permeable is a fair description of conditions overlying parts of the buried valley aquifers in the OKI region but most of the four-county study area, especially Clermont County, faces the opposite challenge. The general soils of Butler, Clermont, Hamilton and Warren counties are relatively impervious and thus do not provide an ideal condition to sustain onsite sewage treatment. Along with the poor soil permeability, several other factors cause problems with this method of sewage disposal. These include prolonged soil saturation, improperly designed or installed systems, excessive sewage loadings, improper maintenance, reduction of bacterial action by chemical wastes, and clogging of absorption fields. These conditions can contribute to serious water pollution.

Where onsite system problems cause environmental degradation and public health nuisances, they also lead to economic woes. Parts of the four-county study area have experienced what the ODH said about Ohio neighborhoods with failing onsite systems: "Property values and resale potential for all homes in these areas can drop to a level where residents may be unable to sell their homes or may not achieve the expected equity gains if they do sell their homes… Resale of homes in areas with (onsite systems) should not be a risky venture for buyers, sellers, lenders and realtors." (*Sewage Treatment Systems: Ohio's Decentralized Wastewater Infrastructure*, ODH fact sheet, 2007)

Water Quality Impacts of Onsite Wastewater Treatment Systems

The factors determining the impacts of onsite systems on water quality are complex and interrelated. These factors include:

- potential for malfunction related to improper design, age, operation and maintenance
- number and density of onsite systems
- distribution in relation to surface drainage ways or underlying sand and gravel aquifers
- soil limitations

Although this chapter distinguishes surface water from groundwater, it is worth noting that they are hydrologically connected. Each influences the other.

OKI is most concerned about three types of pollutants from failing onsite systems: nitrates, phosphorus and pathogens. Here are the reasons why.

Nitrates

In its *2018 Integrated Report*, the Ohio EPA identified nitrates from septic tanks as a major source of groundwater contamination statewide. The Ohio EPA's 2018 Watershed Assessment Unit (WAU) summaries indicated that nutrients (including nitrates) were a cause of surface water impairments in 32 of the 80 subwatersheds in Butler, Clermont, Hamilton and Warren counties. The WAU summaries also identified onsite wastewater systems as the source of surface water impairments in 9 subwatersheds of Clermont and Warren counties. These findings show that onsite systems contribute to nitrate contamination of both the groundwater and surface water in the four-county study area.

Nitrate (NO_3) is a chemical compound of nitrogen and oxygen. It is the most common form for nitrogen found in groundwater. Although low levels of nitrates occur naturally in groundwater, monitoring occasionally finds higher levels that are potentially dangerous to infants. The U.S. EPA and Ohio EPA use a standard of 10 milligrams per liter (mg/l or parts per million) as the maximum concentration of nitrate, expressed as total nitrogen, that is allowed in the water delivered by a public water system. This mandatory standard is a reliable guide for private wells, which are more prevalent in areas that depend upon onsite systems.

Since 1945, health officials have known that high nitrate levels in drinking water pose a risk to infants because the nitrates may cause methemoglobinemia, or "blue baby" syndrome. The conversion of nitrate to nitrite in the blood changes hemoglobin to methemoglobin and reduces the blood's capability to carry oxygen to the tissues. Adults can consume large quantities of nitrates in drinking water or food with no obvious ill effects. The adults' stomachs contain strong acids and do not promote the growth of bacteria that convert nitrate to the more toxic nitrite. Infants under six months of age, however, are most susceptible because their stomach juices are less acidic, allowing the growth of nitrate reducing bacteria. (*Fact Sheet, Nitrates in Drinking Water*, Indiana Department of Environmental Management, undated).

Nitrogen is one of the three nutrients essential to plant growth. The other two are potassium and phosphorus. "Nitrogen and phosphorus support the growth of algae and aquatic plants, which provide food and habitat for fish, shellfish and smaller organisms that live in water… Too much nitrogen and phosphorus in the water causes algae to grow faster than ecosystems can handle. Significant increases in algae harm water quality, food resources and habitats, and decrease the oxygen that fish and other aquatic life need to survive… Some algal blooms are harmful to humans because they produce elevated toxins and bacterial growth that can make people sick if they come into contact with polluted water, consume tainted fish or shellfish, or drink contaminated water." (*Nutrient Pollution*, US EPA 2019) Algal blooms can cause large 24-hour variations in dissolved oxygen concentrations, which consequently can eliminate susceptible fish species. (*Nitrogen and Phosphorus in Streams of the Great Miami River Basin, Ohio, 1998-2000*, U.S. Geological Survey, 2002) Along with phosphorus, excess nitrogen causes eutrophication, a condition where dramatic increases in aquatic plant growth are followed by death, decay, oxygen depletion, and changes in the types of plants and animals that live in the water body.

High nitrite concentrations can deplete dissolved oxygen. At concentrations above 10 mg/l, nitrites are toxic to warm blooded animals. Failing septic systems are a significant source of nitrogen, along with wastewater treatment plants, combined sewer overflows, sanitary sewer overflows, runoff from fertilized lawns and cropland, runoff from animal manure storage areas, and industrial discharges that contain corrosion inhibitors. Where ducks and geese are plentiful, their excrement can elevate nitrogen levels in surface waters. (*Stormwater Monitoring: Pollutants, Sources, and Solutions*, Richland County Stormwater Management Division, 2020)

Incompletely treated sewage contains high levels of nitrates, which are highly soluble and easily contaminate groundwater. A failed septic system can contaminate a nearby well. Septic discharges to streams endanger downstream drinking water supplies. The Ohio EPA considers improperly operated and maintained septic systems to be "significant contributors to elevated nitrate levels in groundwater in vulnerable geologic settings." (*2018 Integrated Report*, Division of Surface Water)

The American Planning Association (APA) states, "Nitrogen is extremely difficult to treat. Nitrogen contamination from decentralized sewage disposal poses the biggest risk to human health where drinking water supplies are drawn from aquifers located in areas with high concentrations of sewage disposal systems." (*Planning Issues for On-Site and Decentralized Wastewater Treatment,* 2006). According to the APA report, conventional onsite systems "provide little treatment" of nitrogen, removing only 10 to 20 percent of the contaminant in 3 to 5 feet of soil above groundwater.

Phosphorus

As one of the three nutrients to aquatic plant growth, phosphorus can have much the same effect on surface water quality that nitrogen does. High phosphate levels may cause fish kills and onsite systems are a significant source of phosphorus. Phosphorus cycles through the environment, changing form as it does. In aquatic systems, phosphorus occurs in organic and inorganic forms. Aquatic plants require inorganic phosphorus. They convert it to organic phosphorus, which animals need.

In most waters, phosphorus is an aquatic plant growth-limiting factor. It is usually present in very low concentrations because it quickly binds with organic matter and soil particles. Because it is the nutrient in shortest supply, even a small increase in phosphorus can set off a chain of undesirable events, including accelerated plant growth, algae blooms, low dissolved oxygen, and the death of certain fish, invertebrates and other aquatic animals. Failing septic systems are a significant source of phosphorus, along with runoff from fertilized lawns and cropland, runoff from animal waste storage areas, disturbed land areas, drained wetlands, water treatment plants, commercial cleaning operations, and home or car cleaning. Many detergents and cleaning products contain phosphates because they bind with dirt. In small wading streams with low flows, total phosphorus levels in excess of 30 to 60 micrograms per liter (µgl or parts per billion) can also cause algal blooms and other problems. (*Saturday Stream Snapshot Parameter Background Information*, Greenacres Foundation, 2003)

The Hamilton County Soil and Water Conservation District has found adequate phosphorus in many soils of the region, meaning that additional phosphorus from septic discharges has run off or leached out excess nutrients into the region's water resources.

Pathogens

Incompletely treated sewage is a potential source of disease-carrying organisms, and until the late nineteenth century was a common cause of illness in this country. Sewage contains four types of pathogenic organisms that infect people (*208 Plan*, TMACOG, 2019):

1. bacteria − With so many species, bacteria comprise a large group of single-celled organisms. The vast majority are harmless and many are beneficial to humans or the environment. A few species, however, cause diseases with gastrointestinal symptoms, such as diarrhea, cramps, nausea and vomiting.

2. viruses − smaller than bacteria, viruses are only able to multiply inside living cells, plant or animal. Symptoms from waterborne viruses range from minor stomach flu problems to fatal liver conditions. Hundreds of different viruses can affect humans, primarily spreading through contact with feces and urine that has entered the environment. Common waterborne viruses can multiply in the human intestines before excretion through feces. Viruses can be asymptomatic or lead to a number of illnesses such as gastroenteritis, meningitis, respiratory disease, conjunctivitis, myocarditis or hepatitis. Microbiologist Terrence McSweeney has suggested that viruses account for at least 35 percent of all waterborne outbreaks of disease where the pathogen could not be identified. (*Microbial Contaminants: What are pathogens and where do they occur?)*, (*Global Water Pathogen Project*, 2017)

3. protozoa − Though usually single-celled, protozoa are more complex in structure and life cycle than bacteria or viruses. Once inside the human intestine, they are able to multiply and continue spreading through bodily fluids. *Cryptosporidium* and *Giardia* are both protozoic parasites that produce hard-shelled cysts to protect them while they are in the environment, outside their human or animal hosts. This makes them harder to eliminate by disinfection. Symptoms from infection include diarrhea, severe dehydration, weight loss and fatigue. *Giarida* symptoms can persist for months, or even longer. *Cryptosporidium* symptoms can be controlled in a shorter time however both are leading causes of waterborne diseases among humans. (*Parasites,* Center for Disease Control and Prevention 2019)

4. worms − Parasitic worms can be propagated by inadequately treated sewage. Transmission occurs most commonly upon the ingestion of contaminated foods. Common species that afflict humans are round worms, hook worms, and whip worms . (*Intestinal Worms,* World Health Organization, 2005)

Sewage pathogens cause many human illnesses, including typhoid fever, gastroenteritis, cholera, dysentery, infectious hepatitis, asceptic meningitis and encephalitis. The pathogens are often transmitted by direct contact with sewage, but the public health risk is even greater by transmission through contaminated drinking water. Surfacing sewage or pooled effluent from onsite systems can be an ideal breeding place for mosquitoes, including those known to carry West Nile virus. (*Sewage Treatment Systems: Ohio's Decentralized Wastewater Infrastructure*, ODH fact sheet, 2007)

Water quality monitoring for the presence of sewage pathogens usually analyzes samples for the presence of fecal coliform or *Escherichia coli* (*E. coli*) bacteria. Fecal coliform are indicator bacteria. They alone generally do not cause diseases, but are present in feces in large quantities, and are therefore easy to detect. *E. coli* is a specific species of bacterium that lives in the intestinal tract of warm-blooded animals. Fecal coliform had been the most common standard for detecting sewage bacterial contamination, but Ohio EPA has used *E. coli* as the standard for many years.

E. coli standards range from 126 to 206 colonies per 100 mL for primary contact recreation waters. For shallow, or secondary contact waters, the standard is 1,030 colonies per 100 mL.. The *E. coli* standards are not triggered by single sampling events, but are based on seasonal geometric means. The U.S. EPA recommends that the analysis of nutrients such as nitrogen and phosphorus should also be based on longer term averages. It gives this explanation on a website titled *Frequently Asked Questions about Nutrient Criteria*: "Nutrients, unlike toxics, typically manifest their effects over an extended period of time, like a growing season or flow year. . . . EPA would not consider a single sample representative of the longer-term conditions that nutrient criteria are designed to reflect and protect."

Certain bacteria are needed to decompose the sewage into a sludge that settles to the bottom of the tank and a partially treated effluent that typically flows to a leach field. Most problems arise when undesirable pathogens escape from the septic tank to the surrounding environment at excessive levels.

The survival of onsite sewage pathogens in the environment varies greatly with the species of pathogen, the saturation level of water, and the presence of food in the form of organic carbon. In Chapter 3 of their *Onsite Wastewater Treatment Systems Manual,* the U.S. EPA rated pathogen survival times in different media, as shown by Table 4-2 below.

Table 4-2: Typical Pathogen Survival Times (U.S. EPA, 2002)

Pathogen	Typical survival time in fresh water & sewage	Typical survival time in unsaturated soils
Viruses		
Enteroviruses	< 120 days, but usually < 50 days	< 100 days, but usually < 20
Bacteria		
Fecal coliforms	< 60 days, but usually < 30 days	< 70 days, but usually < 20 days
Salmonella species	< 60 days, but usually < 30 days	< 70 days, but usually < 20 days
Shigella species	< 30 days, but usually < 10 days	
Protozoa		
Entamoeba histolytica cysts	< 30 days, but usually < 15 days	< 20 days, but usually < 10 days
Helminths (worms)		
Ascaris lumbricoides eggs	many months	many months

The Ohio EPA considers septic systems to be major sources of not only nitrates and pathogens, but also of metals. (*2018 Integrated Report,* Division of Surface Water).

With acknowledgment to the U.S. EPA, the American Planning Association also identifies onsite systems as a source of pollution by metals. In its 2006 advisory report titled *Planning Issues for On-Site and Decentralized Wastewater Treatment*, the APA show "heavy metals" to be one of eight major types of pollutants found in onsite system sewage. Table 4-3 below describes the eight major pollutant types in relation to treatment. It is based on a table in the APA's advisory report.

Table 4-3: Onsite System Effectiveness with Major Types of Pollutants

Pollutant	Description	Decentralized sewage treatment performance	Pollutant removal for conventional systems with 3-5 feet above groundwater
pathogens	Disease causing microorganisms (viruses, bacteria, protozoa and Helminth worms)	Good decentralized systems provide excellent treatment. Some viruses and parasites can survive very long periods.	99.9% removal
nitrogen	Nutrient creates eutrophication in surface waters. High concentrations cause "blue baby" syndrome.	Conventional decentralized systems provide little treatment. Some alternative systems provide good treatment.	10-20% removal
phosphorus	Nutrient creates eutrophication in surface waters. It is typically the limiting factor in fresh water systems.	Good decentralized systems provide excellent treatment.	0-100% removal
biochemical oxygen demand (BOD)	Amount of oxygen depleted from receiving waters to treat waste.	Good decentralized systems provide excellent treatment.	more than 90% removal
total suspended solids (TSS) and turbidity	Solids floating in the water column and their ability to block light (turbidity). Associated nutrients, BOD and lack of light harm the natural biota.	Good decentralized systems provide excellent treatment.	more than 90% removal
volatile organic compounds, hazardous waste, household medicines	Hundreds of natural and manmade pollutants discharged into an onsite system. Cause damage to human and natural biota health.	For some contaminants, often very little treatment is provided. Some pollutants can damage natural biota that are critical for traditional sewage treatment.	more than 99% removal
heavy metals (e.g., lead, copper)	Pollutants discharged into discharged into onsite systems. Cause damage to human and natural biota health.	For some contaminants, often very little treatment is provided. Some pollutants can damage natural biota that are critical for traditional sewage treatment.	more than 99% removal
organic precursors of disinfection byproducts	Organic matter that, when combined with chlorine in public water supplies, can form suspected carcinogens. Related to nitrogen, phosphorus, BOD and TSS.	Good decentralized systems provide excellent treatment.	more than 99% removal

Onsite System Management

Successful management of onsite wastewater treatment systems relies on wise choices among a series of environmental, mechanical and behavioral variables. The type of onsite system is a crucial choice, and varies from place to place. Here are nine major components of sewage treatment systems as described by the Ohio Department of Health's article, *STS Components, Systems and Maintenance* (2019)

Septic Tanks:

Basic Design:
Septic tanks are the most common first step in a wastewater treatment system to homeowners who are not on sanitary sewer. The tanks are manufactured from precast concrete, polyethylene plastic, or fiberglass. The septic tank provides some treatment of the effluent from the house by allowing for the settling of solid materials, and separation of scum, fats and greases. The partially clarified liquid, or effluent, is then drained by gravity to a secondary treatment that can be a variety of different systems.

Advantages:
Septic tanks are simple to operate and maintain. The tanks can last anywhere from 20 to 30 years with proper care and maintenance.

Soil Absorption Trenches

Basic Design:
The effluent that leaves your septic tank or pretreatment device and is then drained by gravity to plastic perforated pipes laid in gravel trenches in the soil. Approved alternatives such as chamber products or bundled expanded polystyrene distribution products may also be used. The soil is used as the primary treatment media to remove the smaller suspended particles (TSS) and organic material (BOD). Research confirms that 2 to 4 feet of unsaturated soil is needed to completely remove bacteria, viruses and protozoans from sewage.

Figure 4-2: Septic Tank to Soil Absorption Trenches

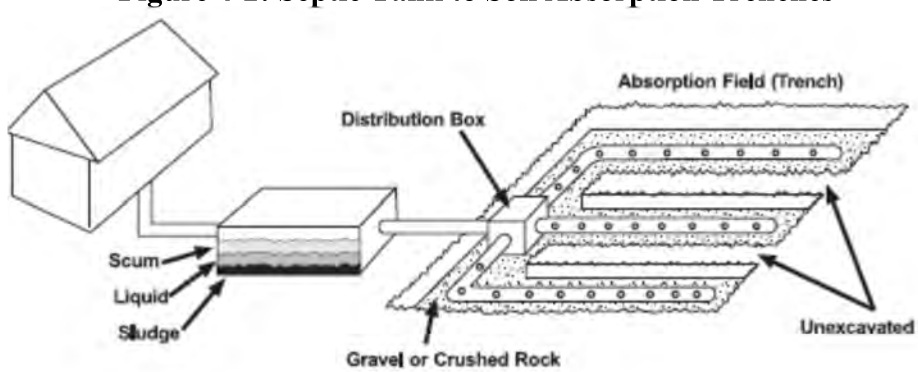


Figure 4-3: Cutaway View of a Soil Absorption Trench

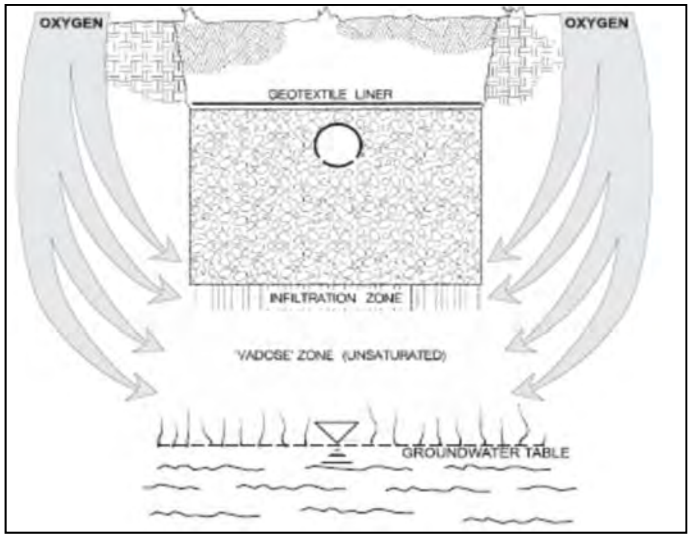
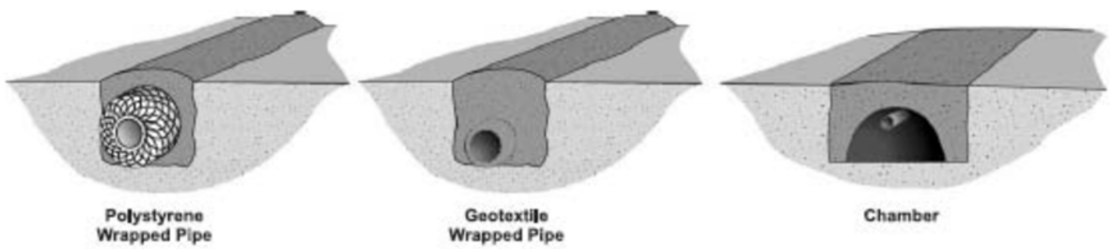


Figure 4-4: Alternative Aggregate or Chamber Products



Advantages:
Soil absorption trenches are passive, simple and low maintenance systems. With the right soils, they can effectively treat sewage. They are also a reasonably priced system where soil conditions permit their installation.

Disadvantages:
These systems require soils that are not seasonally saturated with water to ensure treatment, and prevent ponding or nuisance conditions in yards. Over time, the soil absorption trench will develop a biomat consisting of suspended particles, organic matter and bacterial slimes which will eventually clog the trenches and lead to system failure. Lowering the amount of suspended particles, organic and bacterial load to the trenches by pretreating the wastewater can help extend trench life.

Pretreatment to Soil Absorption Trenches

Basic Design*:*
This system design includes a mechanical pretreatment device that reduces the suspended solids, organic material and bacteria in the effluent. Pretreatment devices consist of a multi-chamber tank that is divided into two or more sections to provide for settling of solids and effluent treatment. These devices use different biological processes to treat sewage including continuous flow, suspended growth aerobic systems (most common), fixed media processing and optional recirculation, and sequencing batch reactors. Aerobic conditions are required for treatment,

subsequently most system add oxygen to the treatment process. These systems can substantially reduce the total suspended solids (TSS), organic matter (BOD), fecal coliform (and other pathogenic bacteria). Some systems use recirculation of effluent to reduce ammonia and nitrogen in the effluent. The treated effluent is discharged to a soil absorption trench. Due to the high level of pretreatment, the size of the soil absorption trench can be reduced by 25 to 30%, thus reducing system costs. The significant reduction of fecal coliform can also allow for less thickness of soil necessary for treatment, and one or two foot soil depth credits (reduction of soil thickness needed by 1-2 feet) can be used to help overcome site limitations such as bedrock or seasonal high water table.

Advantages:
A variety of pretreatment units are available across the state with varying costs, performance levels and operation and maintenance requirements. Pretreatment devices help overcome site limitations like high seasonal water table by providing higher levels of treatment to allow for less useable soil thickness on the lot. They also help to provide treatment when the system is located near or could impact sensitive water environments. These devices also allow for a smaller area for the soil absorption trenches, thus reducing costs associated with the soil absorption component.

Disadvantages:
Pretreatment units are mechanical devices that require regular maintenance by a qualified service provider. Components will have to be replaced over time. A service contract must be maintained to ensure that the system receives proper care and maintenance.

Figure 4-5: Typical Suspended Growth Aerobic Treatment Unit

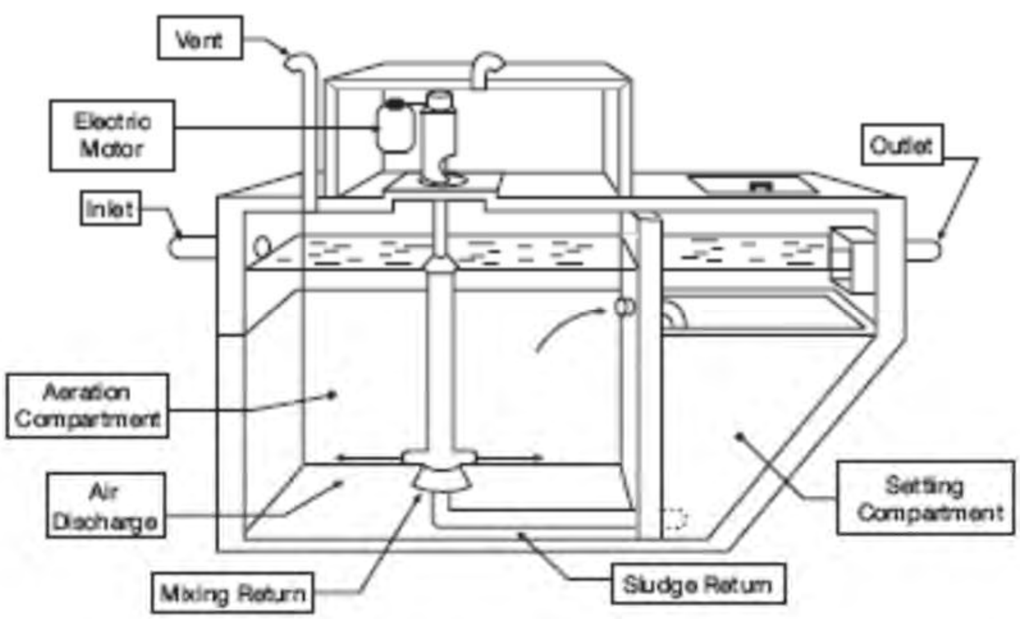
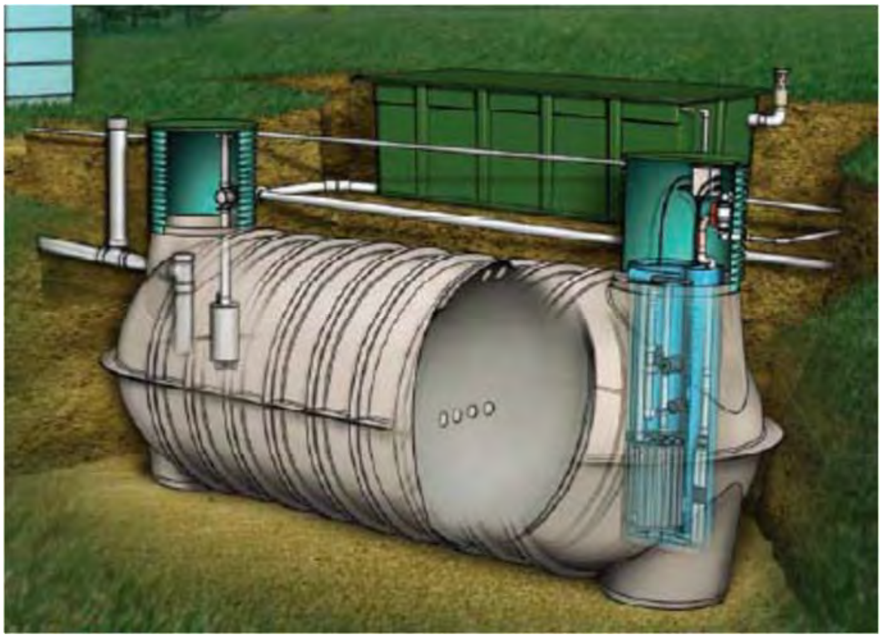


Figure 4-6: Fixed Film Pretreatment Unit

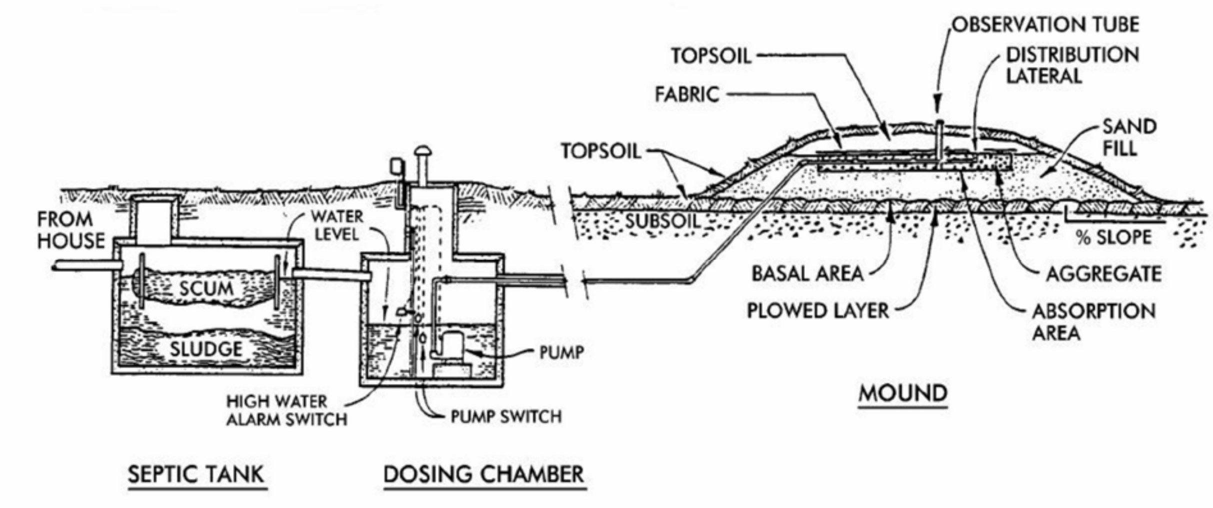


Sand Mounds with Pressure Distribution

Basic Design:

A septic tank and sand mound system is a technology used for treating and disposing of wastewater in areas unsuitable for conventional septic tank soil absorption systems. Mounds are pressure-dosed sand filters placed above, and discharging directly to, the natural soil. Their main purpose is to provide additional treatment to the wastewater before it enters the natural environment. Treatment occurs through physical, biological, and chemical means as the wastewater filters down through the sand and the natural soil. Mound systems are designed to overcome site restrictions such as slow or fast permeability of soils, shallow soil over bedrock, and a perched seasonal water table through elevation of the system with sand. The three components of a mound system are a septic tank or pretreatment unit(s), dosing chamber, and the elevated mound. (See figure below for an illustration.) Some mound systems are designed with a pretreatment unit(s) to reduce waste strength and/or to reduce the mound sizing (see Pretreatment to soil absorption page). The dosing chamber follows the septic tank or pretreatment component and contains a pump, which pressure doses the effluent to evenly distribute the wastewater over the infiltration surface of the mound. The mound is constructed with a soil cover that can support vegetation, and a fabric covered coarse gravel aggregate or gravelless product in which a network of small diameter perforated pipe is placed. The network of perforated pipe is designed to distribute the effluent evenly through the gravel from where it trickles down to the sand media and hence, into the plowed basal area (natural soil).

Figure 4-7: Sand Mound with Pressure Distribution



Source: ASAE, Converse and Tyler, 1998b.

Advantages:
Mound systems allow the development of the use of some sites that would otherwise be unsuitable for in-ground or at-grade onsite systems due to seasonal perched water or other site limitations. The natural soil utilized in a mound system is the upper most horizon, which is typically the most permeable. A mound system does not have a direct discharge to the ground, streams, or other bodies of water; and construction damage is minimized since there is little excavation required in the mound area.

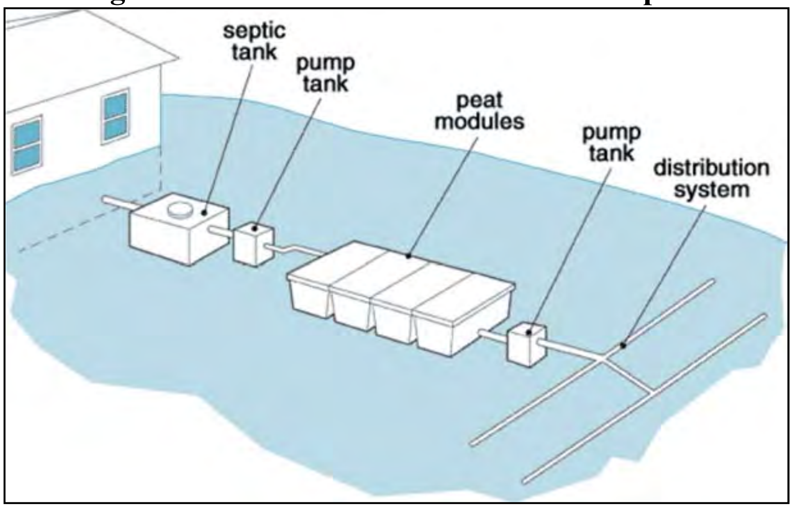
Disadvantages:
Cost is somewhat higher compared to a conventional system due to specialized construction, materials and transportation costs, and possible engineering design fees. Since there is usually limited usable soil available at mound system sites, extreme care must be taken not to damage this layer with construction equipment; the size and shape of mound systems, and their elevation above the natural grade may present some concerns related to grading, landscaping and aesthetics for the site. The mound may have to be partially rebuilt if seepage or leakage occurs; all systems require pumps or siphons.

Peat Biofilter with Soil Absorption

Basic Design:
A peat filter produces secondary-level treatment of septic tank effluent by filtering it through a layer of sphagnum peat before sending it to the soil absorption system. Peat is partially decomposed organic material with a high water-holding capacity, large surface area, and chemical properties that make it effective in treating wastewater. Un-sterilized peat is also home to a number of different microorganisms, including bacteria, fungi, and tiny plants. All of these characteristics make peat a reactive and effective filter. The peat is contained in modules placed above ground or at ground level. Wastewater flows into a septic tank where the large solids settle out. The liquid effluent either gravity flows, or in some models, is pumped in doses to the peat filter where it is pretreated and delivered to the soil absorption system for final treatment. Depending on the installed depth of the peat filter, a dose pump may be required to lift effluent to the soil absorption

system. With a gravity distribution to the filter, wastewater may pond on top of the peat compressing it, reducing the flow of wastewater through the filter. With a pressure distribution system, wastewater is applied evenly over the peat surface, allowing rapid infiltration. Due to the high level of pretreatment, the size of the soil absorption trench can be reduced by 25 to 30%, thus reducing system costs. The reduction of fecal coliform can also allow for less thickness of soil necessary for treatment, and one or two foot soil depth credits (reduction of soil thickness needed by 1-2 feet) can be used to help overcome site limitations such as bedrock or seasonal high water table.

Figure 4-8: Peat Biofilter with Soil Absorption



Advantages:
Peat's high cation exchange capacity means the peat can effectively hold positively charged molecules including ammonium, metals, pesticides, some organic molecules, and possibly viruses. As a filter medium peat is effective in situations where loadings are seasonal or intermittent. The treatment capacity can be expanded through modular design.

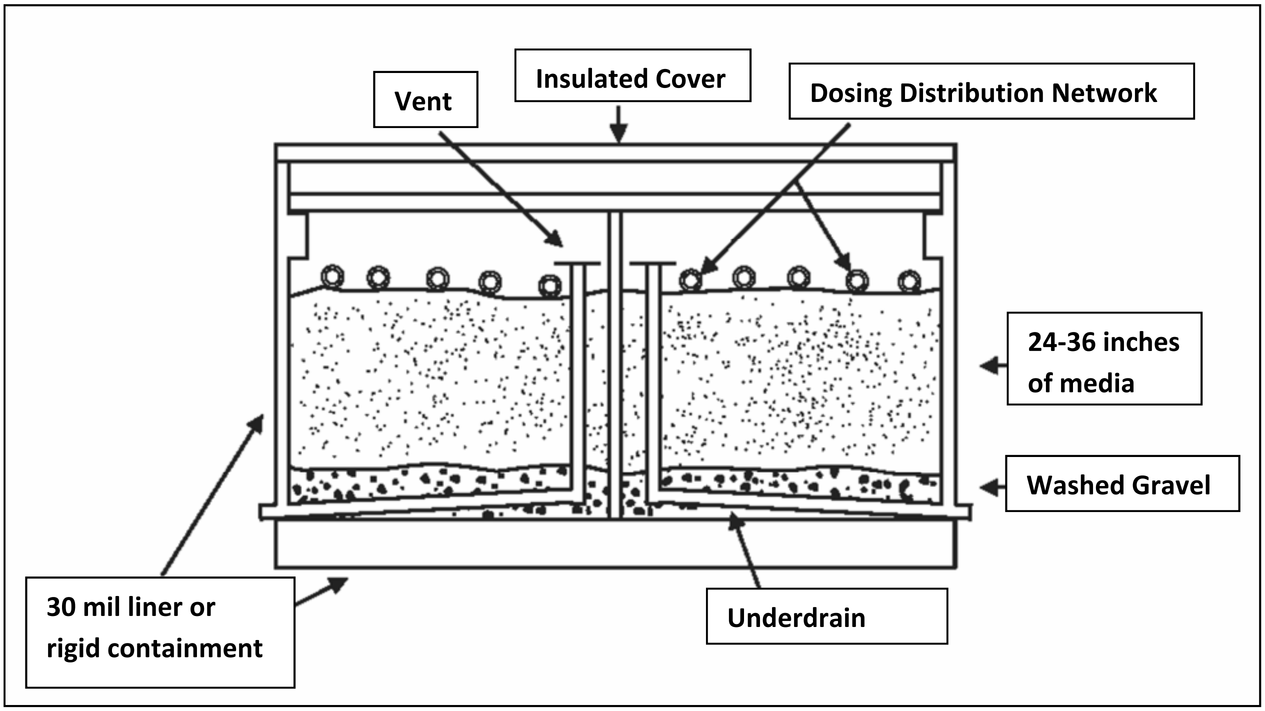
Disadvantages:
Peat filters require more maintenance than conventional septic to soil absorption trenches. Treatment media has a limited useful life of 10-15 years and has to be replaced with new media depending on the use.

Single Pass Intermittent Sand Filter/Bioreactor

Basic Design:
Single Pass Intermittent Sand Filters (ISFs) are fixed-film biological treatment units. In ISFs, wastewater is applied in intermittent doses to a bed of sand or other suitable media. The wastewater first receives primary treatment in a septic tank or an aerobic treatment unit, and then is pumped from a screened vault in the septic tank or separate dosing tank to the water-tight lined sand bed or module where it is evenly distributed over the top of the sand filter bed. The design can also use a series of siphons in lieu of a dosing tank where the use of electricity is not feasible due to system location or social and religious beliefs. Media alternative to sand has been utilized in some designs. As the wastewater passes through the sand filter, treatment is accomplished by physical, chemical and biological actions. The main treatment is accomplished by the microorganisms attached to the

filter media. The treated wastewater is collected in underdrains at the bottom of the sand filter and is then transported to the soil absorption system. ISFs are designed such that the pretreated wastewater passes through the sand filter bed once. With proper design and media sizing ISF's achieve reductions in biochemical oxygen demand (BOD), total suspended solids (TSS), and fecal coliform.

Figure 4-9: Single Pass Intermittent Sand Filter/Bioreactor



<u>Advantages</u>:
Intermittent Sand Filters (ISFs) are simple in design and relatively passive to operate because the fixed-film process is very stable and few mechanical components are used. High flow variations after equalization in a septic tank are not a problem because the residual peaks and valleys are absorbed in the pressurization tank or in the last compartment of the preceding septic tank. A malfunctioning ISF clogs and backs up rather than release poorly treated effluent. ISFs tolerate fluctuations in flow, especially changes from negligible flow to very high flows thus are appropriate for seasonal use. Construction costs for ISFs are moderately low, and the labor is mostly manual.

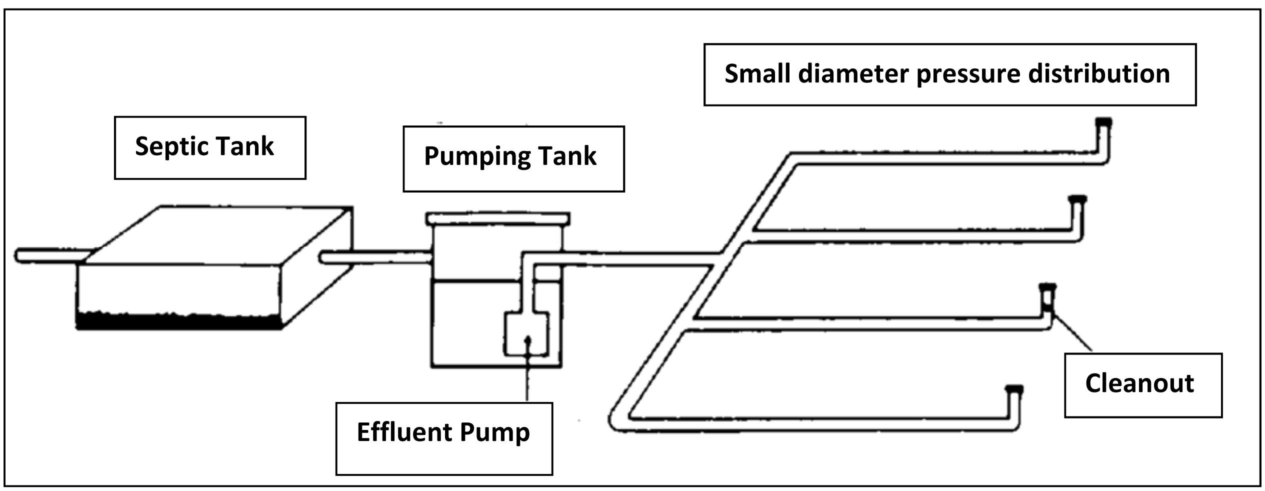
<u>Disadvantages</u>:
Cost is somewhat higher than those of conventional systems due to cost of sand media, pump(s) and possible engineering design fees. The land area required may be a limiting factor. Regular (but minimal) maintenance is required. If appropriate filter media are not available locally, costs could be higher. Premature clogging of the filter media can result from exceeding design loading rates.

Septic Tank/Pretreatment to Low Pressure Pipe

Basic Design:

A low pressure pipe (LPP) system is a shallow, pressure-dosed soil absorption system. LPP systems were developed as an alternative to conventional soil absorption systems to eliminate problems such as clogging of the soil from localized overloading, mechanical sealing of the soil trench during construction, anaerobic conditions due to continuous saturation, and a perched seasonal water table. The LPP system uses several design features to overcome site challenges including: shallow placement, narrow trenches, pressure-dosing with uniform distribution of the effluent, design based on loading, and resting and re-aeration between doses. The main components of a LPP system are a septic tank or an aerobic unit, a dosing chamber (a submersible effluent pump, float controls, a high water alarm, and a supply manifold), and small diameter distribution laterals with small perforations (holes). The septic tank is where large solids are removed and primary treatment occurs. Partially clarified effluent then flows by gravity from the tank to a pumping chamber, where it is stored until it reaches the level of the upper float control, which activates the pump with each dose providing 3 to10 times the lateral pipe volume. The level controls can be set for a specific pumping sequence, or timed dosing, which allows timed breaks between doses and increased time for the soil to absorb the effluent under less saturated conditions. Demand dosed pump sequences deliver effluent based on demand. The pump turns off when the effluent level falls to the level of the lower float control. The pumping chamber is usually sized to provide excess storage of at least one day's capacity in case there is a power failure or pump malfunction.

Figure 4-10: Septic Tank/Pretreatment to Low Pressure Pipe



Advantages:

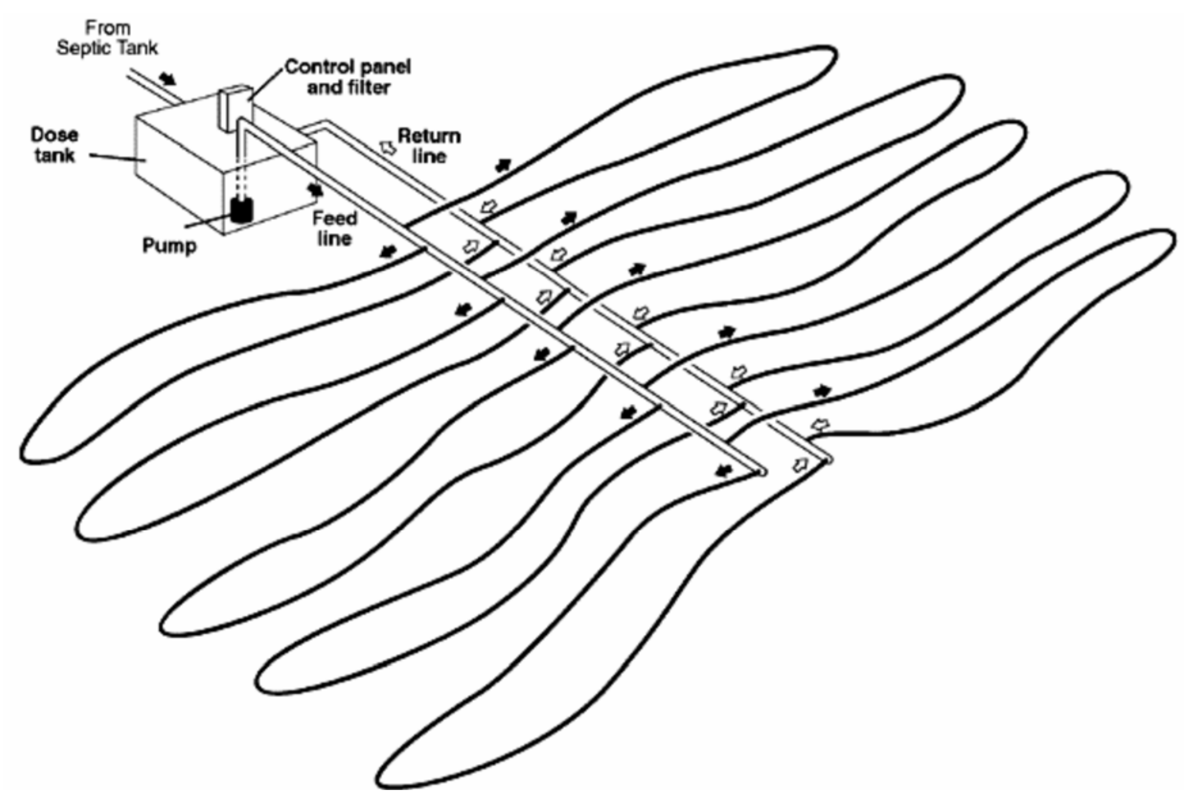
Shallow placement of trenches in LPP installations promotes evapotranspiration and enhances growth of bacteria. Improved distribution through pressurized laterals disperses the effluent more uniformly throughout the entire drain field area. Periodic dosing and resting cycles enhance and encourage aerobic conditions in the soil. Shallow, narrow trenches reduce site disturbances and thereby minimize soil compaction and loss of permeability. LPPs allow placement of the drain field area upslope of the home site. The problem of peak flows associated with gravity-fed conventional septic systems is overcome.

Disadvantages:
Cost is higher than those of conventional systems due to specialized construction and possible engineering design fees. In some cases, the suitability could be limited by the soils, perched seasonal water table, slope, and space characteristics of the location. A potential exists for clogging of holes or laterals by solids or roots.

Drip Distribution System

Basic design:
Drip Distribution Systems are installed very shallow in the soil, at the surface of the ground or on top of a bed of sand, depending on the specific limiting conditions on the property. These systems are pressurized to ensure even distribution of wastewater into the soil. They utilize small diameter tubing with pressure compensating emitters to apply wastewater uniformly over an infiltration surface. Drip Distribution systems are typically split into at least two zones and works on the principle of timed micro-dosing to maintain aerobic conditions in the soil. Timed micro-dosing applies effluent to the soil at uniform intervals throughout a 24-hour period, which allows for improved wastewater treatment. When properly sited, designed, installed and operated, drip systems can help overcome the typical problems associated with uneven wastewater distribution which often result in the surfacing of wastewater in the distribution field, sewage odors and other nuisance conditions.

Figure 4-11: Drip Distribution System



Advantages:
Treats sewage and distributes the effluent in smaller doses. These systems can be installed on wooded lots and challenging terrains. Due to the micro-timed dosing of this system this would lessen the likelihood of failure and creating a public health nuisance. The ability to split the soil

distribution component into two or more zones allows the use of multiple smaller suitable areas on a lot, thus increasing its probability of being a build able lot.

Disadvantages:
These systems require an on-going service contract and are one of the more expensive on-site systems.

Spray Irrigation System

Basic Design:
Spray irrigation is an efficient way to nourish plants and apply reclaimed wastewater to the land; however in order to protect public health and reduce odors, the wastewater must be treated to a very high level before being used in this type of system. Treatment is achieved through the use of septic tanks through mechanical filtration, pretreatment, and disinfection systems. After treatment, filtration, and disinfection, the effluent is sent under pressure through the mains and lines of the spray distribution system at pre-set times and rates. Vegetation and soil microorganisms metabolize most nutrients and organic compounds in the wastewater during percolation through the first several inches of soil. The cleaned water is then absorbed by deep-rooted vegetation, or it passes through the soil to the ground water. The irrigated area must be vegetated and landscaped to minimize runoff and erosion. When properly designed and installed, most spray systems provide uniform distribution to plants and eliminate discharge to streams. Spray irrigation is sometimes permitted as an alternative wastewater disposal method for sites previously considered unsuitable for onsite systems such as difficult sites with slowly permeable soils, with seasonal perched water or shallow ground water or bedrock, or complex topographies.

Figure 4-12: Spray Irrigation System

Spray irrigation system serving a three-bedroom home at The Ohio State University Agricultural Center near London, Ohio.

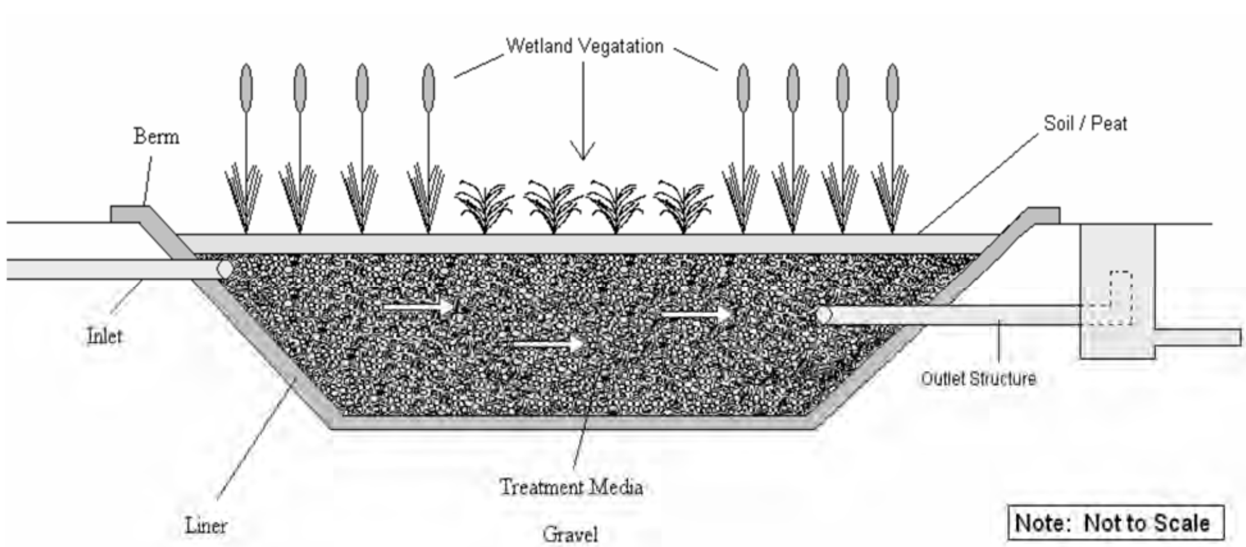
Advantages:
Because irrigation systems are designed to deliver wastewater slowly at rates beneficial to vegetation, and because the wastewater is applied either to the ground surface or at shallow depths, irrigation may be permitted on certain sites with high bedrock, perched seasonal water tables or shallow groundwater, or slowly permeable soils. Irrigation systems also can be designed to accommodate sites with complex terrains. Spray irrigation saves on potable water because the wastewater is used for irrigation. Above-ground spray system components are easier to inspect, control, and service than subsurface drip irrigation components.

Disadvantages:
Cost is higher than those of conventional systems. Temperature factors in Ohio may preclude the use of spray irrigation during certain times of the year. The wastewater may need to be stored in holding tanks during the coldest period of the year, because plant growth is limited and the nitrogen in effluent discharged during this time will be mineralized and unavailable for plant uptake. Sites near surface water or shallow groundwater often are restricted, especially when these are used as drinking water sources. Depending on the level of treatment, spray systems generate aerosols, which can pose a threat to public health; therefore, regulations may require large separation distances or buffer zones that make spray systems inappropriate for small lots. Minimum setbacks of as much as 50 feet of forested buffer or 150 to 500 feet from neighboring residences and water sources are not unusual.

Constructed Wetland

Basic Design:
Constructed wetlands are non-mechanical pretreatment systems designed to capitalize on natural wastewater treatment processes involving wetland vegetation, soils, and their associated microbial assemblages. They pretreat wastewater by filtration, settling, and bacterial decomposition in a natural-looking lined marsh. Flow systems direct effluents through a permeable subsurface medium, thereby managing odors and other nuisance problems. The media−typically soil, sand, gravel or crushed rock − greatly affect the system's hydraulics. Treatment systems are typically constructed in basins or channels with a natural or constructed subsurface barrier to limit seepage. The components of a complete system include: a septic tank for primary settling of the wastewater; one or more bermed or retained cells that contain an impermeable liner, a gravel substrate, mulch and water-loving plants; and a distribution system. A constructed wetland is typically used as a pretreatment component before discharge to a soil absorption system. The overall system reduces biochemical oxygen demand, total suspended solids and fecal coliform. Constructed wetlands have not been approved statewide for soil absorption or soil depth credits.

Figure 4-13: Constructed Wetland



Advantages:
Under the right site conditions, constructed wetlands can be an affordable, natural alternative to conventional wastewater treatment systems. They are generally simple to build, require little or no energy to operate, provide effective secondary effluent treatment, and generally do not emit odors. Wetlands are passive systems that do not require much routine maintenance.

Disadvantages:
Constructed wetlands are site-specific. Expert design and additional calculations to determine the economics are advised. Because year-round flow is necessary to sustain the plants, constructed wetlands are not appropriate for seasonal residences. In colder climates, larger cells are needed for freeze-prevention design, and efficiency will be compromised. On steep slopes, cut and fill may be necessary to keep the effluent flow slow enough for proper absorption. Wetlands potentially have a slow initial start-up period before vegetation is adequately established every year. Burrowing animals may pose a threat. All external sources of flow, including precipitation, affect sizing of these systems.

The different types of onsite systems show that design is a major factor for onsite management. Other factors also come into play. For water quality management planning, the 10 major management factors are:

1. Age
2. Design
3. Siting
4. Installation
5. Operation
6. Maintenance
7. Repairs, Upgrades or Replacement
8. Cost
9. Regulation
10. Enforcement

Brief descriptions of each management factor follow.

Age

As onsite system technology continues to improve, the age of the onsite system becomes an increasingly important factor. Systems installed before 1977 are more likely to be deficient because regulations and standards were lacking at the time of their construction. The year 1977 is a breakpoint because that is when Ohio first enacted onsite legislation. On the federal level, 1977 was the year when the Clean Water Act was amended to induce improvements in onsite funding and design. Regionally, 1977 was when OKI issued its *Regional Water Quality Management Plan*, which pointed out onsite systems as a significant water quality management issue. The Ohio Department of Health addressed the issue of before or after 1977 with this statement: "While many systems installed prior to 1977 are likely functioning to **dispose** (ODH's emphasis) of sewage effluent, the unknown question is how many are likely treating sewage effluent to a reasonable degree to prevent public health impacts and migration of pathogenic bacteria and pharmaceuticals and other chemicals to surface and groundwater." *Survey of Household Sewage Treatment Systems Operation and Failure Rates in Ohio* (2008)

Age is also a factor because older onsite systems have smaller capacities. Many households have since increased water usage, sending more sewage to under-sized, obsolete septic tanks with undersized, obsolete leach fields.

Design life is the main reason that age is factor. The Ohio Department of Health clearly explained this reason in its *Survey of Household Sewage Treatment Systems Operation and Failure Rates in Ohio* (2008): “As with any mechanical component or piece of infrastructure for a home, a sewage treatment system has a design life. . . . Sewage treatment systems should be designed to ensure sustainability and may average 30-40 years of operation or perhaps more under ideal conditions.” If the older onsite systems in the OKI region average 35 years of functionality, the systems installed by 1985 are at the end of their useful life. This involves the systems of hundreds of thousands of people, even after making allowances for major onsite upgrades and replacement or centralized sewage service extensions. Table 4-4 below gives an idea of the number of people in Butler, Clermont, Hamilton and Warren counties who may be relying on over-aged septic systems. It appeared in *On-Site Wastewater Treatment Systems*, OKI, 1978.

Table 4-4: Population Served by Onsite Wastewater Treatment Systems and Sewers in 1975

County	Total Population	Total Onsite	Percentage Onsite	Total Sewered
Butler	248,490	67,090	27%	181,400
Clermont	117,340	58,000	50%	59,000
Hamilton	964,620	67,520	7%	897,100
Warren	106,990	61,990	58%	45,000
Total	1,437,440	254,600	18%	1,182,500

In its *Survey of Household Sewage Treatment Systems*, the Ohio Department of Health mapped the number of houses by county built prior to 1979 in non-municipalities to give an indication of home age, and thereby onsite system age. Butler, Hamilton and Clermont counties were all mapped in the highest category for number of older houses built. Each of the three counties had 13,636 or more houses built before 1979 in the unincorporated areas that are much more likely to use onsite systems. Warren County was mapped in the second highest of four house-age categories, meaning it had 7,612 to 13,365 houses built in non-municipalities before 1979. The ODH maps show that OKI’s four-county study area has a statistically significant number of older homes with onsite systems that may be at or near the end of their useful lives.

<u>Design</u>

Onsite system age and design are inter-related. The OKI region faces similar design issues to those of the TMACOG (greater Toledo) region. As noted in TMACOG’s 208 plan (2019), “The effectiveness and longevity of an onsite system depends on its proper design for site and soil conditions. With a preponderance of slow-draining soils and higher water tables in the region, systems can fail due to a lack of effluent drainage.” In 1978, OKI addressed design improvements by describing four categories of “developments in onsite treatment.” Though more than 40 years old, the four categories are still applicable:

1. Load Reducing Techniques – Such techniques reduce the hydraulic or organic loading on the treatment system. Chemical, incinerating and composting toilets and water conserving shower heads and toilets are examples.

2. Onsite Treatment Techniques – These techniques improve or replace the traditional septic tank with more efficient treatment units. Liquid effluent can be discharged to surface water or land. This category includes aerobic systems with or without tertiary filters, septic tanks with tertiary filters, anaerobic digestion and membrane filtration, and fixed media treatment for greywater. (The OKI region already had some of these units in 1978.)

3. Soil Absorption System Improvements – Such improvements include mounds, field clusters, evapotranspiration (which is not often used locally because in most years the region receives more inches of rain than is lost to evapotranspiration), duplicate fields and hydrogen peroxide rejuvenation of the onsite system.

4. Modified Collection Systems – These are not onsite treatment devices per se, but offer useful alternatives to onsite treatment. The prime techniques for modified collection are gravity, small-diameter gravity, vacuum and pressure collection networks that feed into small flow treatment plants, which will be further explained later in this chapter.

In section 4.6.2 of its *Onsite Wastewater Treatment Systems* Manual (2002), the U.S. EPA recommends the following design considerations:

Volume – Septic tanks must have sufficient volume to provide enough hydraulic residence time to allow sedimentation. Minimums of 6 to 24 hours have been recommended, though actual residence times can vary from tank to tank because of differences in geometry, depth and inlet/outlet configurations. Sludge and scum also affect the residence time, reducing it as solids accumulate.

Geometry – The septic tank's length-to-width ratio and liquid depth are important considerations. Tanks with length-to-width ratios of 3:1 or more will reduce short-circuiting of raw wastewater across the tank and improve suspended solids removal.

Compartmentalization – Compartmentalized tanks or a connected series of tanks are better at removing suspended solids. All compartments should be vented.

Inlets and Outlets – The drop from inlet to outlet across a tank should be at least 2 to 3 inches to ensure that the building sewer does not get flooded and obstructed during high sewage flows. A clear space of at least 9 inches should be designed above the liquid depth (outlet level) to allow for scum storage and ventilation.

Tank Access – Septic tank access is necessary for pumping septage, inspecting inlet and outlet baffles, and servicing the effluent screen. Access ports or manways should reach ground level and have covers, ideally ones that lock.

Construction Materials – Septic tanks smaller than 6,000 gallons are typically premanufactured; larger ones are constructed in place. Though fiberglass and plastic tanks are gaining popularity for ease of shipping, concrete tanks are less susceptible to collapse and flotation. Coated steel tanks are fading from use because they corrode easily. Concrete is the material for most tanks built on site.

<u>Watertightness</u> – Infiltration of clear water to the tank from sources including the building storm sewer or groundwater increases the onsite system's hydraulic load and can upset the treatment process. Exfiltration threatens groundwater quality with partially treated sewage and can lower the liquid level below the outlet baffle, causing treatment processes to be fouled with scum. Outgoing leaks also can cause the tank to collapse. High-quality, preformed joint sealers should be used to achieve a watertight seal over a wide range of temperatures without shrinking, hardening or oxidizing.

Section 5.2 of the U.S. EPA's *Onsite Manual* recommends adaptation to these design conditions: regional geologic and hydrologic features; down gradient soils used for treatment; characteristics of the wastewater to be treated; regulatory requirements; and characteristics of the proposed tank site.

Vertical separation distance between absorption field lines and underlying receptors is a key consideration in onsite system design. The Ohio Departments of Health's recommendations are shown below in Table 4-5:

Table 4-5: Vertical Separation Distances Required by Ohio Department of Health

Receptor	**Relative Risk**	**Vertical Separation Distance Needed**
no limiting condition	low	minimum of 18 inches
seasonal perched water table	low to moderate	18 inches
groundwater or drinking water source	high	36 inches
fractured bedrock or karst limestone	high	36 inches
coarse sand and gravel	high	36 inches

Source: *Report to the Household and Small Flow Onsite Sewage Treatment System Study Commission,* ODH, 2008

Ohio EPA recommends a variety of design practices in its *Interim Onsite Sewage Treatment System Guidance Document.* (OEPA, Division of Surface Water, May 2008). It proposes the following as "Ohio EPA's opinion of what design standards . . . are needed for any OSTS" (onsite sewage treatment system):

- Shallow placement of the trench or infiltration surface (less than 2 feet below final grade)
- Organic loading comparable to that of septic tank effluent at its recommended hydraulic loading rate
- Trenches planned parallel to surface contours
- Narrow trenches (less than 3 feet wide)
- Timed dosing with peak flow storage
- Even distribution of wastewater over the infiltration surface
- Multiple cells to provide periodic resting, standby capacity and space for repairs or replacement

"The designer should attempt to include as many of the above features as possible," the *Interim Guidance Document* advises. "Additional concepts to consider when designing an OSTS include:"

- A minimum of 1:1 ratio of lineal feet gravity leach line to gallons per day (gpd). Unfiltered effluent should have 2:1 ratio in severe soils receiving more than 200 gpd

- A storage capacity of at least 2.5 times the average daily flow, with 1,000 gallons as the minimum recommended capacity
- A dual-compartment septic tank, or, in some cases, two single-compartment tanks
- Septic tank effluent filters, especially where no other pretreatment is provided
- Tankage pumping and inspection schedules should be addressed on detailed design plans for the grease interceptor, septic tank or dosing tank.
- Onsite systems handling more than 1,000 gpd should incorporate pressure distribution, though dosed gravity distribution may be recommended with proper justification. Pressure distribution should be the only option for systems handling 2,500 gpd or more.
- Equalization may be allowed to justify smaller soil dispersal areas for systems with uneven flow distribution throughout the operation of the system
- 100 percent replacement area
- Any gravity leaching lateral should not exceed 100 feet in length
- Trenches should be planned as high as possible to maximize the usable soil for treatment.
- Gravelless technology may be used instead of aggregate, but no reduction in soil distribution area should be permitted.
- A grease interceptor and pretreatment component are strongly recommended for any onsite system that will have restaurant strength wastewater that is high in biological oxygen demand or total suspended solids.

The American Planning Association (APA) offers guidance for improving onsite design in *Planning Issues for On-Site and Decentralized Wastewater Treatment* (APA Report Number 542, Wayne M. Feiden and Eric S. Winkler, 2006). It states the following features are most important for designing effective onsite systems:

Provide an opportunity for treatment. Every onsite system has some type of physical and chemical filtering and biological activity. For an in-ground system, most treatment occurs between the sewage discharge point (leach lines) and the groundwater.

Maximize interaction between sewage disposal and the most active biological zone. This typically means maximizing interaction with native soils above the groundwater. Biological treatment is the single most important aspect of decentralized sewage treatment.

Reduce groundwater mounding under the system. In most systems, this means controlling discharge rates so the sheer volume of sewage being discharged in any one place does not overwhelm the capacity of the ground between the system and groundwater to effectively treat and dispose of the sewage and does not lead to groundwater levels rising under the system.

Provide dilution of sewage discharge. "The wider effluent is spread out on a site, the greater the mixing and dilution between the effluent, rainwater and groundwater."

For quick reference purposes, APA Report Number 542 compares the four design features above to nine design steps. They are tabulated in Table 4-6 on the next page.

Table 4-6: Steps and Features for Improved Design of Onsite Systems

Design Features (right) Design Steps (below)	Maximize interaction with biological zone	Provide opportunity for treatment	Reduce groundwater mounding	Dilute discharge (especially for nitrogen)
Vertical distance to groundwater	●	●	●	●
Vertical distance to ledge	●	●	●	●
Permeable soils (percolation rate)		●	●	
Distance from environmental receptors		●		
Distance from discharge points (e.g., drains)		●		
Long and thin system design	●	●	●	●
Leach field parallel with contours	●	●	●	●
Shallow leach field	●	●	●	●
Even distribution of effluent	●	●	●	●

Siting

In its fact sheet titled *Know How to Select a Home Site,* the Ohio Department of Health offers practical advice on finding a proper site for an onsite system: "Inspect the lot with your contractor to confirm that the site and soil conditions will not cause any unexpected costs during sewage system construction. . . . Isolate the area designated for your sewage system by roping or fencing the area to keep construction traffic from destroying the soil needed for absorption of wastewater. Remember that sewage systems cannot be located under driveways or sidewalks. Ensure that future development such as swimming pools, out buildings, and room additions adhere to the sewage system isolation distances."

Ideally, onsite system locations should be planned in accordance with DRASTIC, a nationally standardized system for pollution potential mapping that rates the relative vulnerability of different areas to groundwater contamination. In collaboration with the University of Cincinnati and Wright State University, the Ohio Department of Natural Resources has prepared separate DRASTIC maps and reports for Butler, Clermont, Hamilton and Warren counties. These planning tools show where it is safer or riskier to conduct land disposal of waste byproducts, including onsite system effluent. DRASTIC is an acronym that stands for these rating factors (*DRASTIC: A Standardized System for Evaluating Ground Water Pollution Using Hydrogeologic Settings*, US EPA, 1987):

- **depth** to groundwater
- net **recharge**
- **aquifer** media
- **soil** media
- **topography**
- **impact** of the vadose zone media
- hydraulic **conductivity**

The U.S. EPA provides extensive guidance on how to properly locate onsite systems. The *Onsite Wastewater Treatment Systems Manual* includes a site evaluation checklist for the following surface features:

- benchmark description
- assigned elevation
- property boundaries
- surface water features
- existing or proposed structures
- existing or proposed water supply wells
- existing or proposed wastewater systems
- utility locations
- soil investigation points
- location of suitable soils area
- contour elevations
- slope aspect and percent
- proposed system component locations
- other significant features

The *Manual's* site evaluation checklist includes these subsurface features:

- depth and thickness of strong textural contrasts
- depth to seasonal saturation
- depth to perched water table
- parent material
- soil formation factors
- depth to bedrock
- type of bedrock
- depth to permanent water table
- groundwater flow direction
- groundwater gradient

In its *Report to the Household and Small Flow Onsite Sewage Treatment System Study Commission,* the Ohio Department of Health recommends extensive site evaluation, saying:
"Site and soil evaluations are the fundamental basis for ensuring that system designs will effectively treat sewage, prevent or minimize ponding in yards, and promote system sustainability for 30-40 years or more. A careful site evaluation should include consideration of the landscape, slope, vegetation, drainage, erosion and other natural features. Site evaluations should identify specific risk factors such as the presence of fractured bedrock or other sensitive conditions. Detailed site soil descriptions through the use of hand augers or test pits are necessary to clearly determine the presence of limiting conditions such as seasonal perched water table, bedrock, fragipans or thick clay layers such as dense till. Consistent evaluation of soil conditions through the use of a standardized form will help ensure uniform system performance statewide."

Ohio EPA's *Interim Onsite Sewage Treatment System Guidance Document* says the site evaluation should determine but not be limited to:

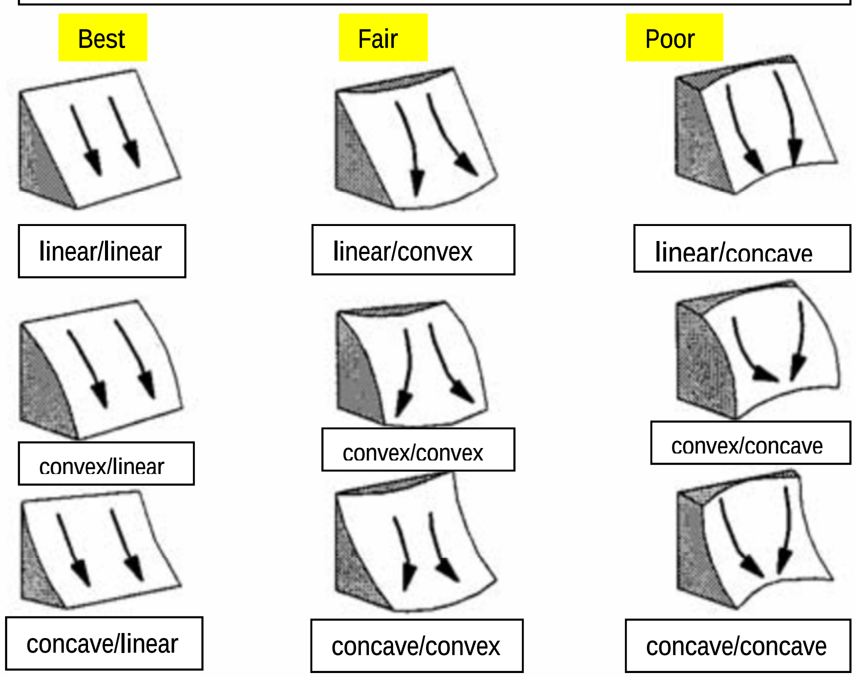
- property setbacks
- any existing tankage or soil absorption units on the site
- low lying areas

- trees, rocks, etc. that would block placement of the onsite system
- any disturbed area
- contour and elevation of the site
- any existing or proposed buildings, side walls, driveways, paved areas or other hardscapes
- locations of streams, wells, or other features that need to be avoided

Landscape position is vital to properly locating an onsite system. Figure 4-14 below illustrates how slope shapes affect surface flow pathways and hydraulic load on the absorption field. The drawings are from the U.S. EPA's *Onsite Wastewater Treatment Systems Manual.*

Figure 4-14: Landscape Position Features and Absorption Field Siting Potential

Slope shape is described in two directions: (1) up and down slope (perpendicular to the contour), and (2) across the slope (along the horizontal contour). In either direction, the three possibilities are: (1) linear, (2) convex, or (3) concave. Arrows show surface flow paths.



Best siting potential: linear/linear, convex/linear, concave linear, because parallel flows across the absorption field or infiltration system are ideal.
Fair siting potential: linear/convex, convex/convex, concave/convex, because additional trench length may not be possible later.
Poor siting potential: linear concave, convex concave, concave/concave, because converging flows could overload absorption field hydraulically.

Underlying soils with a high organic content are not suitable, nor are soils with large boulders or massive rock edges. The *Manual* advises placement of the septic tank in accessible areas for septage removal, but away from depressions where water can collect.

On its website the Ohio Department of Health provides six steps for construction of a new sewage treatment system (https://odh.ohio.gov/wps/portal/gov/odh/know-our-programs/sewage-treatment-systems/INFORMATION-FOR-HOMEOWNERS/). They are shown below verbatim:

1. Contact your local health district for specific information on STS permitting or when beginning to plan for land development with a STS. Local health district staff will visit your site to begin the initial site evaluation process.
2. Obtain a site and soil evaluation. The natural soil is the most commonly used media for final treatment of sewage effluent from a home. A complete evaluation of the soil on the property is needed to determine how much usable soil (thickness) is present and where it is located. Other site conditions must also be determined such as slope, topography and the location of nearby water sources and drinking water supplies. Some local health districts provide site and soil evaluation services. These services are also available from many private companies and local health districts can provide a list of experts that provide these services.
3. Work with a sewage treatment system designer to evaluate the different system types available for your lot. Most lots can accommodate more than one system design. Homeowners should carefully evaluate all system costs including installation, long-term operation and maintenance requirements and service contract costs before making a final system decision. Please refer to the list of STS types on the page below.
4. Obtain quotes and bids from registered STS contractors. Local health districts can provide a list of locally registered STS contractors. Some local health districts require bonding of contractors. Always obtain a written contract and fully discuss all steps of the construction process and services the contractor will provide. Once a contractor is selected and work on your system begins, try to observe as much of the construction process as possible, and even document the installation with pictures.
5. The local health district will perform a final inspection of your system and approve or disapprove the installation. If installations problems occur, work with the system contractor and your local health district to resolve installation issues. Your local health district's role is to ensure proper system installation that protects your investment in your STS and public health and prevents disease.
6. Proper operation and maintenance of your new STS is essential to ensure the system works, does not create odors or other nuisance conditions and prevents exposure to sewage effluent. Depending on the complexity of your system, a service contract may be required. Proper operation and maintenance of your system protects the investment you have made in your property and your system.

Operation

The Ohio Department of Health offers these tips on the wise operation of an onsite system in its 2001 fact sheet titled *Know Your Household Sewage System*:

- Learn about your onsite system. Obtain a sketch and keep an operational record.
- Keep your septic tank cover accessible for inspection or cleaning. Install risers if needed.
- Conserve water to avoid overloading the system. Promptly repair leaky faucets or toilets and install water saving devices.
- Don't use septic tank additives. These products usually do not help and can be harmful to system operation.

- Eliminate or reduce the use of a garbage disposal. The added waste will lead to extra maintenance requirements.
- Don't use your toilet or garbage disposal like a trash can. The following should never be disposed in an onsite system: coffee grounds, dental floss, disposable diapers, kitty litter, sanitary napkins, tampons, cigarette butts, condoms, fat, grease, oil or paper towels.
- Never pour any of the following down the toilet or drain: chemicals, cleaners, paints, varnishes, thinners, pesticides or automotive fluids. Harsh chemicals can kill beneficial bacteria that treat wastewater.

Ohio EPA's *Guide for On-Site Sewage Disposal Systems* offers much of the same operational advice with these added tips on what not to dump down the drain: plastics of any form, caustic liquids, kerosene, table scraps, rubber products, sand and grit, or toilet cleaners that are placed in the bowl. For laundering, the *Guide* recommends the washing of full loads in front loading washers. Do not wash all clothes on a single day, but spread the loads through the week to allow the absorption field time to work. Do dishes by hand whenever possible, using soap and a trickle of hot water. Save the dishwater for those times when dirty dishes really stack up.

The U.S. EPA goes even further in listing items that can pollute water resources or upset the onsite system's biological treatment process. Its *Onsite Wastewater Treatment Systems Manual* adds the following as suspect: cleaners, cosmetics, deodorizers, disinfectants, laundry products, photographic products, preservatives, soaps and medications (prescription or over-the-counter).

Maintenance

The most important maintenance task is periodic tank pumping by a registered septage hauler approved by the local health department. The Ohio Department of Health and Ohio State University Extension Service recommend the pumping frequencies shown below in Table 4-7.

Table 4-7: Recommended Pumping Frequencies, Based on Tank Size and Number of Users

Tank Size (gallons)	Number of People Living in the House							
	1	2	3	4	5	6	7	8
750	9.1	4.2	2.6	1.8	1.3	1.0	0.7	0.6
1,000	12.4	5.9	3.7	2.6	2.0	1.5	1.2	1.0
1,250	15.6	7.5	4.8	3.4	2.6	2.0	1.7	1.4
1,500	18.9	9.1	5.9	4.2	3.3	2.6	2.1	1.8
1,750	22.1	10.7	6.9	5.0	3.9	3.1	2.6	2.2
2,000	25.4	12.4	8.0	5.9	4.5	3.7	3.1	2.6
2,500	31.9	15.6	10.2	7.5	5.9	4.8	4.0	4.0
Pumping Frequency in Years								

The U.S. EPA recommends that tanks should be pumped when sludge and scum accumulations exceed 30 percent of the tank volume or are encroaching on the inlet and outlet baffle entrances.

Inspection is another important maintenance task. The Ohio EPA recommends inspection "at least once a year." In its *Guide for On-Site Sewage Disposal Systems,* the agency also recommends that septic tanks should not be washed or disinfected with detergents, chemicals or additives after pumping. If the onsite system has a flow diverter in the distribution box, the flow should be alternated every six to twelve months. Do not cover the distribution box with earth.

Onsite Wastewater Treatment Systems Manual (U.S. EPA, 2002) advises periodic inspections for three onsite performance factors:
Sludge and scum accumulations – If the sludge layers rise to the bottom of the effluent T-pipe, solids can be drawn through the effluent port and transported into the infiltration field, increasing the risk of clogging. Likewise, if the bottom of the thickening sludge layer moves lower than effluent T-pipe, oils and other scum material can be drawn into the piping that discharges to the infiltration field.

Structural soundness and watertightness – After septage has been pumped from the tank, interior tank surfaces should be inspected for cracks, holes and other signs of deterioration, such as pitting and delamination. The presence of roots indicates tank cracks or open joints.

Baffles and screens – The baffles should be observed to confirm that they are in proper positions, secured well to the piping or tank wall, clear of debris, and not cracked or broken. If an effluent screen is fitted to the outlet baffle, it should be removed, cleaned, inspected for irregularities and possibly replaced.

The Ohio Department of Health recommends "the use of a proactive and preventive approach to managing sewage treatment systems that combines public education, local health district involvement, local planning and management factors, and consideration of area risks to sensitive water or ecological resources." ODH also recommends reliance on the "system manufacturer's recommendations for proper system operation and maintenance" and a requirement for "service contracts where recommended by the manufacturer." (*Report to the Household and Small Flow Onsite Sewage Treatment System Study Commission*, ODH, 2008)

Repairs, Upgrades or Replacement

Local health districts can provide sound advice on whether a repair, upgrade or full-scale replacement is necessary to achieve adequate wastewater treatment. Private contractors are eager to do the work. For the improvement to actually happen, the onsite system owner must find the job to be both necessary and affordable. This can be challenging.

The Ohio Department of Health acknowledges the issue of affordability. It recommends "that system repair be the first option considered for correcting a failing system, and when that is not possible, then consideration of options for system replacement." ODH calls this a "progressive, step-wise approach" that allows "incremental replacement or alteration of system components as appropriate for site conditions to allow the system owner to gradually upgrade the existing failing system and minimize immediate system replacement costs." (*Report to the Household and Small Flow Onsite Sewage Treatment System Study Commission*, ODH, 2008)

Cost

According to *Appendix 1* of *Report to the Household Sewage and Small Flow Onsite Sewage Treatment System Study Commission* (Ohio Department of Health, 2008), the cost of an onsite system in Southwest Ohio ranged from $6,700 to $30,000 per unit in 2007, based on the type of system chosen. Higher prices compel onsite buyers to choose a system more by price than by the system's expected performance at its intended use.

Cost is a key consideration for the replacement of failing onsite systems. The Ohio Department of Health recognizes that replacement "can present a significant financial hardship to some property owners, and can impact the affordability of new homes for certain income groups." ODH states: "Current research indicates that households earning below the 200 percent poverty level have no discretionary funds for household repairs such as replacement of a failing sewage system. Using socioeconomic data from the 2000 Census, ODH calculates that the percentage of non-municipal households earning less than 200 percent of the poverty level ranges from 14.62 percent in Warren County to 18.37 percent in Clermont County. ODH tabulated the statistics for all 88 counties of Ohio in *Appendix 3* to the *Survey of Household Sewage Treatment Systems Operation and Failure Rates in Ohio.* (ODH, June 2008) Table 4-8 below extracts much of ODH's demographic data for Butler, Clermont, Hamilton and Warren counties.

Enforcement

The U.S. EPA advises that "an onsite wastewater compliance and enforcement program should be based on reasonable and scientifically defensible regulations, promote fairness, and provide a credible deterrent to those who might be inclined to skirt its provisions." In its *Onsite Wastewater Treatment Systems Manual,* the agency says a corrective action program should:

- Establish a process for reporting and responding to problems (e.g., complaints, inspections)
- Define conditions that constitute a violation of program requirements
- Establish inspection procedures for reported problems and corrective action schedule
- Develop a clear system for issuing violation notices, compliance schedules, contingencies, fines or other actions to address uncorrected violations

The *Onsite Manual* says enforcement procedures can include:

- Response to complaints
- Performance inspections
- Review of required documentation and reporting
- Issuance of violation notices
- Consent orders and court orders
- Formal and informal hearings
- Civil and criminal actions or injunctions
- Condemnation of systems or property
- Correcting system failures
- Restriction of real estate transactions (e.g., placement of liens)
- Issuance of fines and penalties

"Some of these approaches can become expensive or generate negative publicity and provide little in terms of positive outcomes if public support is not present," the U.S. EPA advises. "Involvement of stakeholders in the development of the overall management program helps ensure that enforcement provisions are appropriate for the management area and effectively protect human health and water resources. Stakeholder involvement generally stresses restoration of performance compliance rather than more formal punitive approaches." A focus on performance requirements "places greater responsibilities on the oversight/permitting agency, service providers (site evaluator, designer, contractor, and operator), and system owners."

Overall, a successful onsite system management program will avoid these 12 pitfalls pointed out by the U.S. EPA in 1986:

1. Failure to adequately consider site-specific environmental conditions (site evaluations)
2. Codes that thwart system selection or adaptation to difficult local site conditions and that do not allow the use of effective innovative or alternative technologies
3. Ineffective or nonexistent public education and training programs
4. Failure to include water conservation and reuse
5. Ineffective controls on operation and maintenance of systems
6. Lack of control over residuals management
7. Lack of program monitoring, evaluation, including system inspection and monitoring
8. Failure to consider the special characteristics and requirements of commercial, industrial and large residential systems
9. Weak compliance and enforcement programs
10. Lack of adequate funding
11. Lack of adequate legal authority
12. Lack of adequately trained and experienced personnel

Because septic tank-leach field systems (absorption fields) were the most common type of onsite treatment systems used in much of the region when suburban development was at its peak, OKI compiled a series of maps on the suitability of different soils for this type of systems in 1987. For Butler, Clermont, Hamilton and Warren counties, the maps identify three groupings of soils:

- Generally ***suitable*** for septic tank-leach field systems provided the systems are properly installed and maintained
- Generally ***require modifications*** to septic tank-leach field systems, such as an operational second leach field or an oversized leach field. Modifications are usually required because:
    - slow soil permeability absorbs less than 0.6 inch per hour in the upper 4 inches of soil
    - a seasonally high water table comes within 3 feet of the surface.
- Generally ***unsuitable*** for septic tank-leach field systems but may be suited for an alternative type of onsite wastewater treatment system. (Current alternatives include pretreatment to soil absorption trenches, sand mounds with pressure distribution, peat bio-filters with soil absorption, or septic tank and pretreatment to low pressure pipe.)
  The soils' unsuitability is usually due to:
    - shallow bedrock within 4 feet of the surface
    - steep slopes of usually12 percent or more
    - extremely poor drainage resulting from a combination of seasonally high water table and slow permeability in a low-lying area
    - the potential for groundwater contamination because permeability exceeds 6 inches per hour in the upper 4 inches of soil

Please note that these groupings are specific to conventional septic tank-leachfield systems, so do not indicate where alternative onsite systems could be used; the groupings are also not intended to replace site-specific investigations. OKI consulted with the Soil Conservation Service (now called the Natural Resources Conservation Service) and health department in each county to develop the three-way classification system.

OKI based its soil suitability ratings on county soil surveys completed in different years, by different crews using county-specific characterizations. As a result, the four soil surveys shared much in common on limiting factors, but showed slight variations in how those limiting factors were characterized by the soil survey scientists. Here are the limiting factors, county by county:

<u>Butler County</u>

- flooding
- filtration
- limited depth to limestone
- permeability or percolation
- ponding
- slope
- slippage
- rocks at shallow depth
- wetness or high water table
- possibility of groundwater contamination

<u>Clermont County</u>

- subject to flooding
- moderately slow, slow or very slow permeability
- moderate depth to bedrock, or shallow depth to rock, or very stony surface layer
- slope
- seasonal high water table
- possible pollution hazard to streams, lakes, springs or shallow wells where permeability is rapid in the substratum

<u>Hamilton County</u>

- floods
- poor filter (coincides with other counties' descriptions of possible pollution)
- percolates slowly
- ponding
- depth to rock
- slope
- slippage
- wetness

<u>Warren County</u>

- somewhat poorly, poorly, or very poorly drained
- subject to flooding
- limited depth to limestone
- moderately permeable; or moderately slow, slow or very slow permeability

- subject to ponding
- X feet to rock, or limited depth to bedrock
- slope
- possibility of underground water contamination

The Ohio Department of Health identified those soils that have "very severe" limitations for onsite systems because of extremely poor drainage. These soils have both seasonally high water table and slow permeability. Although water could be pumped away from the absorption field, the soils are not recommended because the pump could suffer mechanical failure.

Although the potential for flooding is a factor in determining soil suitability for onsite systems, this characteristic has not been used to classify soils in the soil surveys because flooding frequencies cannot be generalized for soil types. The use of dams and reservoirs for flood control makes this characteristic even more unpredictable.

The generally ***unsuitable*** class includes soil survey categories of alluvial land (Clermont County), riverwash (Butler and Clermont counties), gravel pits (Butler, Hamilton and Warren counties), muck (Warren County) and replacement topfills (Butler and Hamilton counties). The generally ***requires modification*** class includes cut and fill land (Clermont and Warren counties).

OKI's maps on the suitability of soils for onsite system absorption fields show that generally ***suitable*** soils cover the least amount of land area in each of the four counties studied. Rounded figures for all three classes of soil suitability are shown in Table 4-9 on the next page.

Table 4-9: Percent of Land Area in Three Classes of General Soil Suitability for Onsite System Absorption Fields

County	Suitable	Requires Modification	Unsuitable
Butler	10%	50%	39%
Clermont	5%	54%	40%
Hamilton	18%	46%	36%
Warren	6%	60%	32%

Figures 4-15 through 4-18 are maps of soil suitability for septic tank-leach field systems in Butler, Clermont, Hamilton and Warren counties. OKI reassessed, updated and converted the paper maps of 1987 into geographic information system (GIS) layers for this water quality management plan update. The work was done in collaboration with the Ohio Department of Natural Resources, Division of Soil and Water Resources.

Figure 4-15: Suitability of Soils for Septic Tank-Leach Field Systems in Butler County
Please note that these soil groupings are not intended to replace site-specific investigations.

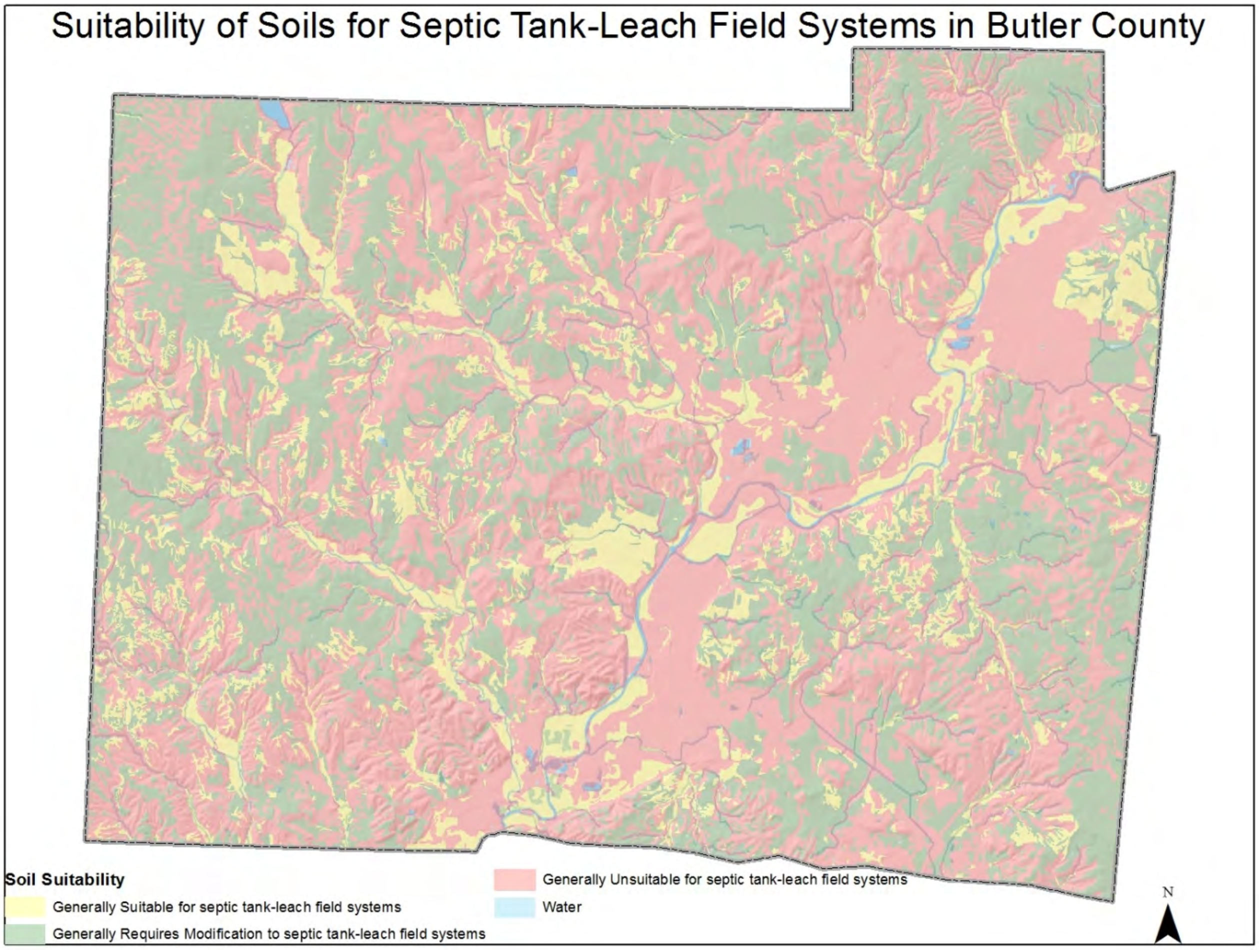


Figure 4-16: Suitability of Soils for Septic Tank-Leach Field Systems in Clermont County

Please note that these soil groupings are not intended to replace site-specific investigations.

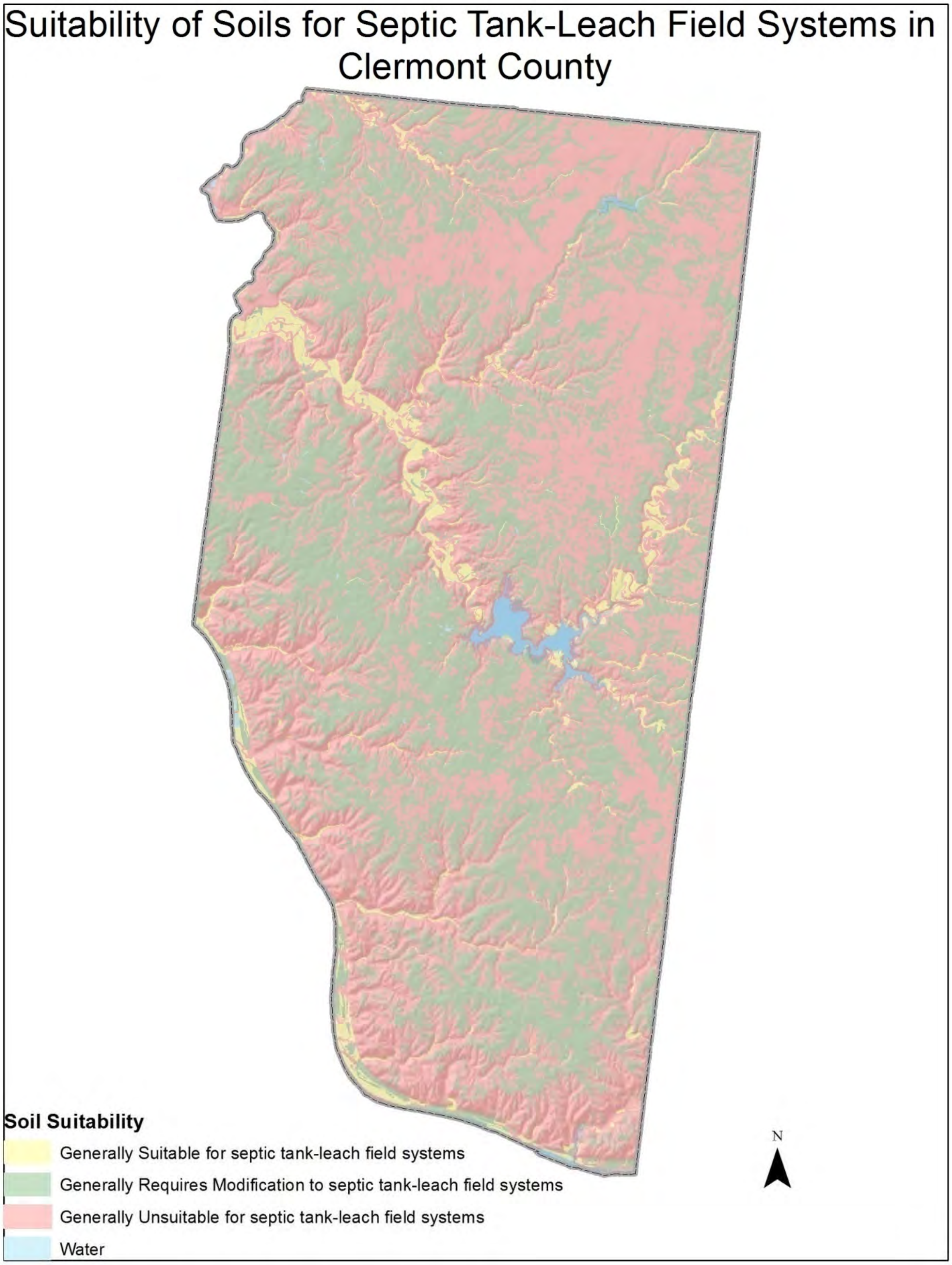


Figure 4-17: Suitability of Soils for Septic Tank-Leach Field Systems in Hamilton County
Please note that these soil groupings are not intended to replace site-specific investigations.

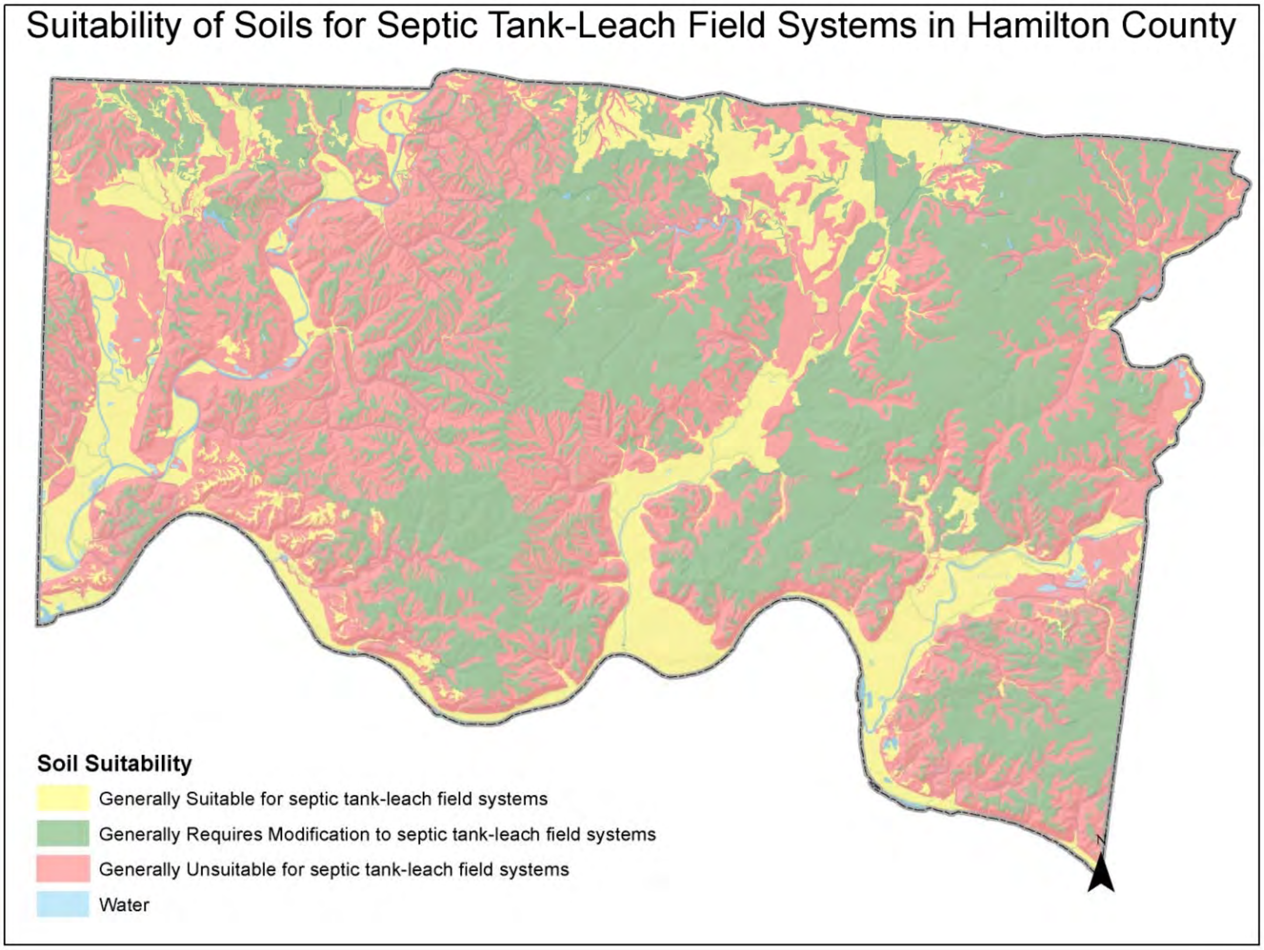
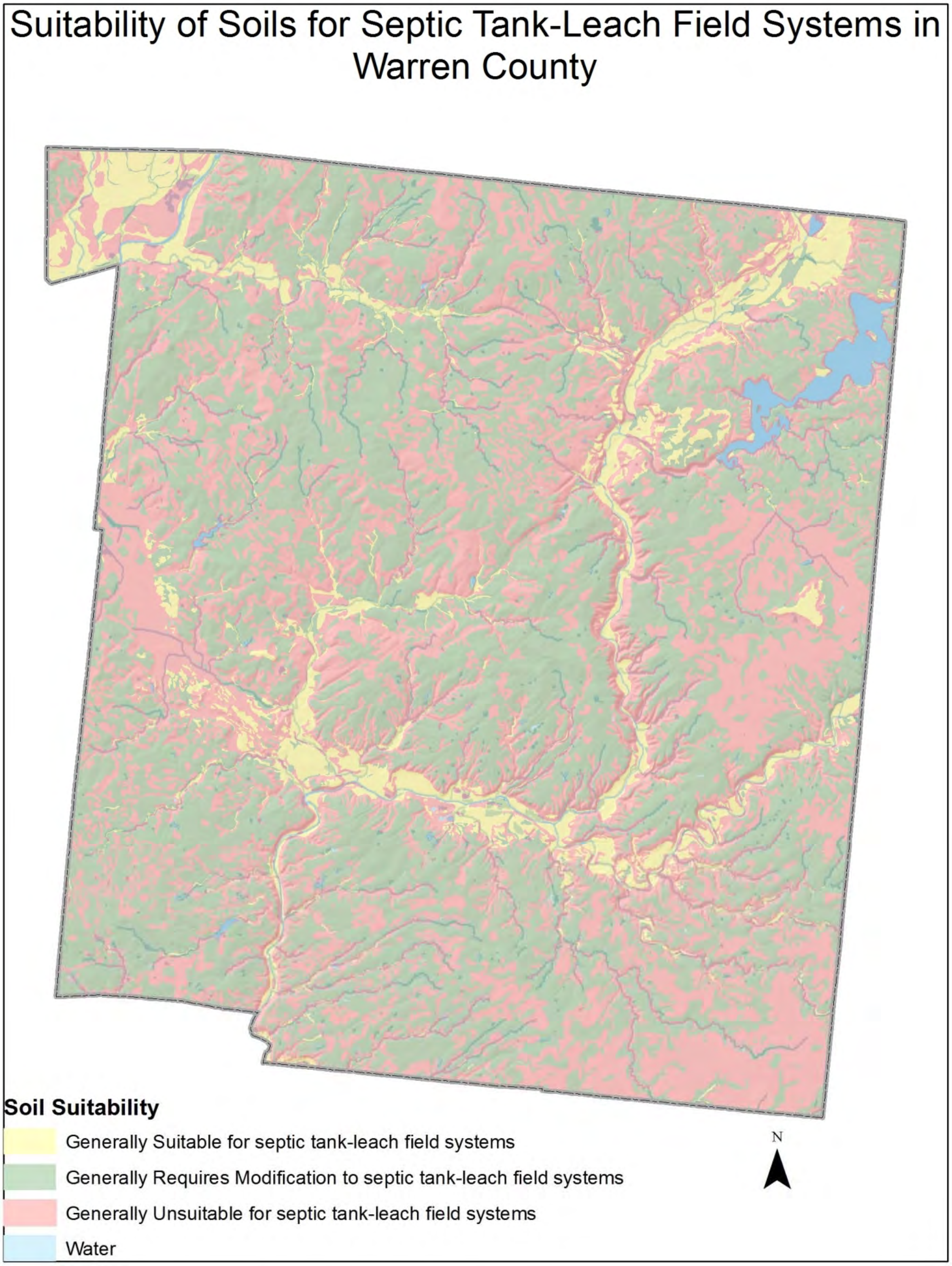


Figure 4-18: Suitability of Soils for Septic Tank-Leach Field Systems in Warren County
Please note that these soil groupings are not intended to replace site-specific investigations.



Besides unsuitable soils, other general siting restrictions include flood hazards, wetlands and the proximity of drinking water wells. Floodways and 100-year floodplains are generally unsuitable because floods hamper onsite system operation. This factor has been addressed by OKI's soil suitability maps. Wetlands are unsuitable for onsite systems because they typically overlie hydric, saturated, seasonally high water table or slow permeability soils. The isolation distance between an onsite system and a public water system wells is usually regulated. It also is a good precaution for private wells, which tend to be most common in areas with onsite systems.

Onsite System Regulation

State and local governments jointly regulate onsite wastewater treatment systems in Ohio. The Ohio Department of Health and Ohio EPA share the state's regulatory duties. Local health departments geographically divide the local regulatory duties, typically by countywide health districts. Such is the case in Butler, Clermont, Hamilton and Warren counties.

Aside from the U.S. EPA's rules on septage disposal, the onsite role of federal government is mostly guidance. Since 1992, Ohio EPA has been delegated federal authority to issue National Pollutant Discharge Elimination System (NPDES) general permits for onsite systems. The process has evolved and the number of permits has changed over time. Beginning January 1, 2017 the Ohio EPA established only one general NPDES permit (OHK000003) for household sewage treatment systems (HSTS) that provides statewide coverage to authorize the discharge of approved sewage treatment systems from households. From January 1, 2007 to January 1, 2017 there were two general permits but since the inception of the new statewide sewage treatment rule implementation on January 1, 2015, there was no longer a need for two permits. The current household sewage treatment system rules are within Ohio Revised Code Chapter 3701-29.

Sewage treatment systems include one, two and three-family dwellings and small flow on-site sewage treatment systems (facilities that treat up to 1,000 gallons per day). Proper system siting and design, soils evaluation, system owner education and operation inspections and maintenance of systems are essential to help prevent future contamination and public health nuisances.

The Ohio Department of Health (ODH) regulates sewage treatment systems across the state by statutory authority established under Ohio Revised Code (ORC) Chapter 3718 and Ohio Administrative Code Chapter 3701-29, which became effective on Jan. 1, 2015. ODH provides and maintains information and resources for the local health departments for implementing the ORC Sewage Treatment System Rules including a standard permit application form and the required bond forms for systems and installers. The processing of permits, inspections and enforcement are conducted by the local health districts who may also adopt more stringent rules and standards.

OKI reviewed permitting, inspection, and enforcement procedures at the four health districts serving Butler, Clermont, Hamilton and Warren counties and found all four to be utilizing the ODH materials and consistently adhering to ORC. Counties requiring supplemental rules or programs are summarized below.

Butler County General Health District
Butler County General Health District (BCGHD) actively promotes a Household Sewage Treatment System Replacement and Repair Loan Program for eligible residents in need of replacing or repairing a failing home sewage treatment system. This program is funded through the Ohio Water Pollution Control Loan Fund (WPCLF) from the Ohio EPA, however, not every county promotes its availability with a local program.

Clermont County General Health District
The Clermont County General Health District (CCGHD) maintains their 2009 Household Sewage Treatment Installation Manual and emphasize the importance of proper system installation on their program webpage.

In cases of failing systems where homeowners cannot afford a full replacement, CCGHD requires that major repairs be conducted through their Sewage Nuisance Abatement and Repair Plan (SNARP) program. This plan breaks down system repairs into more manageable phases, allowing the homeowner to make repairs as needed that will eventually build to a full replacement system. CCGHD works with homeowners to discern the best course of action during repairs. The health district develops this plan with steps to mitigate the impact of homeowner expenditures by spreading costs over a longer time period. Phasing allows homeowners to save funds for the next step if the failure reoccurs.

Hamilton County General Health District
Hamilton County Public Health (HCPH) Department of Environmental Health Services maintains a Sewage Treatment System (STS) Management Plan highlighting the programs, policies and procedures used by the HCPH to ensure all of the critical elements, when dealing with onsite sewage treatment systems, are properly addressed.

HCPH allows STS owners to submit documentation of maintenance and compliance with the operation, monitoring and maintenance requirements in lieu of a Health District inspection for permitting and compliance inspections. HCPH staff also helps homebuyers avoid unforeseen repair or replacement costs by offering a voluntary septic system inspection service prior to the purchase of a home.

Warren County Combined Health District
Warren County Combined Health District (WCHD) has adopted Supplementary Local Rules to the Ohio Department of Health Sewage Treatment Rules (ORC Chapter 3701-29). WCHD has included clarification of their opted requirements for installer registration, electrical inspections, soil absorption standards, grey water recycling, and other provisions of the ORC Chapter.

The WCHD staff also provides free consultative services to homeowners who are experiencing problems with their existing sewage treatment system upon receipt of a consultation request.

Table 4-12: Survey Results of Interim Regulations Adopted by the Health Districts of Butler, Clermont, Hamilton and Warren Counties

County	Base Code	Installer Bonding	Installer Testing	System Sizing	Separation Distances (in feet)	Soil Evaluation	Soil Depth Credit	Site Plan, Layout Plan, As-Built Drawing
Butler	2015	yes	yes	Tyler Table	1' seasonal 2' highly impermeable 4' bedrock	soil scientist	yes	installer, designer
Clermont	2015	yes	no	Modified Tyler Table	2' VSD 4' to bedrock	soil evaluator	yes	installer
Hamilton	2015	yes	no	county soils & loading rates	2' VSD 3' to restrive layer and bedrock	soil evaluator & designer	yes	installer, designer
Warren	2015	yes	no	county soils & loading rates & Tyler Table	0" seasonal 4' bedrock	health dist. & soil scientist	yes	installers

Tyler Table: a tabulated series of hydraulic wastewater loading rates to soils, by E.J. Tyler, 2001, part of Ohio's interim Sewage Disposal Rules
VSD: vertical separation distance

Clustered Sewage Service

A simplified approach to wastewater quality management planning typically presents two options for sewage service:

(1) tap into a public sewer network that collects sewage from urbanized or urbanizing areas and delivers it via a system of sewer pipes to a centralized wastewater treatment facility
(2) purchase and install an onsite wastewater treatment system for the sewage generator, which is typically a household or small business in a sparsely developed area beyond the reach of a centralized sewage service utility

An increasingly viable third option for sewage service, especially in lower density developments, is the creation of a clustered sewage system. The U.S. EPA defines a clustered system as "a wastewater collection and treatment system under some form of common ownership that collects wastewater from two or more dwellings or buildings and conveys it to a treatment and dispersal system located on a suitable site near the dwellings or buildings." (*Voluntary National Guidelines for Management of Onsite and Clustered [Decentralized] Wastewater Treatment* Systems, U.S. EPA, 2003) Also known as small community sewage systems, clustered systems have gained more attention through the efforts of the National Small Flows Clearinghouse and National Environmental Services Center, which are funded by the U.S. EPA. As described in *Alternatives for Sewering Unsewered Areas*, Henderson and Bodwell Consulting Engineers LLP, 1998, small community systems fit into three main categories:

Alternative Collection Systems

This category typically includes small diameter pressure and gravity sewers. In contrast to the heavy pipes of conventional gravity flow sewers, this technology uses lightweight polyvinyl chloride (PVC) pipes buried at shallow depths. The approach offers significant cost and construction advantages in areas with:

- sparse population and long sewer lengths between houses

- hilly terrain
- subsurface challenges, such as high groundwater, seasonal water table or shallow bedrock

Pressure sewers can be used with or without septic tanks, depending on the community. Gravity flow sewers are an option where the topography allows, but must be used with septic tanks. Gravity and pumped effluent systems have been combined in hybrid collection systems that may eliminate lift stations.

Natural Treatment and Disposal Systems

Natural systems depend primarily on soil, plants and sunlight to treat wastewater. In most cases, such systems cost less to build and operate than mechanical treatment alternatives, which use more energy. Examples of natural systems are:

- constructed wetlands
- lagoon systems
- subsurface disposal systems
- intermittent sand filters
- recirculating fine gravel filters, which are cost competitive under 100,000 gallons per day
- land application by irrigation, which does not need stream discharge permits

Mechanical Treatment Systems

These combine biological and physical processes into the overall sewage treatment train. Examples include extended aeration "package plants," trickling filters and variations, sequencing batch reactors, and oxidation trenches. Mechanical treatment systems can provide high quality effluent and require less land than natural treatment systems.

According to *Alternatives for Sewering Unsewered Areas,* clustered systems can make sense not only for isolated communities, "but also communities or new developments on the fringe of availability of a regional system which may be at or near capacity, or costly to access." The best type of treatment system for a small community depends on many variables, including:

- nature, source and quantity of sewage
- collection, treatment and disposal options
- capital, operational and maintenance costs versus projected revenues and budgets
- more subjective factors, such as constructability, expandability, regulation and timing
- appropriate management model, which is addressed in Table 4-13

Table 4-13 on the next page addresses decentralized wastewater management models. It originates from *Handbook for Managing Onsite and Clustered (Decentralized) Wastewater Treatment Systems* (U.S. EPA, 2005)

Table 4-13: Decentralized Wastewater Management Models

Typical applications	Program description	Benefits	Limitations
Homeowner Awareness Model			
Areas of low environmental sensitivity where sites are suitable for conventional onsite systems	• Systems sited and built based on prescribed criteria • Maintenance reminders • Inventory of all systems	• Code-compliant system • Ease of implementation • Inventory of systems that is useful for tracking and areawide planning	• No compliance identification mechanism • Sites must meet siting requirements • Cost to maintain database
Maintenance Contract Model			
• Areas of low to moderate environmental sensitivity where sites are marginally suitable for conventional onsite systems due to small lots, shallow soils or low-permeability soils • Small cluster systems	• Systems properly sited and constructed • More complex treatment options (mechanical, home clusters) • Service contracts must be maintained • Inventory of all systems • Contract tracking system	• Lower risk of treatment system malfunctions • Homeowner's investment protected	• Difficulty tracking and enforcing compliance due to reliance on the owner or contractor to report a lapse in services • No mechanism provided to assess the effectiveness of the maintenance program
Operating Permit Model			
• Areas of moderate environmental sensitivity, such as source water protection zones or bathing water contact recreation areas • Systems treating high-strength wastes, or large-capacity systems	• Performance & monitoring requirements • Engineered designs allowed but may provide prescriptive designs for specific sites • Regulatory oversight by issuing renewable operating permits that may be revoked for noncompliance • Inventory of all systems • Tracking and operating permit and compliance monitoring • Minimum for big-capacity systems	• Systems can be located in more environmentally sensitive areas • Regular compliance monitoring reports • Noncompliant systems identified and corrective actions required • Less need for regulation of large systems	• Higher level of expertise and resources for regulatory authority to implement • Requires permit tracking system • Regulatory authority needs enforcement powers
Responsible Management Entity (RME) Operation			
• Areas of moderate to high environmental sensitivity where reliable and sustainable system operation and maintenance is required (Sole Source Aquifers, source water protection zones, critical aquatic habitats, and outstanding value resource waters) • Cluster systems	• System performance and monitoring requirements • Professional O&M services through RME (public or private) • Regulatory oversight by issuing operating or NPDES permits directly to RME, while system ownership remains with property owner • Inventory of all systems • Tracking system for operating permit & compliance monitoring	• O&M responsibility transferred from the system owner to a professional RME that holds the operating permit • Problems identified before malfunctions occur • Onsite treatment in more environmentally sensitive areas or for treatment of high-strength wastes • One permit for a group of systems	• Enabling legislation might be necessary to allow RME to hold the operating permit for an individual system owner • RME must have owner's approval for repairs; might be conflict if performance problems are identified and not corrected • Need for easement or right of entry • Need for oversight of RME by the regulatory authority
Responsible Management Entity Ownership Model			
• Areas of greatest environmental sensitivity, where reliable management is required. Includes Sole Source Aquifers, source water protection zones, critical aquatic habitats, and outstanding value resource waters • Preferred management program for cluster systems serving multiple properties under different ownership	• Establishes system performance and monitoring requirements • Professional management of all aspects of decentralized systems • RMEs own or manage individual systems • Trained and licensed professional owners/operators • Regulatory oversight through NPDES or other permit • Inventory of all systems • Tracking of operating permit and compliance monitoring	• High level of oversight if system problems occur • Model of central sewerage that reduces risk of noncompliance • Treatment in environmentally sensitive areas • Effective planning and watershed management • Potential conflicts between the user and RME removed • Greatest protection of environmental resources and homeowner investment	• Enabling legislation or formation of special district might be required • Might require significant financial investment by RME for installation or purchase of existing systems or components • Need for oversight of RME by the regulatory authority; might limit competition • Homeowner associations may not have adequate authority

The U.S. EPA's *Handbook for Managing Onsite and Clustered (Decentralized) Wastewater Treatment Systems* also includes a framework for exploring the management issues of onsite and clustered wastewater treatment. The framework follows in Table 4-14:

Table 4-14: A Framework for Exploring the Management of Onsite and Clustered Wastewater Treatment Systems

Issue	Questions to be addressed
Time frame	• At what point will the planned management program structure be sustainable? • If the program is sequentially implemented, when will each sequence be completed? • When will the management program be fully operational?
Service area	• What areas or which systems will the management program serve? • Are these areas compatible with a local public jurisdiction that would have the necessary powers to make the program effective and sustainable? • Do specific subareas need different management approaches (system designs, staffing, regulatory controls)?
Purpose	• What public health and water resource problems will be addressed? • What monitoring and measurements should be made to verify success?
Structure	• Can existing entities be modified or be included in a partnership to provide management services; or will a new entity be needed? • Should the management program be limited to decentralized wastewater treatment, or should other water, stormwater, or wastewater infrastructure be included? • How will the program elements of the management program be staffed and administered? • Will formal agreements, ordinances, or other legal mechanisms (articles of incorporation, public charter) be needed to create the structural elements of the program?
Authority and liability	• Which systems will be under the jurisdiction of the management program? • Will the onsite treatment systems be privately or publicly owned? • How will future systems be planned, designed, installed, operated, maintained, inspected, and repaired or replaced? • What is the relationship between the management program and the regulatory authority? • What formal agreements, ordinances or other legal mechanisms (e.g., with system or property owners) are necessary to implement each element of the program? • How will the program be funded through its planning, construction and operational phases?

The Ohio Department of Health has recognized decentralized wastewater management as an alternative to centralized sewage service or onsite sewage treatment. In its *Survey of Household Sewage Treatment Systems Operation and Failure Rates in Ohio*, ODH states, "Decentralized management offers a public and private sector tool that provides assistance and support to system owners, offers a cost structure that is affordable, and helps ensure that systems in wide range of density configurations are properly managed."

Potential Problem Areas

As the designated water quality management planning agency for its region, OKI has repeatedly tracked potential problem areas for onsite wastewater treatment systems. Though it does not have regulatory, police or proprietary powers over onsite systems, OKI collaborates with county health districts, conservation districts, sewer districts, watershed groups and others to help identify and address the places where onsite systems threaten or degrade water quality. From a regional perspective, the three key indicators to potential problem areas are:

1. Where water quality monitoring, assessment and evaluation programs indicate water pollution by onsite systems

2. Where the soils or other natural characteristics are unsuitable for most onsite systems
3. Where onsite systems are concentrated in relatively dense patterns

For the first indicator of potential problem areas, OKI refers often to the work of the Ohio EPA, especially:

- integrated biennial water quality monitoring and assessment reports
- biological and water quality studies
- total maximum daily load reports

Other sources of useful water quality data include the U.S. Geological Survey, U.S. EPA, Ohio Department of Natural Resources, Ohio Department of Health, local health departments, soil and water conservation districts, stormwater districts, sewer districts, local universities, watershed groups, consulting firms and member local governments. OKI also works with two volunteer stream monitoring programs to gain a better understanding of potential problem areas.

For the second indicator of potential problem areas, OKI first worked with the Soil Conservation Service (now the Natural Resources Conservation Service) and local health departments to map three general categories of soil suitability for onsite systems. OKI later reviewed and updated its soil suitability maps in collaboration with the Soils Information Manager for the Ohio Department of Natural Resources. The updated maps are shown as Figures 4-15 through 4-18. The categories of soil suitability are explained by text that precedes the four maps.

For the third indicator of potential problem areas, OKI confers with county health districts and sewer districts. As residential development spreads or intensifies and centralized sewage service reaches out to some but not all suburbanizing areas, the locations of onsite system concentrations change. This compels OKI to periodically update and refine its geo-spatial data about onsite system concentrations. Such work began more than 20 years ago, when OKI stated: "The distribution of onsite systems is indicative of potential water quality problems. Where onsite systems are concentrated, their location is of special concern because their high densities potentially contribute to surface and groundwater contamination. Even if individual systems function properly, the cumulative effect of multiple systems in a limited area may degrade water quality, creating nuisance problems and possible health hazards." (*Onsite Wastewater Treatment Systems in Clermont County, Ohio*, OKI, 1987)

Currently, OKI's geographic information system (GIS) identifies any place with 100 or more onsite systems per square mile as an area with a high concentration of onsite systems. By that standard, Hamilton County clearly has the most land area covered by onsite system concentrations in the four-county study area. Butler County has the second largest land area with onsite concentrations, followed distantly by Warren and Clermont counties. Water quality management planners find it useful to analyze onsite system concentrations in relation to stream impairments, watershed boundaries, wastewater facility planning area boundaries, political jurisdictions and a variety of natural features. Figures 4-19 through 4-22 show the locations of onsite system concentrations in Butler, Clermont, Hamilton and Warren counties in relation to the surface waters in each county.

In 2018 and 2019 OKI completed an updated analysis in an attempt to further identify areas of onsite systems that should be prioritized for replacement or elimination in Butler, Clermont, and

Hamilton Counties (Warren County will be completed in 2020-2021). Onsite systems in each county were evaluated using a weighted raster system using available water resource, water quality, and system density data to create heat maps. These heat maps showed locations where existing onsite systems impact water quality the most. Figure 4-23 shows the data sets used and the weight assigned to them. OKI worked with health department staff to determine which data sets should carry the most weight. Those choices also reflect the availability of data. In some instances, such as streams identified as impaired by HSTS or onsite systems, data was not available for streams in the region reflecting gaps in analysis by Ohio EPA.

OKI then used the heat maps to identify areas most likely to be contributing to water quality impairments. Figures 4-24-29 show the results of this analysis.

Figure 4-19: Butler County Concentrations of Onsite Wastewater Treatment Systems in Relation to Surface Waters

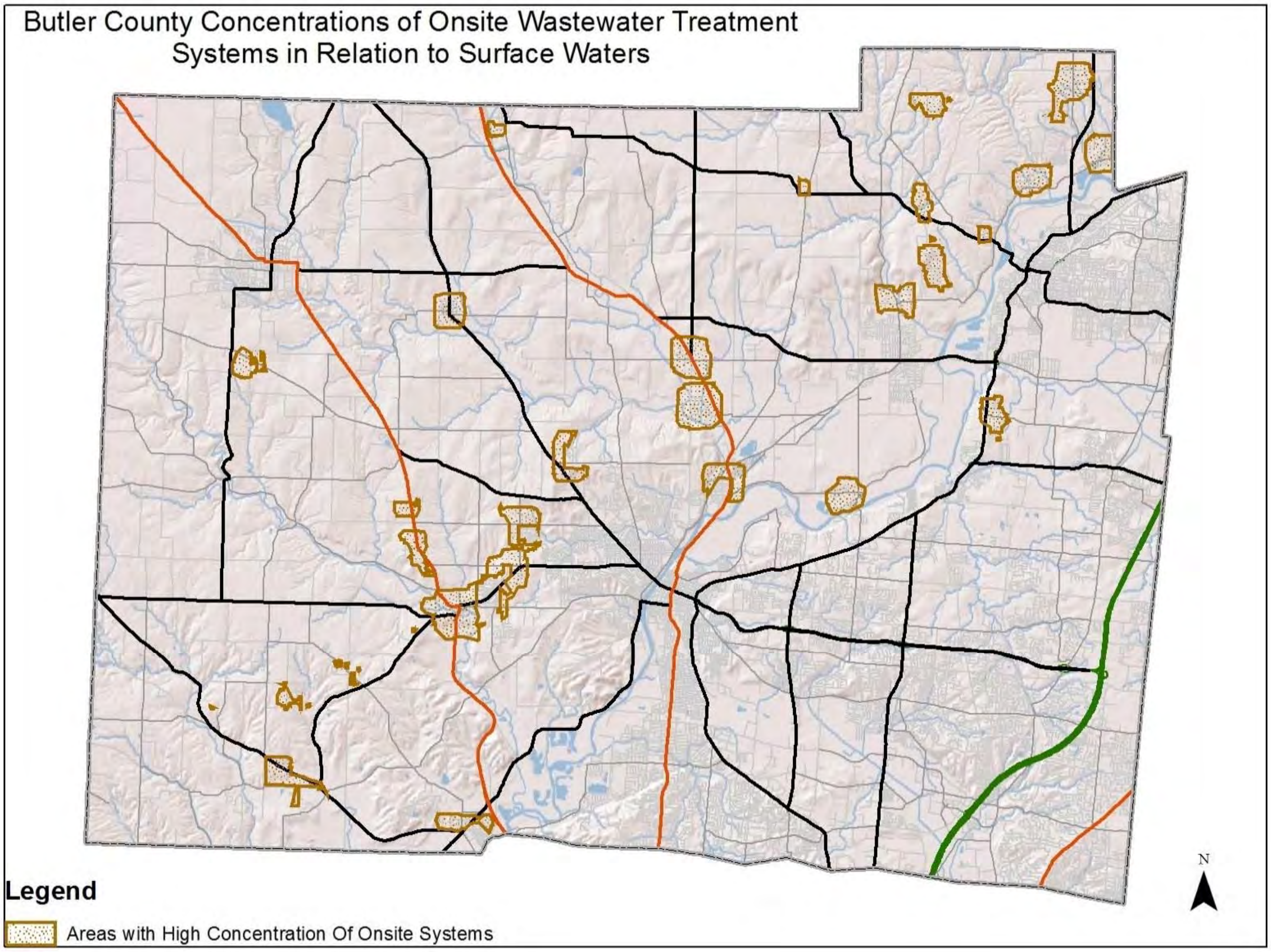


Figure 4-20: Clermont County Concentrations of Onsite Wastewater Treatment Systems in Relation to Surface Waters

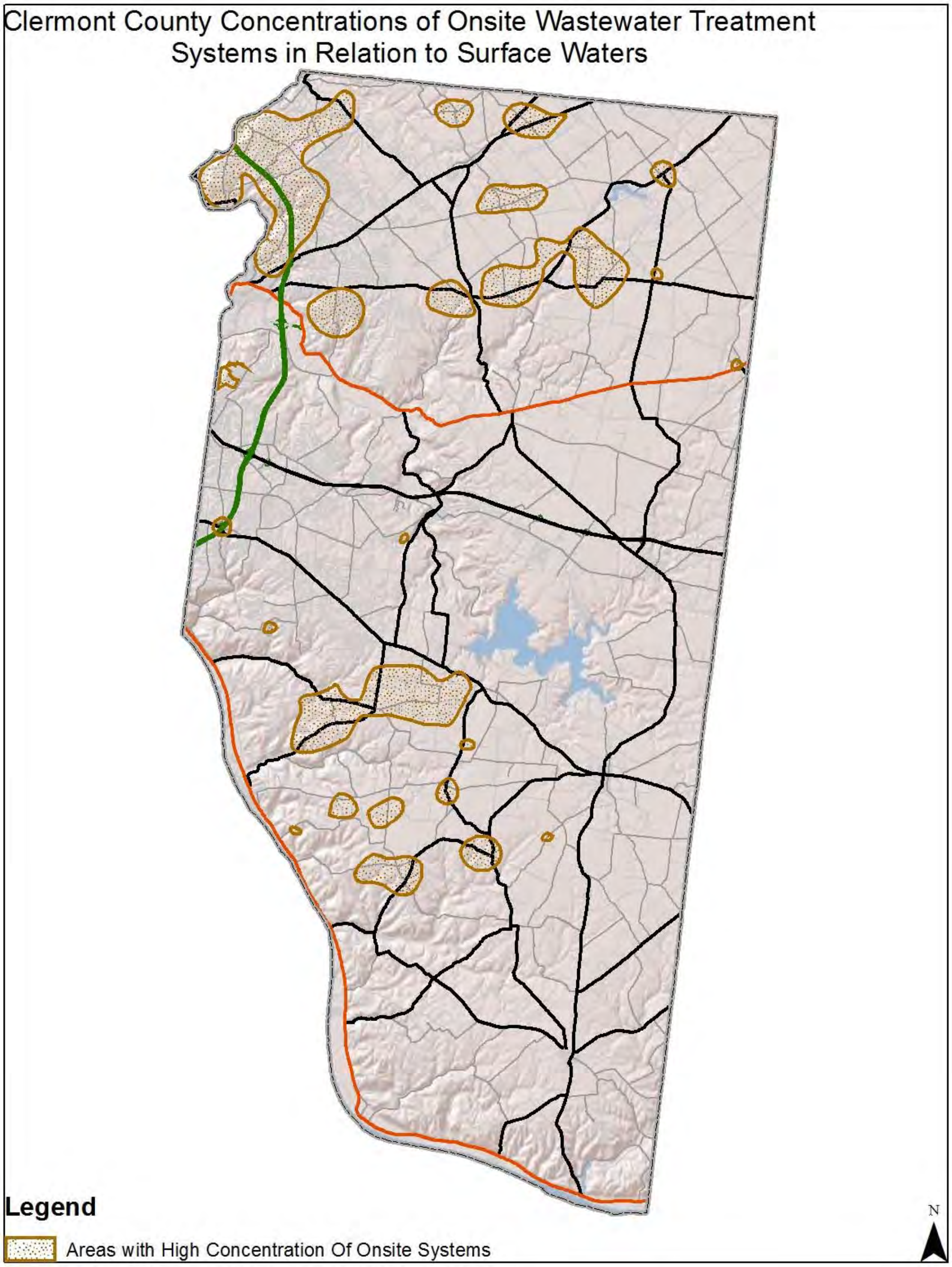


Figure 4-21: Hamilton County Concentrations of Onsite Wastewater Treatment Systems in Relation to Surface Waters

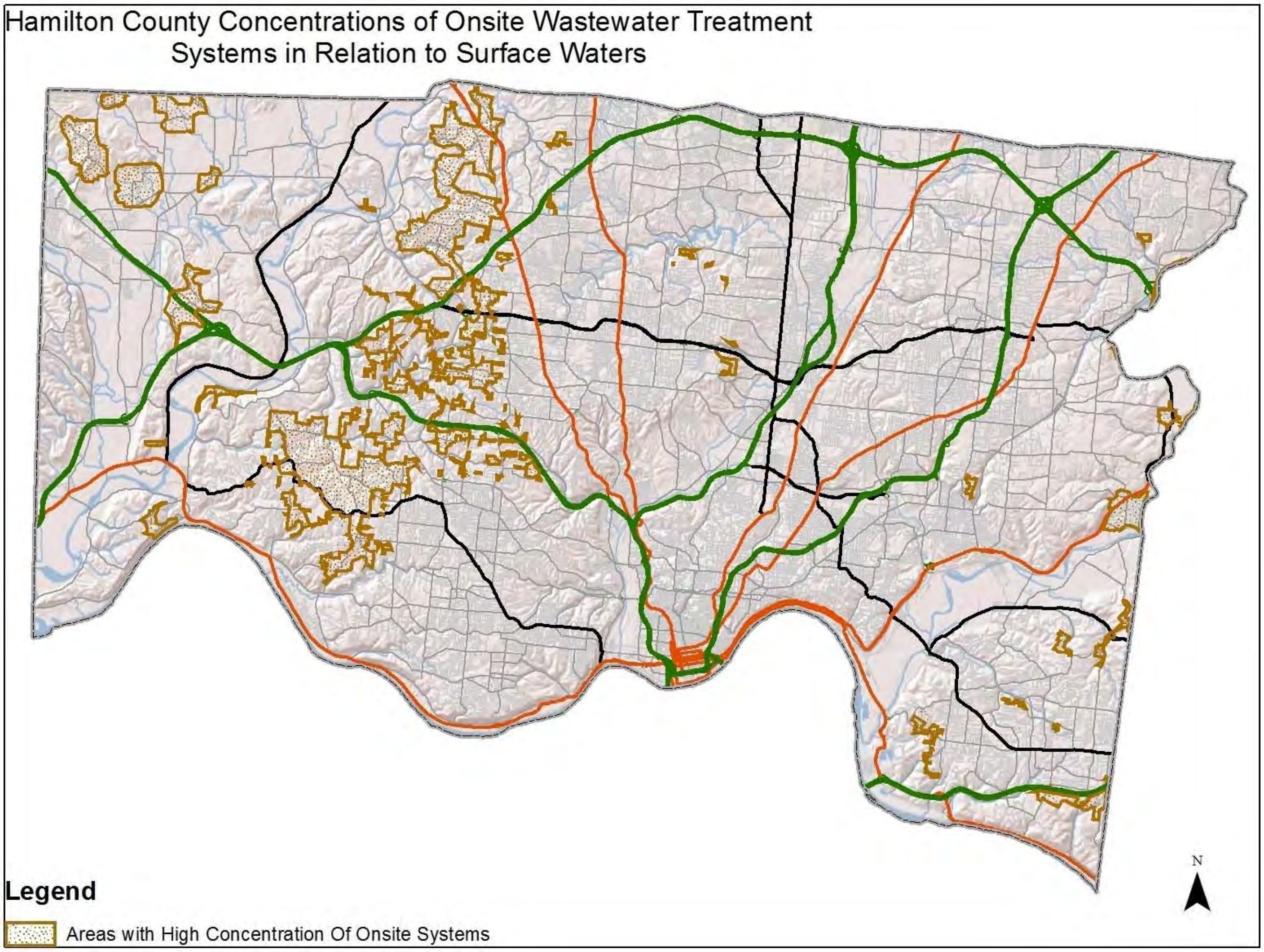


Figure 4-22: Warren County Concentrations of Onsite Wastewater Treatment Systems in Relation to Surface Waters

Figure 4-23 2018-2019 Raster Weighting Diagram

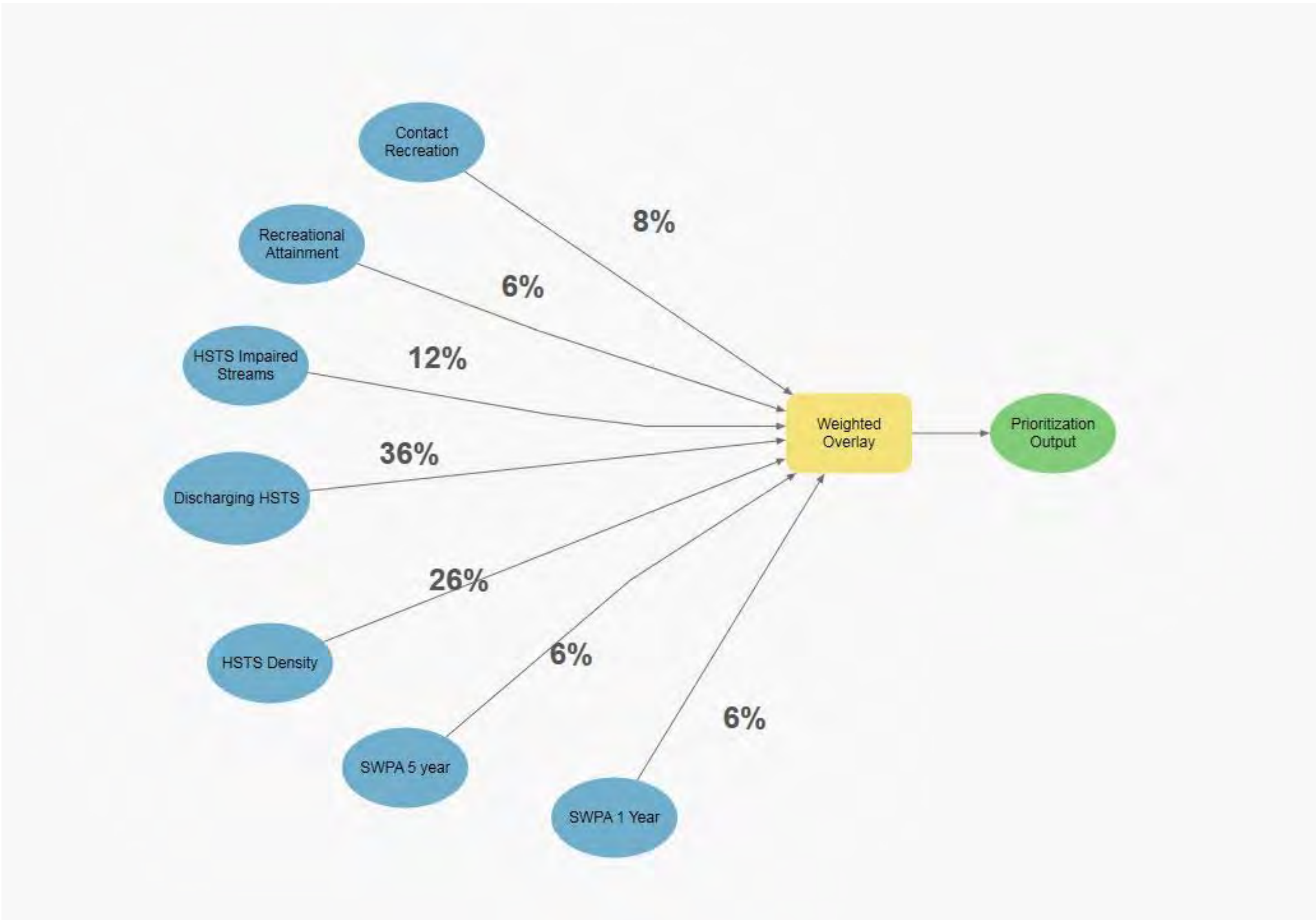


Figure 4-24 Butler County Onsite System Raster Analysis Heat Map

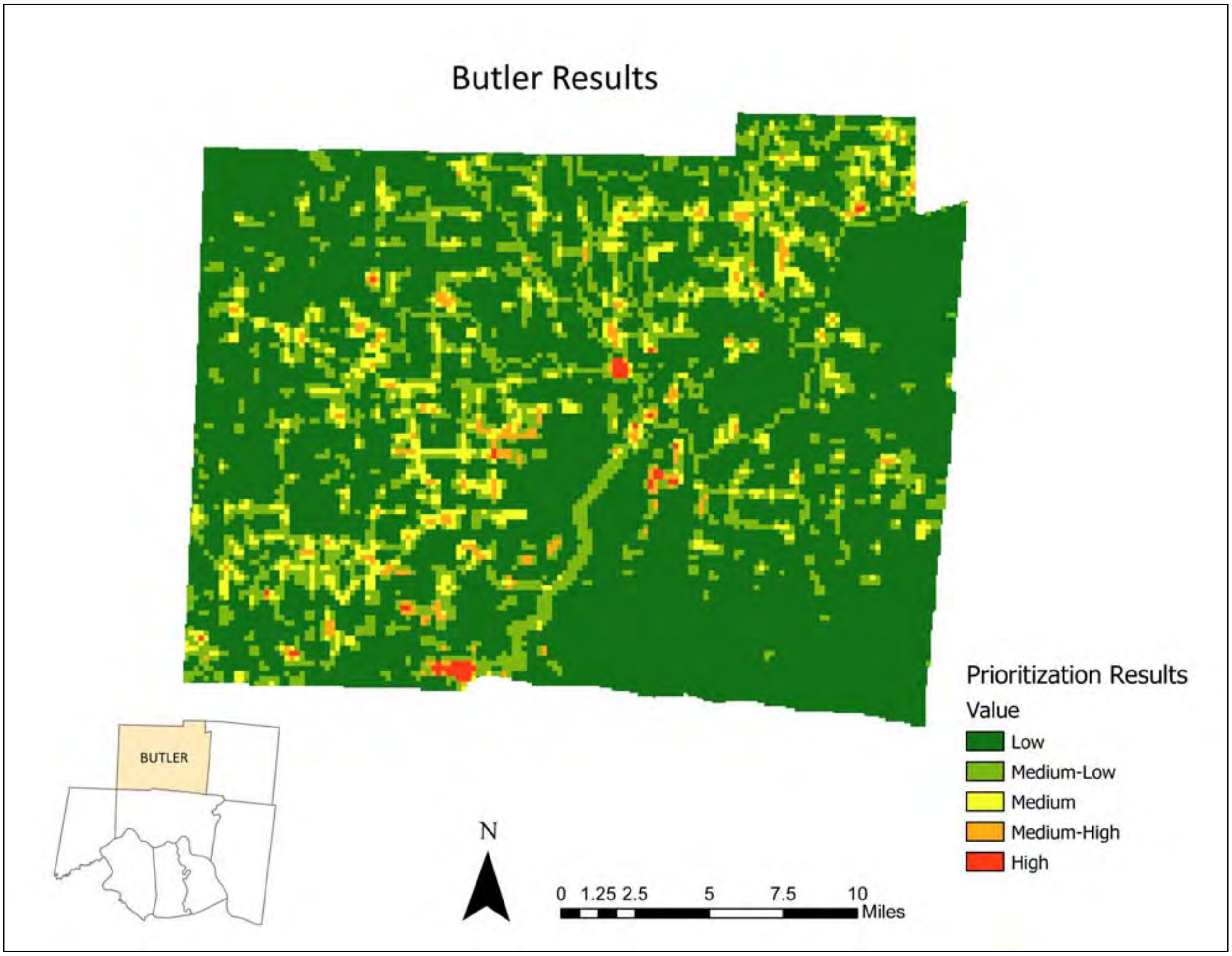


Figure 4-25 Butler County Onsite System Priority Areas

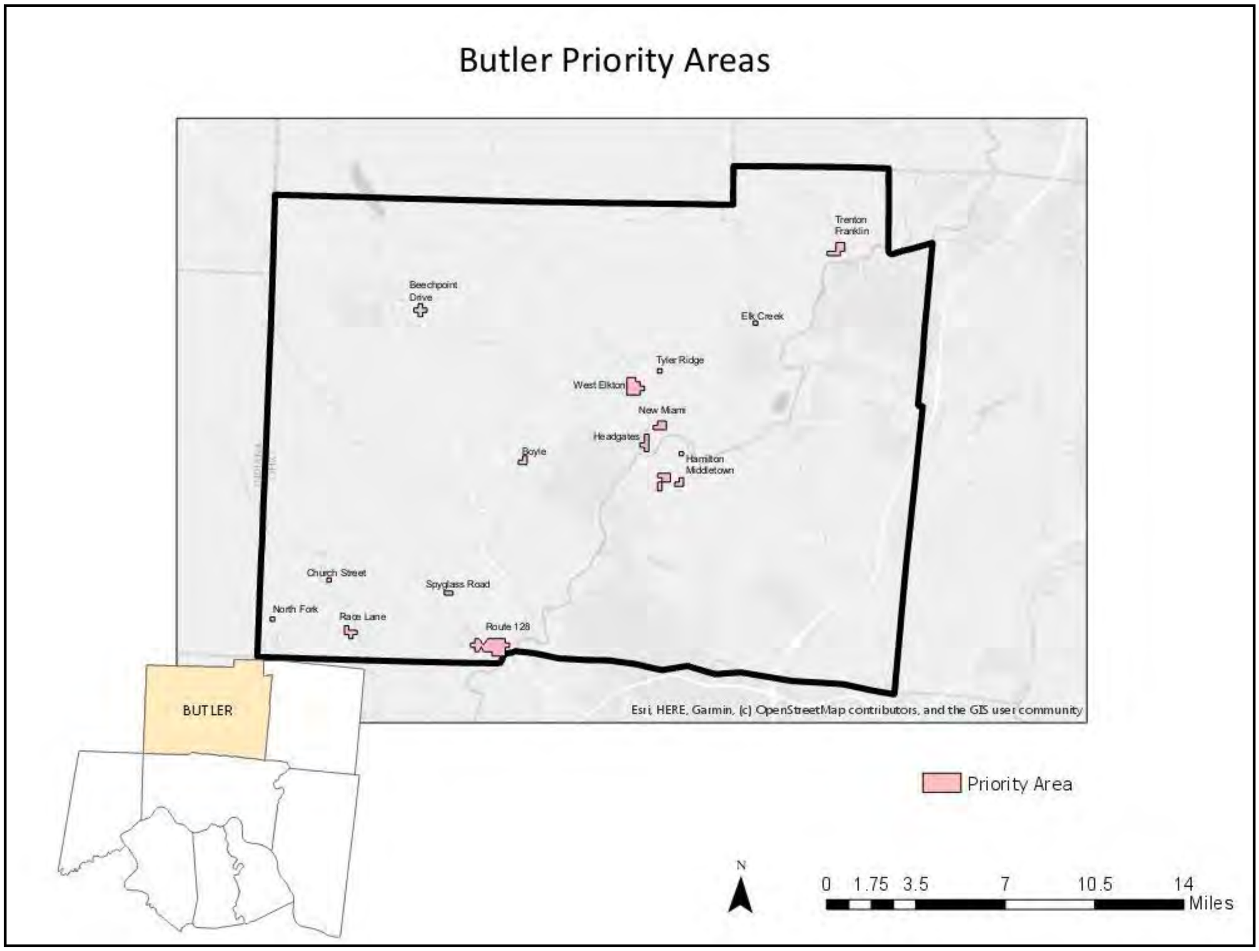


Figure 4-26 Clermont County Onsite System Raster Analysis Heat Map

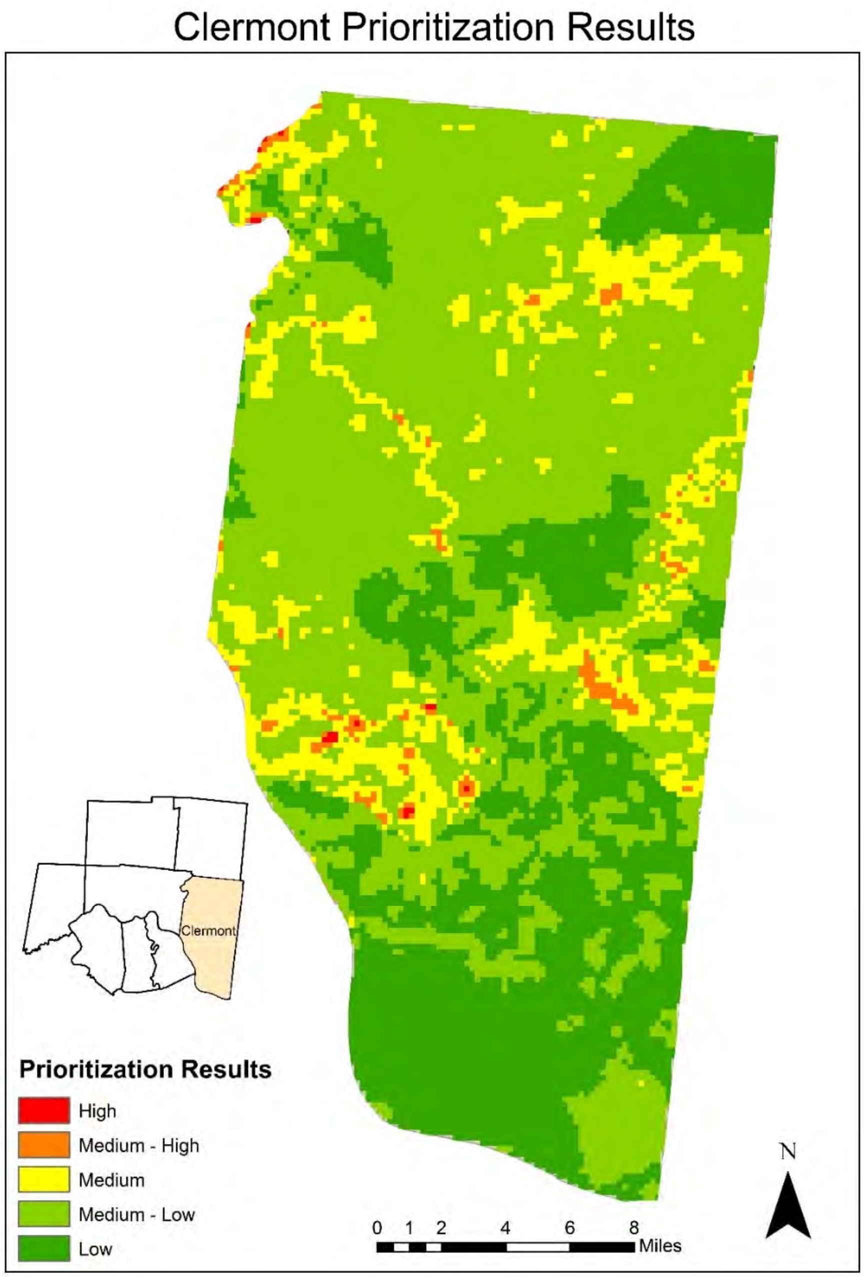


Figure 4-27 Clermont County Onsite System Priority Areas

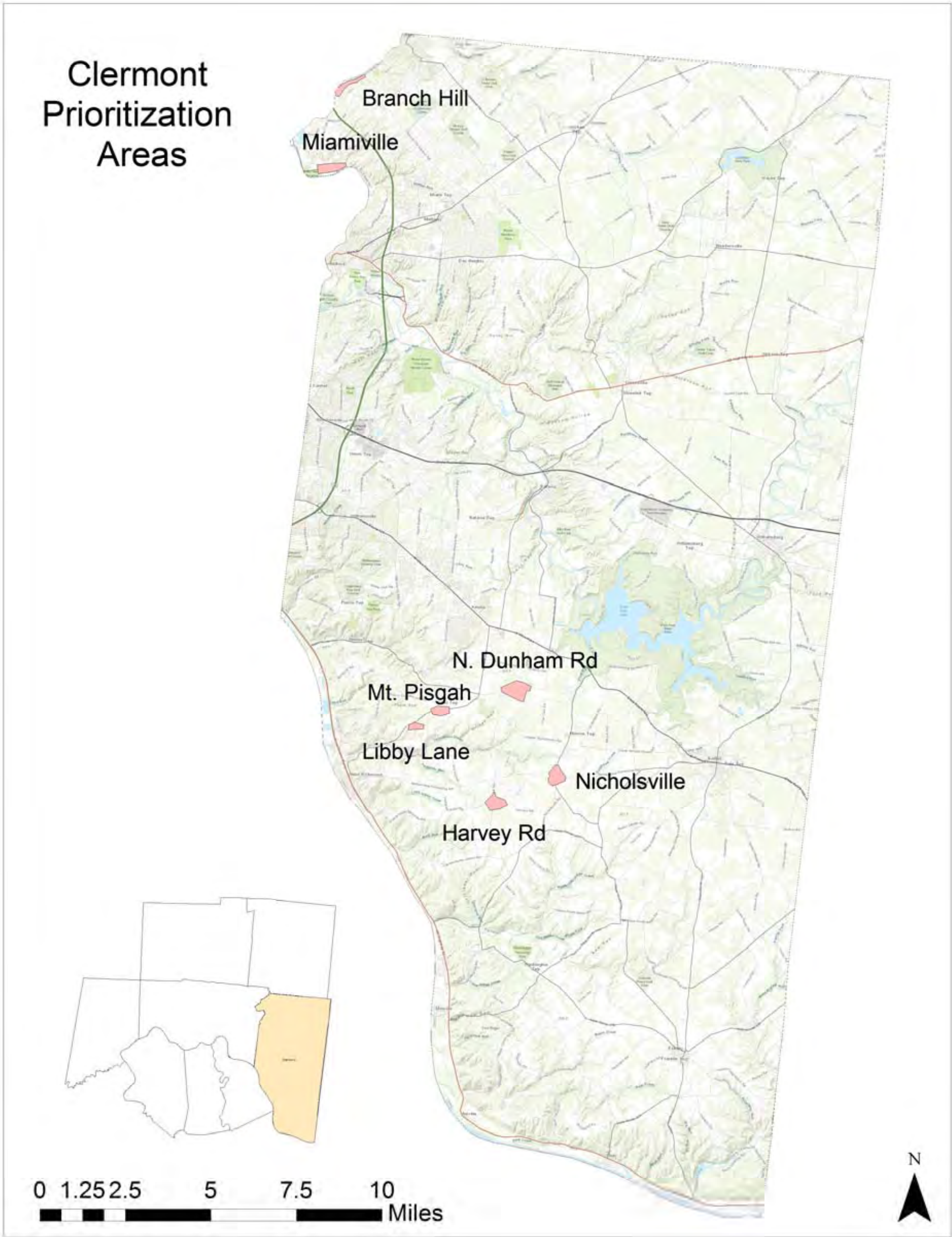


Figure 4-28 Hamilton County Onsite System Raster Analysis Heat Map

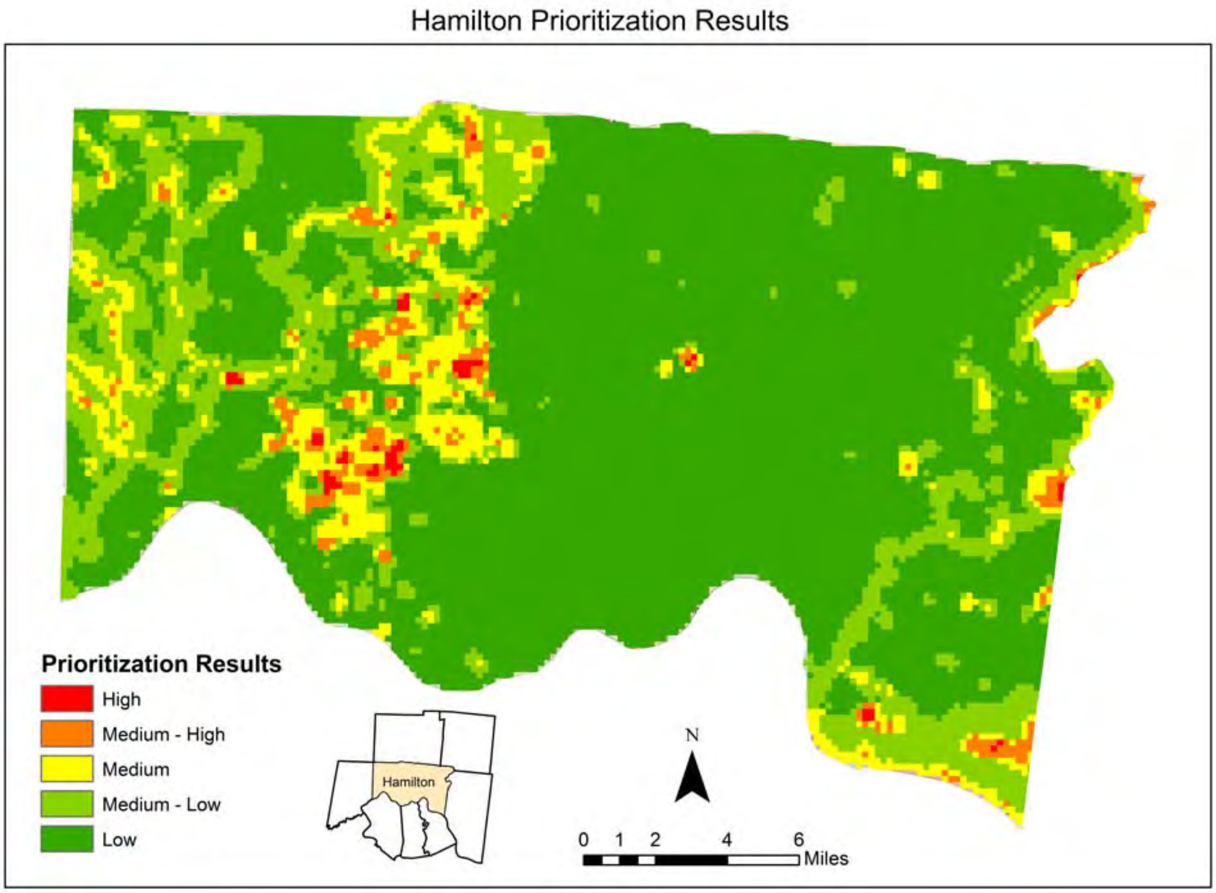
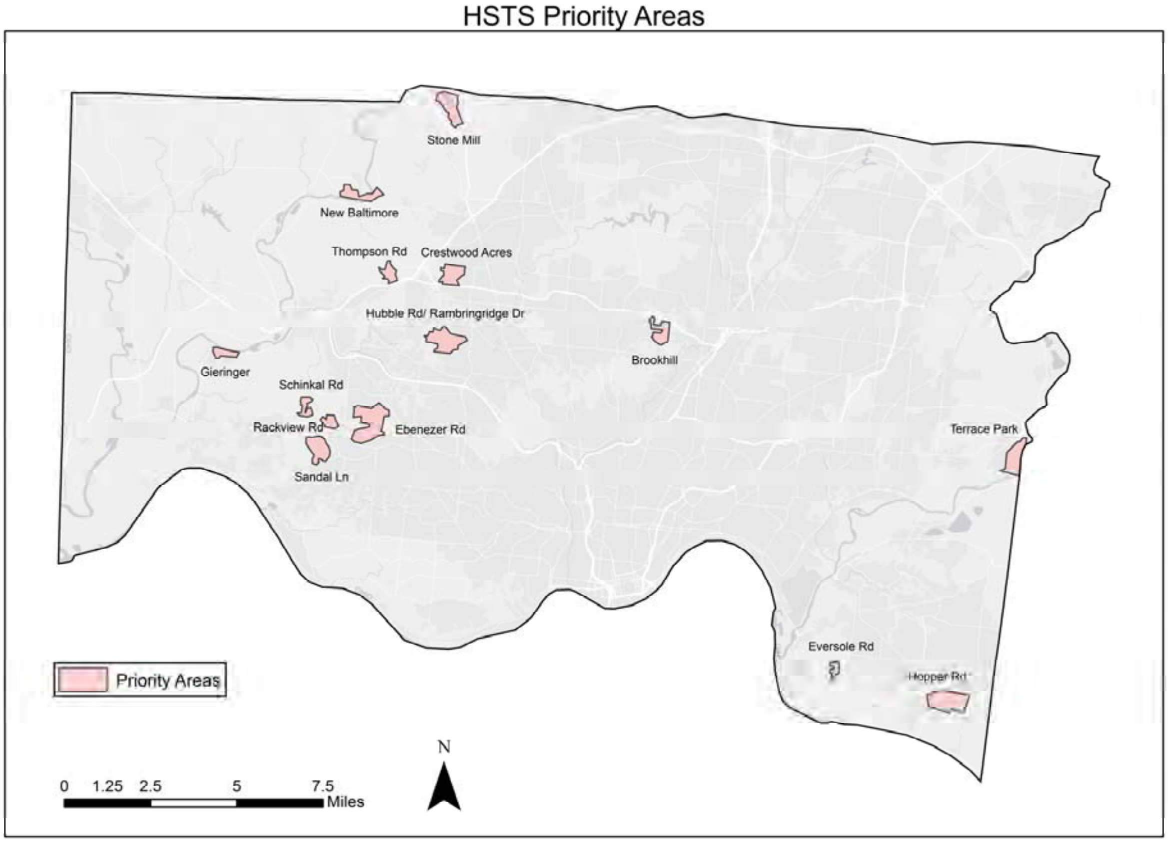


Figure 4-29 Hamilton County Onsite System Priority Areas



While county health districts have provided OKI with detailed data on the numbers and distributions of onsite systems, the Ohio Department of Health has summarized where stream impairments are attributable to onsite systems. According to the *Survey of Household Sewage Treatment Systems Operation and Failure Rates in Ohio* (ODH, 2008), the following watersheds in OKI's four-county study area are impaired by "household sewage treatment systems:"

- **Four Mile Creek** (ending in Butler County) − ODH recommends "better septic system management." It identifies "livestock and agriculture" as "other sources of impairment." Seven Mile Creek, a tributary to Four Mile Creek, is in full attainment of water quality standards for recreational activities. Four Mile Creek, however, is in non-attainment of water quality standards for recreational activities that put people in contact with the stream's water. Recreationally impaired tributaries to Four Mile Creek are Darr's Run and Fleisch Run. Bacteria is the cause of impairment. No failing home systems were reported for the Seven Mile Creek subwatershed, but 500 failing systems were reported for the Four Mile Creek subwatershed.

- **Indian Creek** (in Butler County) − "Better septic system management" is recommended. "Livestock and agriculture" are identified as "other sources of impairment." Indian Creek is in non-attainment of water quality standards for recreational activities. Recreationally impaired tributaries to Indian Creek are Little Indian Creek, Lick Run, Salmon Run and Reserve Run. Bacteria is the cause of impairment. The number of failing home systems was not reported.

- **Upper Little Miami River** (ending in Warren County) − "Better septic system management" is recommended. "Phosphorus and ammonia" are named as "other sources of impairment." The river segment is in non-attainment of water quality standards for recreational activities. Recreationally impaired tributaries to the upper Little Miami River are Gladys Run and Caesar Creek, where pathogens are identified as the source of impairment. The reported number of failing home systems was 25 for Gladys Run and 800 for Caesar Creek.

- **Mill Creek** (in Butler and Hamilton counties) − "Better watershed management" is recommended. "Municipal discharges" are identified as "other sources of impairment." The urban stream is in non-attainment of water quality standards for recreational activities. Recreationally impaired tributaries to Mill Creek are Town Run, Congress Run and East Fork Mill Creek. Bacteria is the cause of impairment. The number of failing home systems was not reported.

- **Twin Creek** (ending in Butler and Warren counties) − "Better septic system management" is recommended. "Agriculture" is identified as another source of impairment. The Great Miami tributary is in non-attainment of water quality standards for recreational activities. Bacteria is the cause of impairment. The number of failing home systems was not reported.

It is worth noting that the ODH's survey report of 2008 divided the findings by eleven-digit hydrologic unit code (HUC 11) boundaries. The Ohio EPA has since switched to 12-digit hydrologic unit code (HUC 12) boundaries, which in some cases subdivide the HUC 11 watersheds into smaller HUC 12 units.

The Ohio EPA's Division of Surface Water has identified watersheds in which onsite systems are believed to be sources (origins) of impairment to the aquatic life uses of rivers and streams. According to the division's online Watershed Assessment Unit Summaries, the following watersheds in OKI's four-county study area are aquatically impaired in part by "onsite wastewater systems (septic tanks)" or "unpermitted discharge (domestic wastes)"

- **Middle Caesar Creek** (partly in Warren County) − Hydrologic Unit Code [HUC] of 050902020404 "Onsite wastewater systems (septic tanks)" are one of five types of sources of impairment to the watershed's aquatic life uses.
- **Flat Fork** (partly in Warren County) − HUC 050902020405 "Onsite wastewater systems (septic tanks)" are one of five types of sources of impairment to aquatic life uses.
- **Lower Caesar Creek** (partly in Warren County − HUC 050902020406 "Onsite wastewater systems (septic tanks)" are one of five types of sources of impairment.
- **Second Creek** (partly in Warren County) − HUC 050902020702 "Unpermitted discharges (domestic wastes)" are one of four types of sources of impairment.
- **Solomon Run-East Fork Little Miami River** (partly in Clermont County) − HUC 050902021101 "Onsite wastewater systems (septic tanks)" are one of three types of sources of impairment.
- **Five Mile Creek-East Fork Little Miami River** (partly in Clermont County) − HUC 050902021102 "Onsite wastewater systems (septic tanks)" are one of three types of sources of impairment.
- **Todd Run-East Fork Little Miami River** (partly in Clermont County) − HUC 050902021103 "Onsite wastewater systems (septic tanks)" are one of three types of sources of impairment to the watershed's aquatic life uses.
- **Poplar Creek** (partly in Clermont County) − HUC 050902021201 "Onsite wastewater systems (septic tanks)" are one of six types of sources of impairment.
- **Cloverlick Creek** (partly in Clermont County) − HUC 050902021202 "Onsite wastewater systems (septic tanks)" are one of six types of sources of impairment.
- **Lucy Run-East Fork Little Miami River** (entirely in Clermont County) − HUC 050902021203 "Onsite wastewater systems (septic tanks)" are one of six types of sources of impairment.
- **Backbone Creek-East Fork Little Miami River** (entirely in Clermont County) − HUC 050902021204 "Onsite wastewater systems (septic tanks)" are one of six types of sources of impairment to the watershed's aquatic life uses.

It is worth noting that the Ohio EPA's conversion from 11-digit and 14-digit hydrologic unit codes (HUC 11 and HUC 14) to 10- and 12-digit codes caused the state agency to transfer data for a single HUC 11 watershed to one or more HUC 12 subwatersheds carved out of the former HUC 11 watershed. This caused overgeneralization in some cases. More precise evaluations will gradually be possible as the Ohio EPA monitors watersheds by the newer HUC 12 system.

Total maximum daily load (TMDL) reports and watershed management plans also identify watersheds where onsite systems are degrading surface water quality. Examples follow.
The TMDL report for the upper Little Miami River partly attributes nutrient enrichment from "failing septic systems" and "wastewater loadings" in the Little Miami River above Caesar Creek and in Caesar Creek, from South Branch to Caesar Lake. Page 61 of the report states: "Septic systems impact water quality in the upper Little Miami River watershed through both point and nonpoint discharges from failed, faulty, or discharging systems and improper disposal of wastes (septage) from septic systems."

The watershed management plan for headwaters of the East Fork Little Miami River says some onsite systems in the watershed "are not providing adequate wastewater treatment due to a variety of reasons that include poor design, poor construction, or installation of a system inappropriate for the soil type." The plan also notes that "failing septic systems" contribute excessive nutrients and biological oxygen demand to the watershed's streams.

The watershed management plan for the lower East Fork Little Miami River provides detailed information about onsite systems in the Clermont County drainage basin. It states that "an estimated 1,517 parcels rely on septic systems, although only 800 systems have been recorded by the County Health Department. It is assumed that the remaining 717 parcels are also served by septic systems, since it is known that these parcels are not served by central sewer."

According to the lower East Fork plan, the Clermont County General Health District "estimates that 570 soil absorption systems were placed in soils not suitable for onsite effluent disposal." The Health District also estimates that 1064 systems are over 25 years old. "Many of these systems were not designed to handle today's flows, fail to meet current codes, and may result in system failures. Most onsite sewage systems designed for homes that used a cistern for their water source have since been connected to a public water supply. In many of these cases, the homes' septic system were never upgraded to accommodate the higher flows associated with an "unlimited" public water supply. Failures are likely in such situations."

The lower East Fork plan continues that "septic systems in areas of Avonburg, Clermont and Blanchester soils are most likely to be failing. These soils are more common in the Shayler Run subwatershed, especially in the southernmost third of the watershed. Additionally, septic systems on soils with greater than 6 percent slope (and especially greater than 12 percent slope) may be allowing untreated waste to surface downslope. Sloping soils are more common in the Lower East Fork subwatershed."

Onsite system installation practices are also addressed in the lower East Fork plan, which states: "On small crowded lots or other poorly planned properties, improper landscape positioning of sewage systems has resulted in many soil absorption systems being installed off contour, in places with disturbed soil, or placed in poorly drained areas. Small properties also do not account for an adequate septic system replacement area."

The watershed management plan for tributaries to East Fork Lake says a percentage of the onsite systems are providing inadequate wastewater treatment for a variety of reasons. It adds: "Because of seasonal ponding common to the Avonburg, Blanchester and Clermont soils, approximately 60% of the watershed is not suitable for traditional leach-field home sewage treatment systems

(HSTS). When a HSTS is not providing adequate treatment of wastewater, untreated sewage will collect on the ground surface or be carried directly to a ditch or stream."

The watershed management plan for the middle East Fork Little Miami River says the watershed has about 1,134 onsite systems, of which 532 are discharging systems.

The watershed management plan for Stonelick Creek says the predominantly Clermont County watershed has about 3,608 onsite systems, of which 1,332 are discharging systems. "Some local estimates put the percentage of failing systems in the Stonelick Creek watershed at 10%, which means that 133 of the 1,332 discharging systems are failing."

The watershed management plan for Todd's Fork says that "nutrient loading, caused by poor or failing septic systems, affects the water quality of Cowan Lake."

The TMDL report for the Mill Creek watershed lists "onsite sewage systems" among the multiple sources of impairment to aquatic life uses of the urban watershed.

The watershed management plan for the upper Mill Creek says the watershed has about 100 Butler County residences with onsite, non-mechanical sewage systems. None of the onsite systems are known to have discharges. The plan expresses reservations about soil suitability for onsite systems, saying, "soil characteristics that limit the treatment of sewage in soil absorption systems are common in the upper Mill Creek watershed." It adds that "slow percolation in the subsoil is common throughout the watershed, and some areas also have a seasonal high water table, steep slopes, or flooding hazards."

Recommendations

OKI's first report about onsite issues stated "Onsite treatment of wastewater is responsible for significant problems in the OKI region." (*Onsite Wastewater Treatment Systems*, OKI, 1978) Though more than 40 years have passed, the statement remains true to this day, even as various agencies and organizations have issued dozens of recommendations on how best to deal with onsite problems. What follows are those recommendations that are most pertinent to the current situation with onsite systems in Butler, Clermont, Hamilton and Warren counties.

Recommendations by Ohio EPA

- Refer to the Ohio EPA's list of impaired watershed assessment units, particularly watersheds for which "onsite wastewater systems (septic tanks)" or "unpermitted discharge (domestic wastes)" are listed as a source of impairment to a stream segment's aquatic life uses

Recommendations by U.S. EPA

(from *Onsite Wastewater Treatment Systems Manual, Chapter 2: Management of Onsite Wastewater Treatment Systems*, U.S. EPA, 2002)

- Integrate comprehensive planning and zoning programs with onsite wastewater program management to provide a stronger foundation for determining the appropriate level of treatment needed for both the individual site and the surrounding watershed

- Consider onsite management by having these elements in a comprehensive planning program:
  - Define management program boundaries
  - Select management entity or entities
  - Establish human health and environmental protection goals
  - Form a planning team composed of management staff and local stakeholders
  - Identify internal and external planning resources and partners
  - Collect information on regional soils, topography, rainfall, water quality and water quantity
  - Identify sensitive ecological areas, recreational areas, and water supply protection areas
  - Characterize and map past, current and future development where onsite wastewater treatment systems are necessary
  - Coordinate with local sewage authorities to identify current future service areas and determine treatment plant capacity to accept septage
  - Identify documented problem areas and areas likely to be at risk in the future
  - Prioritize and target problem areas for action or future action
  - Develop performance requirements and strategies to deal with existing and possible problems
  - Implement strategy; monitor progress; modify strategy if necessary
- Consider the establishment of onsite system performance requirements at a watershed scale by taking the following steps:
  - Identify receiving waters (groundwater, surface waters) for onsite system effluents
  - Define existing and planned used for receiving waters (e.g., drinking water, recreation, aquatic life use)
  - Identify water quality standards associated with designated uses (as set by Ohio EPA)
  - Determine types of onsite-generated pollutants (e.g., nutrients) that might affect use
  - Identify documented problem areas and areas likely to be at risk in the future
  - Determine whether onsite pollutants pose risks to receiving waters
  - If there is a potential risk:
    - Estimate existing and projected onsite contributions to total pollutant loadings
    - Determine whether onsite pollutant loadings will cause or contribute to violations of water quality or drinking water standards
    - Establish maximum output levels (mass or concentration in the receiving water body) for specified onsite effluent pollutants based on the cumulative load analysis of all sources of pollutants of concern
    - Define performance boundaries for measurement of onsite effluent and pollutant concentrations to achieve watershed- and site-level pollutant loading goals

Recommendations by American Planning Association

(from *Planning Issues for On-Site and Decentralized Wastewater Treatment*, APA, Planning Advisory Service, 2006)

Five recommendations "stand out for planners working in communities with decentralized wastewater treatment systems." They are printed below, verbatim from the APA publication:

- "First, health and sanitary codes should never be a replacement for planning and growth management controls. Communities should plan as if decentralized wastewater treatment systems can be placed anywhere and for all types of development. This allows communities to be ready for development that might occur as new technologies become available or as the economics of projects allow investment in existing but previously unaffordable technologies.

- Second, communities should plan for both those areas that should be served by centralized sewerage systems and those that should be served by decentralized systems. Issues of cost, community service, desirable densities, and water quality should all be considered in making these decisions.
- Third, although design of decentralized wastewater treatment is typically the province of other professionals, planners should understand the technology and the issues enough to understand how wastewater treatment influences the way a community develops.
- Fourth, planners can bring to the table the skills necessary to ensure that decentralized wastewater systems are managed correctly, especially in communities that choose to adopt waste management districts.
- Fifth, and finally, all of these issues should be considered when reviewing project specific applications to ensure that a community's overall planning objectives are not lost in the review of a specific project."

Recommendations by OKI Regional Council of Governments

(from *On-Site Wastewater Treatment Systems*, OKI, 1978)

- In areas where better operation and maintenance will not alleviate onsite problems, funding assistance should be sought from the Ohio EPA.
- In areas where better operation and maintenance will alleviate the problems, public information programs should be encouraged. Municipal ordinances or township resolutions that encourage water conservation and septic tank pumping should be considered. Surface discharge systems should be regularly monitored.

(from *On-Site Wastewater Treatment Systems in Clermont County, Ohio,* 1987)

- Evaluate the local applicability and monitor the performance of alternative onsite systems.
- Institute provisions to de-certify or fine installers who do inferior work.
- Sponsor a seminar to promote developers' and public officials' understanding of the most appropriate types of onsite systems for local conditions.
- Make OKI's map of "soil suitability for onsite systems with leach fields" available.
- Periodically notify homeowners of the need for septic pump-outs.
- Encourage pre-sale inspections of onsite systems prior to real estate transactions.
- Install permanent signs with maintenance guidelines in homes with onsite systems.
- Evaluate new recordkeeping forms and associated databases.
- Establish a sampling program for private wells in areas with onsite systems.
- Monitor drainage systems, ditches and small tributaries in problem areas or areas with the largest onsite system concentrations.
- Monitor streams in watersheds with more than 100 onsite systems in concentrations.
- Do not use evapotranspiration systems during the times of year when precipitation exceeds evapotranspiration.
- Monitor the groundwater around soil absorption systems installed in soils with high groundwater tables for longer than a year to determine whether untreated effluent contaminates the groundwater.
- Include soil morphological features, such as 3-chroma mottles and iron and manganese nodules or cutans, in site evaluations to obtain a more accurate prediction of the presence and duration of the high groundwater table.

OKI's Current Recommendations

- Contingent on available funding, OKI staff should develop profiles of watersheds with impaired stream segments and significant numbers of malfunctioning onsite systems. Those watersheds to be profiled could be selected through consultations among OKI, the Ohio EPA, local health districts and soil and water conservation districts. To increase collaboration with the local health districts and conservation districts, OKI would strive to profile at least one watershed in each of these counties: Butler, Clermont, Hamilton and Warren.
- OKI should arrange for qualified guest speakers to address onsite management issues in Butler, Clermont, Hamilton and Warren counties at one of the public forums for which OKI provides a meeting place, logistical support and promotional communications, such as the Groundwater Committee, Regional Conservation Council, or Regional Planning Forum.
- OKI should provide links and/or space on its website, social networking sites and lobby displays for educational materials and reports about onsite system issues.
- Contingent on available funding, OKI staff should work with local health districts to periodically update and refine geo-spatial data about onsite system concentrations in Butler, Clermont, Hamilton and Warren counties.
- Contingent on available funding, OKI should work with the study area's volunteer monitoring programs that have been certified by the Ohio EPA as credible data sources, including Saturday Stream Snapshot in Clermont County, Great Miami River Watershed Monitoring Project in Hamilton County and the Butler County Stream Team at Miami University.