National Decentralized Water Resources
Capacity Development Project





Creative Community Design and Wastewater Management

University of Rhode Island Cooperative Extension
Kingston, Rhode Island

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Creative Community Design and Wastewater Management

Submitted by the University of Rhode Island Cooperative Extension Kingston, RI

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ABSTRACT

This manual demonstrates how advanced decentralized wastewater treatment systems can be used to support more compact land use patterns that would otherwise be infeasible with conventional wastewater treatment systems. Without rigid design restrictions and often with smaller land area requirements, alternative wastewater treatment systems can free land use planners and engineers to let land use goals and resource protection needs guide land development design. Properly managed alternative and cluster systems enable communities to remediate failing or substandard systems, revitalize traditional development, and direct investment to new growth centers. Perhaps most importantly, these approaches offer a practical alternative to conventional sewers, which enables communities to avoid the three most commonly associated pitfalls: high cost of sewers, loss of control over land use with intensified development pressures, and associated environmental impacts of urbanization, including dramatic increases in stormwater runoff and loss of groundwater recharge.

Written for planners and local officials, this guide is designed to show how decentralized technologies can be powerful tools in directing sustainable community development while protecting local water resources. Developers, wastewater treatment system designers and installers, and homeowners will also find ideas on fitting septic systems into landscapes in a way that retains natural features and unique architectural elements of a community and adds value to property.

This manual builds on the *South County Design Manual*, a handbook on applying conservation development techniques to southern New England landscapes developed for the Rhode Island Department of Environmental Management. This companion publication uses artists' renderings to help local officials better visualize how a parcel of land might appear if developed using conventional versus alternative and more flexible ordinances.

Here the authors carry the design process a step further to illustrate realistic decentralized wastewater treatment options that can be used to accommodate future growth scenarios. This next step is critical since many of the alternative land development patterns simply cannot be built using only conventional septic systems. For each design alternative, we have identified and illustrated practical wastewater treatment options using a range of technologies. Supporting technical information on decentralized wastewater treatment options is included, along with numerous case studies illustrating practical use of alternative systems to achieve the goals of better land use design, sustainable development, and improved water resource protection.

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1 INTRODUCTION

New suburban development at the rural fringe and divorced from historical growth patterns has been loosely labeled as “sprawl.” Widely recognized as “the dominant trend in land use over the last half century in New England and across America” (CLF, 2002), suburban sprawl refers to a “low-density, large-lot, scattered and inefficient development pattern” that consumes an unnecessarily large amount of land and natural resources (Grow Smart RI, 1999). Large-lot subdivisions (Figure 1-1) and shopping centers easily accessed only by automobiles are classic examples. The result of sprawl is that land is developed at rates that far exceed the pace of population growth. The impacts are the loss of farmland and open space, fragmented forests, and degradation of water resources.

Figure 1-1
An Example of Suburban Sprawl

The causes of suburban sprawl are complex, multifaceted, and deeply rooted in the problems of urban decay. Yet, conventional onsite wastewater treatment systems are considered partly responsible for promoting wasteful land use patterns due to the land area needed to ensure proper wastewater treatment while also maintaining safe distances from water supply wells and surface waters.

Nationwide about 25 percent of homes depend on onsite wastewater systems. Outlying areas subject to the heaviest growth pressures are often entirely dependent on onsite wastewater treatment systems. Sewers may be unavailable, extending lines may not be cost effective, or communities may be restricting sewer service in an effort to direct growth to existing urban centers.

Need for a Creative Approach to Community Design in Unsewered Areas

Rural and suburbanizing communities need wastewater treatment solutions that balance smart growth with safe water quality. This manual describes how properly managed decentralized wastewater treatment systems, combined with wise land use planning, can overcome these barriers to support better community design. Using a combination of hypothetical development scenarios and numerous examples of constructed projects, this manual demonstrates how decentralized wastewater treatment systems can support more compact land use patterns that could not otherwise be built with conventional onsite wastewater treatment systems. These examples show how decentralized wastewater treatment systems can provide a practical and environmentally sound alternative to conventional sewers. These treatment systems often represent a lower cost without the pressures to rezone for more intensive development that is inconsistent with community plans—a loss of control over land use that so often accompanies availability of sewers.

Spanning the wide range between conventional onsite systems and sewering, decentralized wastewater treatment systems offer communities an array of options to

- Effectively target failing and substandard systems
- Revitalize existing developed areas
- Direct investment to new growth centers

For small unsewered communities and those wishing to limit sewer expansion, this manual is designed to show how decentralized systems can provide a powerful tool to meet wastewater treatment challenges while achieving community goals for wise land use.

The field of wastewater management is evolving rapidly with new technologies and management methods continuously emerging. There are three areas of emphasis where current decentralized wastewater planning and management has shifted from the past:

1. **Building in management frameworks—**Proper system maintenance has always been considered essential. Now the emphasis is on establishing management methods to ensure all wastewater treatment systems, from individual onsite systems to cluster systems, are properly managed, preferably with maintenance oversight centralized at the local or county level.

2. **Focusing on treatment and recycling—**Wastewater is increasingly viewed as a resource to be recycled rather than a waste to be disposed.

3. **Maintaining Flexibility—**Use of managed individual onsite systems and shared cluster systems bridge the gap between conventional onsite systems and sewers. This decentralized concept opens new opportunities to achieve community land use goals and meet wastewater treatment challenges.

To avoid confusion, and to ensure consistency with other United States Protection Agency (EPA) documents, the following terms are used in this manual:

- **Septic system—**Generic term used to describe a conventional wastewater treatment system.
- **Onsite wastewater treatment system**—A system that relies on natural processes and/or mechanical components that is used to collect, treat, and disperse or discharge wastewater from single dwellings or buildings. Either conventional methods or alternative technologies that provide advanced treatment may be used.
- **Cluster system—**A wastewater collection and treatment system that serves two or more homes.
- **Decentralized system**—An onsite and/or cluster wastewater treatment system that treats and disperses or discharges small volumes of wastewater, generally from dwellings or buildings that are located relatively close together.

A more complete description of terms used in this manual is included in the glossary.

Creative Community Design—An Antidote to Sprawl

Although there are no simple answers to the problems of sprawl, planners and designers agree that one antidote is “smart growth” using more sustainable practices and compact development (Downs, 2001). The problem with general terms such as sprawl and smart growth is that they are broad terms that mean different things to different people. Smart growth represents an array of community growth and planning techniques that many planners simply consider good community planning. A good overview is provided in EPA’s list of 10 Smart Growth Principles, available online at http://cfpub.epa.gov/sgpdb/sgdb.cfm. These principles include, for example, mixing land uses, creation of pedestrian-friendly neighborhoods, and preserving open space, farmland, and natural beauty in critical environmental areas. Surveys by the Brookings Institute show that builders and preservationists alike tend to agree on certain smart growth elements. Four basic concepts that have broad support include:

- Preserving large amounts of open space and protecting the quality of the environment. Even pro-growth advocates who argue for maximum development of a particular parcel recognize the benefits of preserving outlying forest, farmland, and open space at lower densities.
- Redeveloping and expanding existing village centers and urban areas. This concept involves new and renovated structures, in-fill, and helps to revitalize and preserve historic downtowns.
- Removing barriers to design innovations. Flexible zoning standards can encourage pedestrian-friendly neighborhoods, mixed land uses, town centers, and other design elements that make communities more interesting and blend in with historical development.
- Creating a sense of community within individual localities and neighborhoods and greater recognition of regional interdependence throughout the community. EPA describes this feature as creating “Distinctive and Attractive Places”—regions, towns, and communities where architectural and natural elements reflect the interests of all residents, and reinforce and contribute to community cohesiveness.

Another widely used term, often used interchangeably with smart growth but with a more directed focus on maintaining and protecting long-term water quality is “sustainability”—a kind of carrying capacity for humans and their environment. The South County Design Manual (Flinker, 2001) defines sustainable development as a product of good design that:

- Maintains a unique natural and cultural environment in which to live.
- Allows growth and change to occur in a way that respects this existing condition, by working with it rather than destroying it.
- Is sustainable at a practical level, requiring fewer resources to build and maintain and requiring a minimum amount of energy for its use.
- Ties neighborhoods and towns together with a common thread of attractive architecture and site design that builds on local traditions.

This manual focuses on community design by applying these widely accepted smart growth and sustainable concepts for rural development as well as Main Street.

Since large-lot zoning often is considered wasteful of land and other resources, this manual also focuses on the use of “conservation development” principles to design new land development projects. Conservation development is a general term for a method of site planning and design. This approach, which lends itself well to the use of decentralized systems, typically makes use of careful site analysis to identify distinctive and sensitive preservation areas and suitable sites for development. The concept of concentrating development in suitable areas is similar to cluster development, but much greater flexibility is also needed to site buildings, wastewater treatment and leaching areas, and roads according to site suitability and natural landforms. When properly applied, conservation development enables a community to guide growth to the most appropriate areas within a parcel of land to preserve at least 50 percent permanent open space, avoid impacts to the environment, and protect the character-defining features of the property. Where preservation of large contiguous tracts of farmland, forest, or river corridors is paramount, a conservation subdivision—a development designed using conservation development methods—emphasizes site plans that reflect an understanding of town-wide open space systems.

In rural areas, advanced treatment systems can support conservation development to cluster houses more closely, thereby preserving natural landscapes, farmland, and critical habitat (Figure 1-2). As large parcels of land are subdivided and developed using conservation design, preserved open space can be connected in larger more substantial tracts of active farmland, unfragmented forest, and continuous greenways.

Figure 1-2
An Example of a Rural Area Where Advanced Treatment Systems Can Support Conservation Development to Preserve Open Space

In village locations, a different approach to conservation development, sometimes termed flexible development, emphasizes the design of streets, houses, and neighborhood structures over open space protection.

In theory, these ends could be met with conventional subdivisions using standard cluster provisions. However, in practice, traditional cluster options are based on inflexible zoning districts, lot sizes, setback distances that result in rigid lot configurations, and grid-like subdivision layouts that are incapable of accommodating the unique features of a site. In contrast, conservation development and other innovative design methods enable flexible use of various design techniques, such as reduced frontage widths, variable setbacks, narrower road widths, shared driveways, and smaller lot sizes.

An alternative shared wastewater treatment system can foster traditional town and village design. In the conservation development project example shown in Figure 1-3, there is an overall density of one unit per acre, but the new homes have been gathered along an old-fashioned village street. Each house enjoys views from private rear decks and patios of more than two-thirds of the site, which was protected as open space. The forty homes in the development are served by a single shared wastewater treatment system.

Figure 1-3
Example of a Conservation Development Project

Sensitive site design using the flexible standards of conservation development can have significant environmental and aesthetic benefits that result in reduced site disturbance, less impervious area, avoidance of wetland buffers and other marginal land, and less stormwater runoff. Decentralized wastewater treatment systems can be sited on the most suitable areas of a property. When applied regionally, conservation design, with its more compact development combined with maintenance of average densities, can:

- Minimize water quality impacts of development
- Maintain habitat and corridors
- Protect scenic qualities
- Prevent encroachment of suburban development into agricultural areas

In creative conservation development designs, houses may or may not be closer together, but overall density remains the same as in a conventional subdivision. In the example shown in Figure 1-4, the houses are about where they would be in a standard plan. However, by using the flexibility of conservation development, the developer has created a common open space that will benefit each resident much more than if that same space were part of each home's front yard.

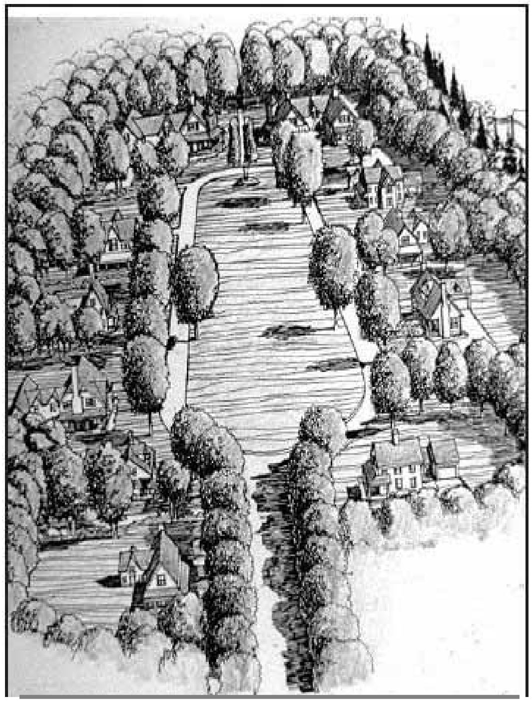

Figure 1-4
An Example of a Conservation Development Subdivision Design

Limitations of Conventional Wastewater Treatment Systems

There is a growing interest in creative community design in communities throughout the country where progressive planners and inspired developers are applying conservation development techniques. The problem is, many of these flexible and compact designs simply cannot be built using conventional wastewater treatment systems. The dual problem of fitting systems into the landscape and meeting treatment needs becomes more difficult when onsite wells are used and where problem soils or other limiting conditions exist.

One of the original reasons for the lot size, frontage, and setback requirements in most zoning ordinances was to accommodate individual wastewater treatment systems. Ironically, the sprawling pattern of development that results is too dispersed to economically allow for other forms of wastewater collection and treatment. Large-lot zoning is designed to reduce impacts by limiting overall densities. Low-density zoning is appropriate and necessary in many sensitive areas. This zoning controls gross impacts, but makes it difficult to mitigate incremental and cumulative effects of low levels of groundwater contamination from septic systems; runoff from streets, roofs and lawns; and loss of open space and visual character.

Site constraints such as high water table and slope require extensive clearing, regrading and filling when using conventional systems. These requirements involve high costs, aesthetic impacts, and alteration of local drainage, often without better wastewater treatment. In their classic text on conservation design, Randall Arendt and colleagues note “the issue that most frequently dominates the discussion of creatively designed development proposals in unsewered rural areas concerns the treatment and disposal of human wastes” (Arendt et al., 1994).

Conventional wastewater treatment system siting and design standards may still reinforce the need for large lots and extensive disturbance. The house shown in Figure 1-5, center left, uses a raised “mounded” or “fill” drainfield constructed in gravel fill and contained by sidewalls. This uses almost all of the available lot and illustrates large space requirements for single family homes where water tables are elevated.

Figure 1-5
An Example of a Drainfield System That Requires a Large Space to Meet Siting and Design Standards

At the neighborhood scale, visual and environmental impacts are multiplied due to the use of rigid zoning frontage and setback rules in combination with the space and land alteration required for on-lot wastewater treatment. The homes shown in Figure 1-6 were constructed in a high water table area, requiring extensive filling for conventional “fill” wastewater treatment systems in each front yard. The road and driveways are at the original grade. The completely altered landscape and monotonous pattern of development that results is utterly divorced from any relationship to the land or historical development patterns.

Figure 1-6
Examples of Homes in a High Water Table Area That Require Extensive Filling for Conventional Fill Wastewater Treatment Systems

Advanced treatment systems provide an alternative to minimize landscape alteration and create more inviting neighborhoods. In the house under construction in Figure 1-7, an advanced treatment system that uses a media filter (green unit on far right) and a bottomless sand filter (on far left) eliminates the need for a raised leachfield. The house is also set much closer to the street and in line with older homes to maintain the existing character of the area.

Figure 1-7
An Example of an Advanced Treatment System That Eliminates the Need for a Raised Leachfield

For existing development in difficult soils or substandard size lots, the need for alternative wastewater treatment options is more urgent. Repair of failing wastewater treatment systems on the smallest and most difficult sites may simply be impossible using conventional systems. Without alternative technologies, the results are chronic failure, limited use of property, and degraded water quality. The public health and environmental problems are magnified when whole neighborhoods are affected, reducing property values individually and discouraging economic investment in affected areas. For example, lack of wastewater treatment capacity in traditional village business districts is often noted as a “negative aspect of doing business in town” and a contributing factor to declining property values (URI Community Planning Studio, 1997). Without proper wastewater capacity, downtown business districts and village centers will find it difficult to keep existing businesses and will remain hard-pressed to attract new investment.

Small town and village centers in rural areas often rely on conventional wastewater treatment technology that does not meet current state standards, and cannot be made to do so in the available spaces. This practice can cast a pall over efforts to revitalize Main Street with new offices, shops, and restaurants. Advanced wastewater technology can support reuse of town center buildings, while maintaining the simplicity of individual systems.

The character and growth of Main Street in an historical seaside village as well as shellfishing standards were preserved using alternative wastewater technology (Figure 1-8).

Figure 1-8
An Example of an Historical Seaside Village Where Character, Growth, and Shellfishing Standards Were Maintained Using Alternative Wastewater Treatment Technology

The rear alley shown in Figure 1-9 is the only available leachfield area for a Main Street commercial building with apartments above. Wastewater from an antiquated cesspool was discharging directly to the nearby harbor. The septic tank and advanced treatment unit for this system were installed in the basement of the building. Limited space made a conventional system repair totally impractical for this situation. A town wastewater management program with mandatory inspection and reporting ensures regular maintenance.

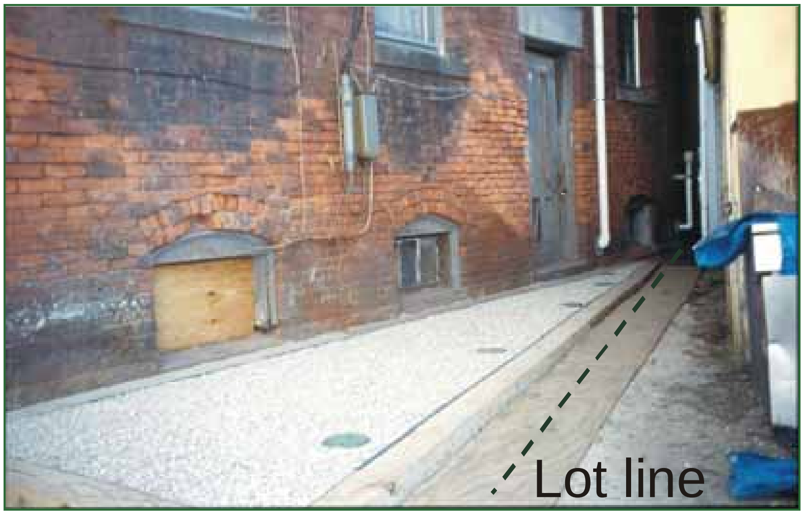

Figure 1-9
An Example of a Bottomless Sand Filter Treatment System in the Rear Alley of a Main Street Building

Managed Wastewater Treatment Systems—Tools for Sustainable Development

Until recently, wastewater treatment options were limited to either large-lot conventional systems or traditional sewers with central collection to a distant treatment plant. Although intermediate options such as smaller community decentralized treatment units have been available for years, use of these systems was often constrained by a variety of factors such as large space requirements, treatment efficiency, or lack of management oversight.

Sewers are not a realistic option for many communities. Conventional sewer systems are expensive, especially without generous federal subsidies that were once widely available. Sewers also bring additional pressure for growth that may be inconsistent with local plans. Based on a growing body of evidence regarding the water quality impacts of runoff in urban areas with extensive pavement, it has become apparent that sewers often substitute one pollution problem for another. Increased runoff from impervious cover, loss of groundwater recharge, and increased risk of leaks and spills all lead to degraded water quality, even where sewers may have been installed to alleviate pollution problems.

Decentralized treatment systems may be the best choice in many areas from an economic and environmental point of view. Due to advances in technology, a wide spectrum of innovative systems are now available that can overcome site constraints while providing a high degree of purification to protect important water resources. Alternative systems, designed to treat and recycle wastewater close to the source, can be sized to serve individual lots, two or three houses, or a village center. Most importantly, models for state and local management of alternative systems have been developed and are ready to be implemented to ensure proper maintenance and operation of alternative technologies (USEPA, 2003). The new drive towards management of decentralized wastewater treatment systems as an alternative to sewering opens the possibility for more widespread use of advanced treatment systems (USEPA, 1997).

Depending on one's perspective, more widespread use of advanced wastewater technologies can be an unsettling prospect. Unleashed from soil suitability requirements of conventional sanitary codes, advanced technologies could open land for development once considered unbuildable. No doubt some communities have relied on wastewater treatment system codes as a means of zoning to limit growth in unsuitable or environmentally sensitive areas. However, sanitary codes were never intended to be a substitute for local planning and sound land use regulations. To direct development to suitable areas and better control the range of impacts associated with development, some communities are successfully integrating standards for impervious cover, stormwater infiltration, and wetland buffer protection with advanced treatment requirements (Jamestown, 2002).

Advanced treatment systems provide repair solutions to keep older neighborhoods distinctive and attractive while restoring critical resources. In the example shown in Figure 1-10 an advanced treatment system provides a repair solution to a failed cesspool that was flowing into a sensitive coastal wetland. A bottomless sand filter serves as a drainfield on this high water table site. This system protects the wetland and coastal pond, and enables full use of the property with little site disturbance. Treated effluent averages 9 mg/l total nitrogen, which is less than the state standard of 19 mg/l.

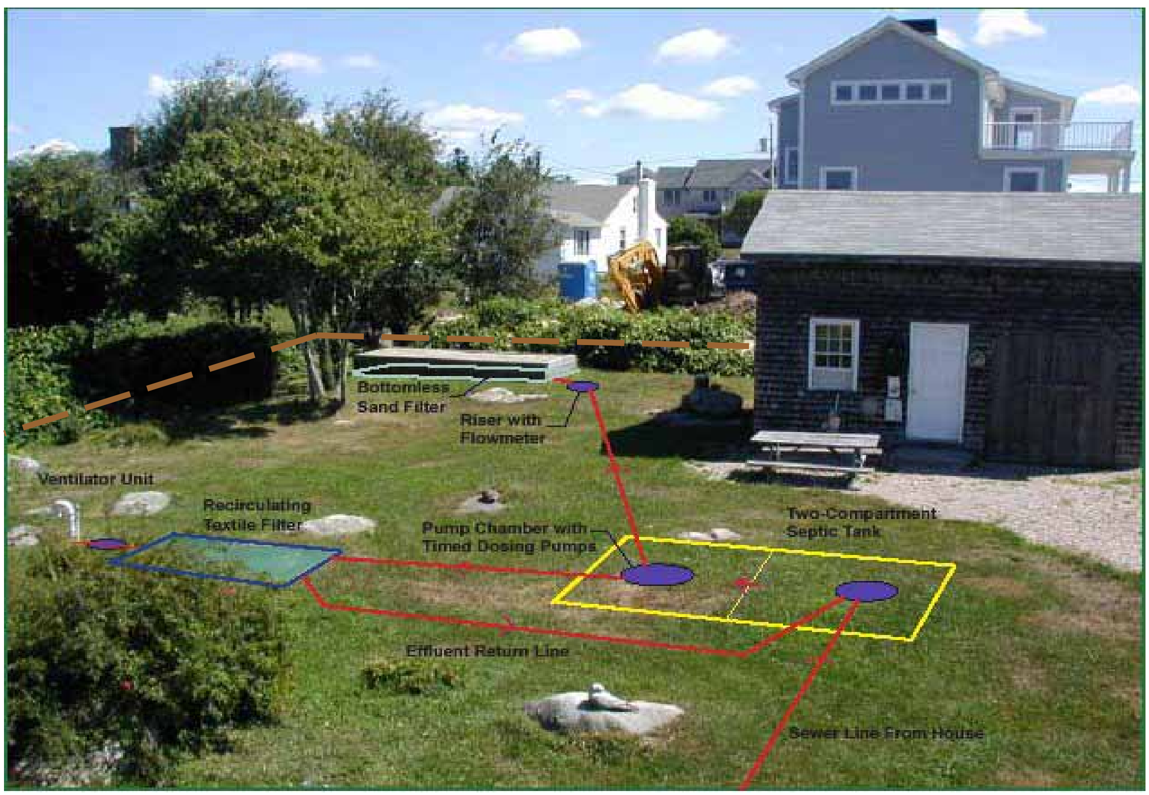

Figure 1-10
An Example of an Advanced Treatment System

The conventional repair for the site shown in Figure 1-10 would have been a raised fill system (Figure 1-11), which requires extensive disturbance and drastically alters the lot and its relationship to surrounding properties. To accomplish this repair, all boulders would be excavated, trees and shrubs cleared, and gravel fill brought in to a height of five to seven feet to compensate for slopes and provide the required four-feet separation distance to shallow groundwater. Concrete retaining walls would be needed to contain the fill on either side. The shed would probably need to be removed (see Figure 1-12). The site excavation and retaining walls would make the cost greater than the cost of the advanced system. The fill system would have provided minimal treatment, with total nitrogen in the effluent expected to be 40–60 mg/l.

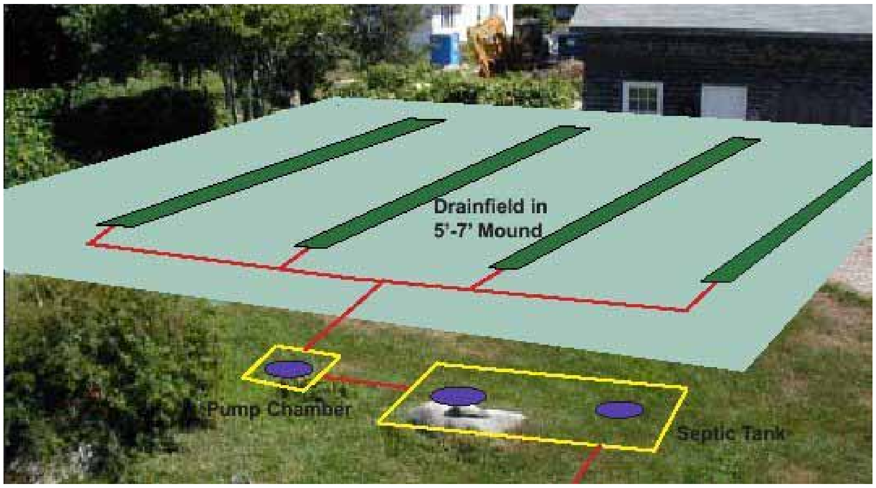

Figure 1-11
The Conventional Repair Option for the Site Shown in Figure 1-10, Showing Approximate Location of the Septic Tank, Pump Chamber, and Leachfield Footprint

Figure 1-12
A View of the Same Site Shown in Figure 1-10 Looking Toward the House With the Shed on the Left

Note: The house in the center-left is directly on a coastal pond wetland.

Manual Overview and Format

This manual illustrates how onsite wastewater treatment systems can be used to support more creative and sustainable land development design that would otherwise be impractical with conventional wastewater treatment system standards and technologies.

The concepts in this manual build on the *South County Design Manual*, a handbook on applying conservation development techniques to southern Rhode Island landscapes that uses artists renderings to help local officials better visualize how a parcel of land might appear if developed using conventional versus alternative and more flexible ordinances (Flinker, 2001).

This manual carries the design process a step further to illustrate realistic decentralized wastewater treatment options using a range of technologies to accommodate future growth scenarios. This next step is critical since many of the alternative land development patterns simply cannot be implemented using only conventional systems.

Five central case studies are used to represent a different type of traditional New England landscape. Supporting technical information on the wastewater treatment options is included to show how the proposed treatment system would work. In each case, the actual location and site conditions are real but the development scenario and wastewater treatment options are hypothetical. To ground these case studies in reality, each is followed by several real-world examples that show how alternative systems have been used in similar situations to achieve the dual goals of better land use design and improved water resource protection.

What This Manual Offers for Different Groups

Different groups will find this manual helpful in different ways as follows:

- For planners and community leaders exploring sprawl management techniques, this manual introduces creative design concepts supported by practical alternative treatment systems.
- For communities adopting wastewater management programs, this manual provides practical guidance in selecting alternative systems to minimize risk to local water resources and support land use goals.
- For developers and site designers, this manual illustrates alternative land development techniques specifically designed to preserve the most distinctive and sensitive features of a site to enhance property values and enable full use of property.
- For wastewater treatment system designers and installers, this manual describes how to select appropriate treatment technology for a site and offers guidelines on fitting systems into the landscape for an efficient and attractive installation that will enhance property values.
- For landowners and treatment system owners, this manual summarizes the range of wastewater treatment options and describes siting, design, and treatment issues for different situations.

About the Study Area for the Five Central Case Studies

This manual makes use of hypothetical case studies within southern Rhode Island and actual constructed projects within Rhode Island, the Northeast, and beyond. The five central hypothetical case studies for this manual draw from actual sites within southern Rhode Island communities loosely labeled "south county" (Figure 1-13). The resource protection needs in this area form the basis for making decisions on the level of wastewater treatment appropriate for each of the case study scenarios. This area is a priority for management due to

- The presence of EPA-designated sole source groundwater aquifers
- Shellfish and eelgrass habitat in coastal pond watersheds
- Prime farmland
- Unfragmented forest
- A federally designated scenic and recreational river
- Abundant unique natural habitat for numerous rare and endangered species

Figure 1-13
Southern Rhode Island with the Pawcatuck River System and Coastal Ponds to the South

Pollution from runoff and wastewater treatment systems has impaired surface and groundwater quality. The local economy depends on tourism and recreation centered along coastal waters. Since groundwater is the sole source of supply for both private and public wells, groundwater contamination is of great concern and will determine the area's long term potential for sustainable development.

Both the land use design and wastewater technology options used in this manual are applicable to any community in the country that is faced with strong growth pressures, similar site constraints, and resource protection issues as is Rhode Island. This manual does focus on technologies used in Rhode Island and in other developing areas of the Northeast where high land values, combined with the need to minimize development impacts, make advanced treatment systems with smaller footprints more cost effective. This situation would be equally applicable in almost any rapidly developing area, especially at the suburban/rural edge of expanding cities. While the land design objectives and specific technologies may vary around the country, the general concepts for better land use design supported by alternative technologies can help meet the needs for community development and resource protection in any area facing suburban sprawl.

Organization

This *Creative Community Design and Wastewater Management* manual encompasses the planning and development process for effective wastewater management. Topics include:

- Selection of treatment levels with an emphasis on watershed-scale pollution-risk assessment for a diversity of landscapes
- Comparison of conventional and alternative systems
- Selection methodology
- Factors to consider in selecting treatment options

The report is organized into five chapters as follows:

Chapter 1, *Introduction*—Introduces the benefits of alternative wastewater treatment system technologies in supporting a more flexible approach to standard development patterns. This overview also outlines the manual approach and its contents.

Chapter 2, *Understanding Decentralized Wastewater Systems*—Summarizes and illustrates the range of conventional and alternative treatment technologies available. This chapter describes system siting and design issues that determine land area and site suitability needs and outlines factors to consider in selecting treatment technologies for individual and community use.

Chapter 3, *Creative Vision: The Planning and Design Scenarios*—Using actual locations in southern Rhode Island, this chapter presents future development scenarios for five different types of land use settings. Comparisons are provided of the conventional likely build out under present zoning versus a more creative option using conservation development supported by advanced wastewater treatment systems. The case study settings include:

- Making New Rural Neighborhoods – Focuses on conservation subdivision designs for low-density areas to preserve large tracts of protected open space with new development projects.

- Revitalizing Main Street – Illustrates options for repair and limited expansion of existing use in keeping with the traditional character of small downtown business districts.
- Rebuilding an Historic Village – Describes opportunities for infill and expansion of existing villages, to support repairs and construction of new neighborhoods.
- Creating a New Town Center – Outlines issues in meeting water supply and wastewater treatment needs to create new growth centers.
- Building a Rural Economic Center – Identifies wastewater treatment options for farm-related businesses and compatible recreational uses where farmland protection is a priority.

One or more possible wastewater management options for each site are presented and factors used in making the selection are described. Each of the five case studies are followed by projects constructed in Rhode Island and elsewhere, which show practical use of alternative systems to achieve better land use and improve resource protection.

Chapter 4, *Alternative Systems for Individual Lots*—This chapter explores design issues for individual lots using actual systems as examples. Sustainable growth and redevelopment in environmentally sensitive areas is a key theme.

Chapter 5, *Resources for Applying Creative Design*—Provides additional resources to support implementation of design concepts and wastewater management practices.

This manual is not intended to be a comprehensive source of information about the wide range of wastewater technologies currently available, nor does it attempt to address the equally wide range of design and siting standards that may be required by various local, county, or state regulators. Design and siting specifications may differ. Not all of the systems shown in this manual may be approved for use in all areas.

The locations and site conditions of the five central case studies in the manual are based on map analysis and other readily available data. The wastewater treatment solutions are not based on field data that would normally be required. Detailed engineering designs have not been developed. Although the wastewater solutions proposed are hypothetical, they still represent practical treatment options using a range of alternative technologies. To the greatest extent possible, generic terms are used to represent different types of technologies. In no way should mention or depiction of any proprietary technology included herein be construed as endorsement of such devices or manufacturers.

2 UNDERSTANDING DECENTRALIZED WASTEWATER SYSTEMS

The wastewater treatment field is rapidly changing and new ideas, management concepts, and technologies are continuously emerging. New treatment options are powerful tools to achieve community land use and resource protection goals. Alternative onsite wastewater treatment systems can provide a high level of treatment to

- Protect critical water resources
- Help maintain community architectural or natural features
- Enable individual landowners to overcome site constraints

As a result, advanced technologies create new land use opportunities that may have been completely impractical only a few years ago. These opportunities carry the added responsibility and challenge to apply these tools to achieve community goals and support appropriate use of property that balances the need for resource protection with the interests of individual landowners.

Appreciating the new opportunities available using decentralized systems requires a basic understanding of how the systems work and the options available. This chapter provides an overview of wastewater treatment systems that range from conventional systems to alternative technologies that are becoming more commonly used to solve today's wastewater treatment challenges. This overview centers on two key aspects:

1. Site factors such as land area requirements and flexibility in blending systems into a landscape to meet land use objectives

2. Treatment performance to meet water resource protection needs

Factors to consider in making wastewater treatment decisions for a lot, a group of homes, or a neighborhood are addressed. The chapter is organized according to the following topics:

- Conventional and substandard systems
- Modifications of conventional systems to accommodate difficult sites
- Alternative treatment systems, including advanced treatment technologies
- Collection and treatment options for shared systems
- Factors to consider in making community wastewater management decisions

The type of technologies permitted varies widely from state to state, and the decentralized wastewater treatment field is evolving rapidly. Systems considered state-of-the-art today may be outdated tomorrow and replaced by a new generation of technologies. As a result, the specific design and operation features of each technology are emphasized less in favor of basic function, siting, and treatment issues raised by each type of system. The technologies are described using the concept of “treatment trains” where additional treatment units can be added as needed to provide better or more specialized treatment.

Alternative technologies included in this chapter are discussed using the Rhode Island code as an example. This code grants various reductions in drainfield size according to the type of advanced treatment technology and drainfield distribution methods chosen. The amount of drainfield reduction granted varies between 25 and 50 percent of what would normally be required using a conventional wastewater treatment system. This reduction is not universally applied throughout the United States for a given technology. Typically, these reductions are established on a jurisdictional basis. Before applying any of the examples used in this document, the reader is encouraged to check with state or county officials regarding rules for drainfield size reduction and use of alternative technologies.

Some regulatory programs may also allow some advanced wastewater treatment systems to be used in soils that are marginal (or not approved) for use of conventional wastewater treatment systems. An important consideration to recognize is that some sites are unsuitable for development using any type of treatment system. When using advanced treatment systems to develop marginal sites, extreme care should be taken to ensure that other development impacts are adequately controlled to prevent either localized or cumulative impacts to water resources. This consideration should include controlling both the rate and volume of stormwater runoff, ideally to maintain pre-development conditions in critical areas, erosion control, and protection of wetlands and riparian buffers.

Conventional Onsite Wastewater Systems

When properly designed, installed, and maintained, conventional wastewater treatment systems like the system shown in Figure 2-1 can be simple, low-cost, and environmentally sound treatment options for low-intensity development. Their main limitation is that they rely on good soils and sufficient land area to treat or dilute waste. Also, improper use, lack of maintenance, outdated systems, poor soil conditions, poor initial site assessment, or densely settled neighborhoods can all lead to expensive repairs, unsanitary conditions, and impaired water quality.

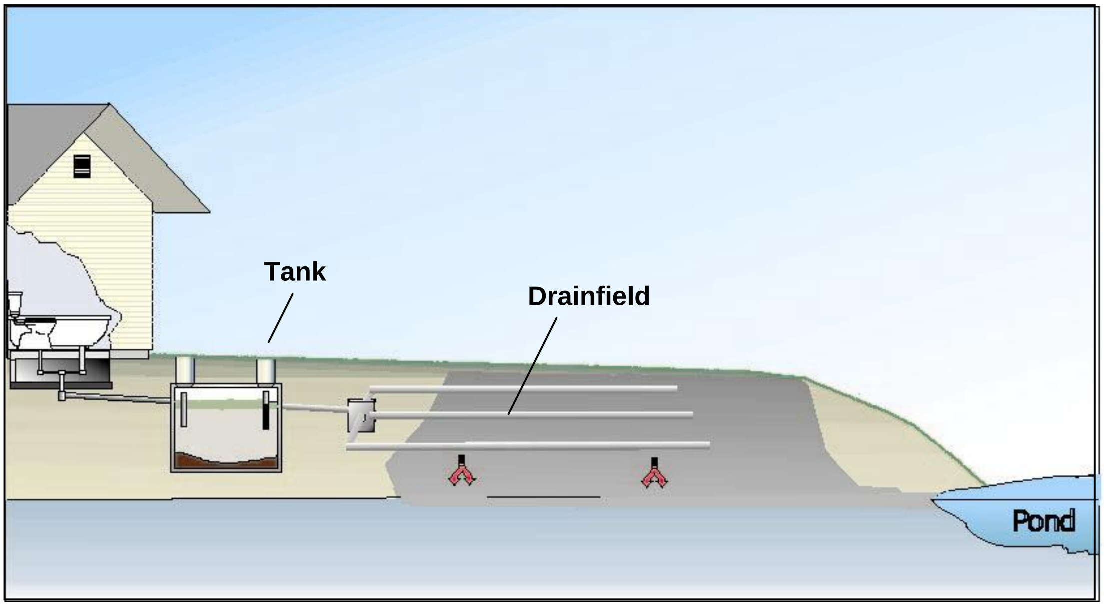

Figure 2-1
Conventional Septic System with Septic Tank and Trench Drainfield

How Conventional Onsite Wastewater Systems Work

The basic elements of a conventional wastewater treatment system are a septic tank and a drainfield, also called a leachfield. The septic tank receives wastewater generated in the house and traps the solids, allowing only liquid waste to exit through the tank outlet pipe. As wastewater enters, the same amount leaves the tank by hydraulic displacement, flowing by gravity to the leachfield. A distribution box (D-box) may be used to split the flow as equally as possible to all parts of the drainfield.

The actual look of a drainfield can vary considerably, but the most commonly used type is a series of perforated PVC pipes laid in stone-filled trenches. Wastewater seeps out of the pipe, through the stone and into the surrounding native soil material. The soil environment with all its living organisms, oxygen, and physical and biochemical properties actually treats the wastewater before it enters the groundwater. The depth of dry soil from the base of the drainfield to the water table (referred to as vertical separation distance) is an essential part of the treatment system, as is the horizontal distances to wells and surface waters and drops in land slope.

Septic Tank Facts

Basic septic tank facts are as follows:

- Tanks are prone to leak unless properly assembled and sealed, so they must be tested for water tightness.
- Most tanks are concrete but fiberglass or polyethylene may be used; they may have single or multiple compartments.
- Solids accumulate faster than they decompose, so tanks must be inspected regularly and pumped as needed, generally every three to five years.
- Basic improvements to tanks include: effluent filters that efficiently trap solids and prevent outflow to leachfield; and risers (also called manholes) to the ground surface to provide easy access for routine maintenance (Figure 2-2).

Figure 2-2
Concrete Tank with Access Risers Above Inspection Ports. When Backfilled, Riser Lids Will be at Ground Surface.

Drainfield Facts

Basic drainfield facts are as follows:

- The type and size of a drainfield selected for a site depends on the depth to water table, soil permeability, and available area that can be used with minimal disturbance.
- PVC pipe in stone-filled trenches is most commonly used. Other variations using synthetic material around the distribution pipe exists.
- Concrete leaching chambers are bottomless box-like or beehive-shaped structures with a network of holes for effluent seepage, commonly placed in a series, and surrounded in stone. In some states, they may be used under parking lots. Deep units have small footprints, but depth of placement in sandy and gravelly soils provides little treatment and use may not be permitted in sensitive areas.

- Plastic chambers are similar to shallow concrete leaching chambers but much lighter. These chambers may be used with or without stone.
- Prefabricated cuspated plastic and filter fabric bundles are combined with a six-inch layer of sand to help promote more efficient treatment and, in some cases, slightly reduced drainfield size.

Commonly Used Drainfield Options

Figure 2-3 shows typical drainfields that provide a conventional level of treatment including, from left to right, deep-leaching chambers (four feet in height), shallow-leaching chambers (two feet in height), stone-filled trench, and prefabricated cuspated plastic and filter fabric bundle.

Deep Leaching Chamber | **Shallow Leaching Chamber (Flow Diffuser)** | **Trench** | **Prefabricated Plastic Filter Fabric Bundle**

Figure 2-3 Typical Drainfield

The cross-sections of leaching units pictured in Figure 2-3 are shown in Figure 2-4. This figure shows their placement relative to groundwater and ground surface. All of the types shown are designed to be placed in deeper subsoil where pollutant removal is minimal. In some states, technologies such as plastic chambers (not shown) and the filter fabric bundle may be credited with a drainfield size reduction; however, all are generally considered to provide equivalent treatment. Deep leaching chambers are not recommended in sensitive areas due to the potential for groundwater contamination

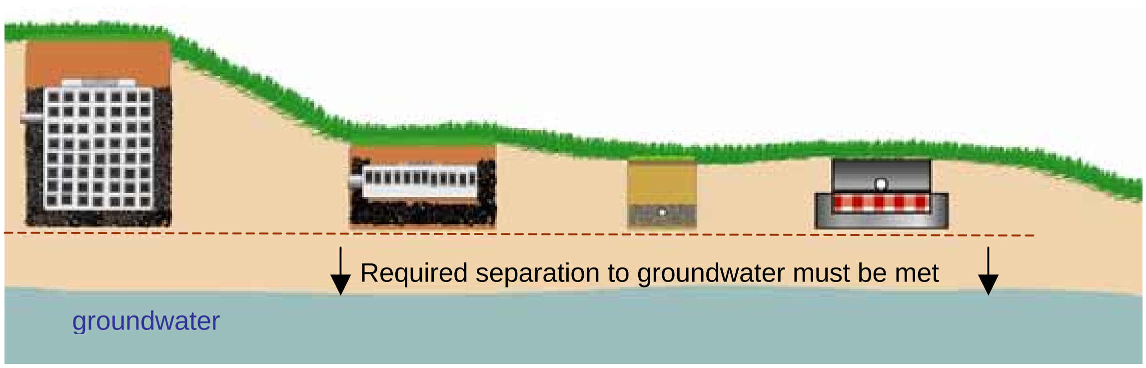

Figure 2-4
Cross-Sections of the Typical Drainfields Shown in Figure 2-3

Drainfield Siting Issues

Criteria for siting drainfields vary considerably throughout the United States. A typical system siting is shown in Figure 2-5. The Rhode Island information that follows is used only for examples. Users of this manual should consult with state or local regulators for specific drainfield siting criteria.

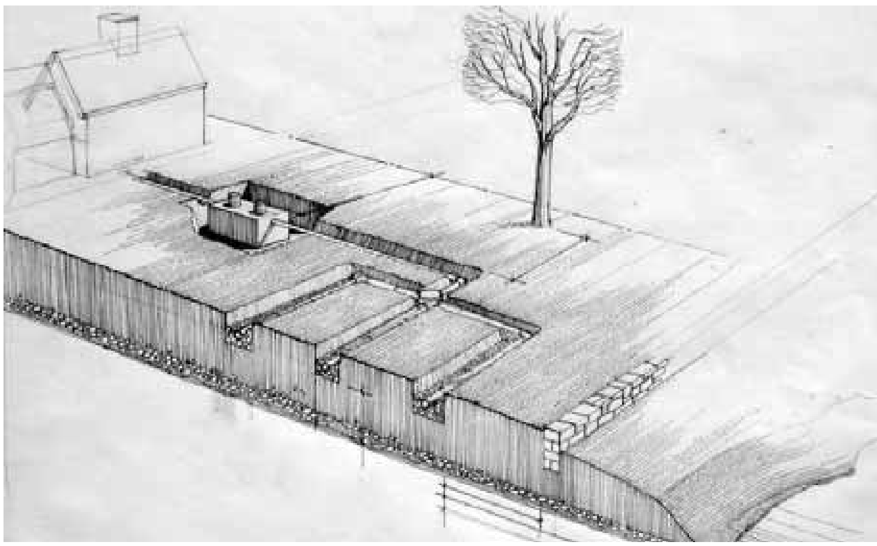

Figure 2-5
Conventional Septic Tank and Stone-Filled Drainfield System Siting

Typically, siting criteria includes:

- The vertical separation distance from the base of a leachfield to groundwater is generally one to four feet; the actual distance varies among regulatory jurisdictions. In Rhode Island, for example, depth to groundwater must be at least five-feet deep (from original ground surface) to accommodate conventional trench-type leachfield at natural grade and deeper for leaching-chamber-type drainfields.
- Size of the leachfield is based on soil types—slowly permeable soils require a larger leaching area than do sandy soils that drain rapidly.
- Horizontal setback distances typically required from the edge of leachfield are:
  - 100 feet from private wells
  - 400 feet from public wells
  - 50 to 200 feet from different types of wetlands
  - 10 to 25 feet from trees and shrubs
  - 25 feet of level area required before a change in land slope that is below the level of the drainfield pipe, except where a retaining wall is used to contain fill
- For new systems, an alternate leachfield area is generally required. In some jurisdictions, variances to minimum standards may be granted, especially for repair systems.

Cesspools and Other Substandard Systems

Cesspools are antiquated systems that receive waste from the house and allow the liquid portion to seep into the surrounding soil (Figure 2-6). The solids portion is contained in the cesspool interior. Cesspools might consist of a covered pit with loose dry fitted rock sidewalls, a concrete leaching chamber, or leaking steel tank. Many cesspools are in direct contact with groundwater for several months during the wet season. Because of the potential for direct, concentrated discharge of untreated waste to groundwater, cesspools are a high risk to public health and water quality. They have been prohibited for new construction for several decades, but there are many thousands of them still in use throughout the country. Some towns in Rhode Island and elsewhere have cesspool sunset or phase-out clauses in their zoning or wastewater management ordinances that would require these cesspools to be removed by certain dates.

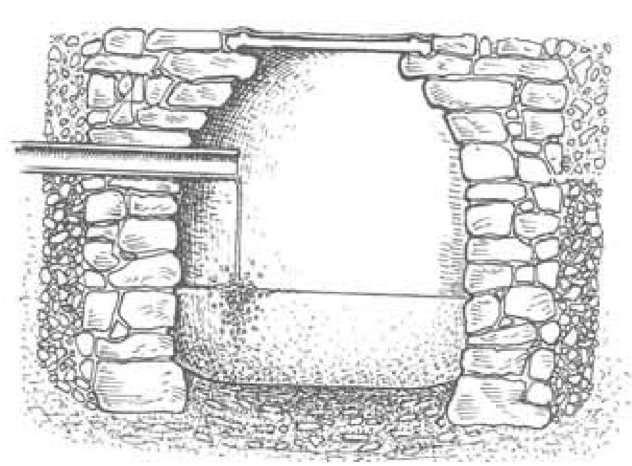

Figure 2-6
A Cesspool

Modified Conventional Wastewater Treatment Systems

This section provides information about:

- Raised mound fill systems
- Treatment in a fill system versus a Wisconsin mound
- Holding tanks—one option when no other exists

Raised Mounded Fill Systems

When faced with site constraints, system designers have devised many clever modifications to the standard septic system. On marginal sites where water tables are close to the ground surface, “fill” or “mound” systems are a standard modification to the traditional trench drainfield. Figure 2-7 shows a “Wisconsin mound” system. Although this particular technology may be an approved method in some states, it often creates more problems.

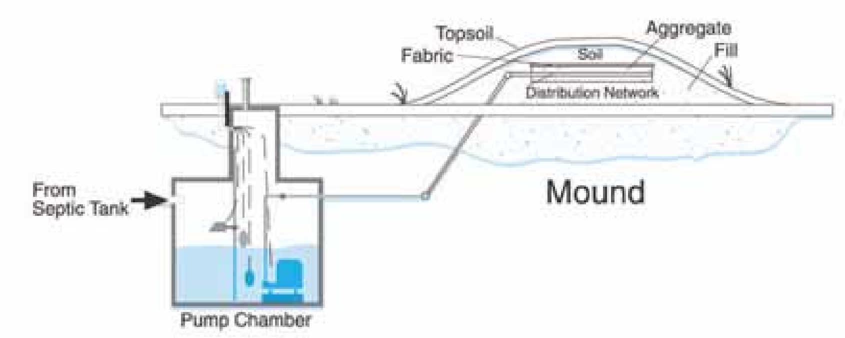

Figure 2-7
A Wisconsin Mound System Where the Original Soil Below the Fill Is Retained

In mound or fill systems, effluent from the tank and other treatment unit is pumped to a raised leachfield constructed above the existing ground elevation. When space is available, a low, wide mound is used. When the available area is small, a high mound is needed. In general, the higher the water table, the more fill needed.

In order to meet the required separation distance on wet sites, gravel fill is typically brought in to raise the leachfield above the water table. A conventional trench, plastic chamber, or filter-media leaching system is then placed in the fill. The same method may be used on smaller lots where retaining walls may be required to contain the fill.

How Raised Mound Fill Systems Work

In mound or fill systems, wastewater enters the septic tank where solids settle and liquid effluent exits to a pump chamber. Effluent is then pumped up to the leachfield where it flows by gravity through the leaching distribution system and fill. On some new construction lots, a pump may not be needed as long as the house is elevated (often times well above the original ground surface) to provide gravity flow to the drainfield.

Siting, Design, and Treatment Issues

Use of raised fill systems creates large mounded areas that look characteristically out of place with the neighborhood natural features and normal home landscapes of neighborhoods. The height of the mound may range from several inches to several feet above the original ground surface (Figure 2-8). This mounding causes extensive disturbance to the yard and drastically alters the original ground surface and natural lay of the land, destroying mature landscaping, restricting use of the lot, and altering the visual and architectural character of individual lots and whole neighborhoods. The raised fill often disrupts stormwater drainage patterns, creating nuisance flooding and impairing septic system function on neighboring properties. The problem is most severe in densely developed neighborhoods and in older historic villages where even small mounds can detract from traditional architectural and natural characters.

Figure 2-8
An Example of a Mound System That Is Five- to Six-Feet High

The fill system shown in Figure 2-9 was installed to repair an outdated cesspool in an historical mill village. Since the gravel fill permanently blocks the shed door, the owner has lost partial use of the shed. The mature tree in the filled area is not likely to survive such treatment.

Figure 2-9
A Fill System Located in an Historical Mill Village

The degree of wastewater treatment in a standard fill system is about the same as a conventional onsite treatment system. With gravel fill and retaining wall construction, the cost can be about the same or considerably more than the cost of an advanced treatment system.

The fill system used for the newly renovated and “mansionized” house shown in Figure 2-10 totally changes the look of the neighborhood. The home now towers above older homes in this coastal neighborhood. The system provides only conventional treatment, without additional nitrogen removal. Zoning standards can be set to specify the level of wastewater treatment and also maximum size and lot coverage that more closely reflect traditional proportions.

Figure 2-10
A Fill System for a Newly Renovated House that Changes the Look of the Neighborhood

The design engineer for the development shown in Figure 2-11 chose to use a conventional treatment system approach instead of alternative technology. A raised fill system was used for a new private elementary school in Rhode Island. The expected large flows from the school and high water table soils required an extensive area for the drainfield, which consumed most of an existing orchard. Because the filled area is difficult to mow, what would have been fruit trees or an open field for recess or sports is now a weed patch. An advanced treatment system with a shallow drainfield could have been installed level with the existing ground surface for multi-use recreation while maintaining the original look of what was once an historic farm.

Figure 2-11
A Raised Fill System for an Elementary School that Required Most of an Existing Orchard for the Drainfield

Treatment in a Fill System Versus a Wisconsin Mound System

The terms “fill” and “mound” system are often used interchangeably. Although the design requirements are similar in terms of site disturbance, fill, and land area, the wastewater treatment potential is different. A brief explanation is offered here to help eliminate any confusion.

Like the fill system, the Wisconsin mound system also uses a raised dispersal method, but it is engineered to provide better treatment and may be considered an alternative system. The Wisconsin mound system requires about the same amount of space and site disturbance as a conventional fill system. However, it provides better treatment due to three key differences:

- Use of specified, uniform sand media as fill material
- The native top soil is left in place for enhanced treatment
- The effluent is pressure- and (typically) time-dosed to the Wisconsin mound surface for even distribution and, therefore, better treatment

In essence, the Wisconsin mound system is more akin to a bottomless sand filter than to the previously described raised fill systems.

Specified sand fill used in the Wisconsin mound, shown on the left in Figure 2-12 is required to enhance wastewater treatment. “Bank run” gravel (on the right) is often used in other “fill” systems. The coarse fragments and stones provide little surface area for physical or microbiological treatment in the fill-type drainfield.

Figure 2-12
Sand Fill Used in the Wisconsin Mound (left) and Bank Run Gravel Used in Other Fill Systems (right)

Holding Tanks – One Option When No Other Exists

On code-sanctioned and difficult sites, a holding tank, also called a “tight tank,” may be used. As the name implies, this is simply a watertight septic tank without a drainfield. It must be pumped when full. A high-water alarm may be used to indicate when pumping is needed. Some regulatory programs completely prohibit holding tanks; others typically use them as a temporary solution while a repair is completed, or as a permanent system for difficult sites where advanced treatment systems are not permitted or are impractical

Alternative Treatment Systems

Alternative and innovative systems, also referred to as advanced treatment systems, are general terms for any wastewater treatment system that is different than the conventional model. These terms may refer to a complete treatment system or just one component within a system. These systems encompass a broad range of technologies that vary widely in treatment performance and space requirements.

The unique feature that sets alternative treatment systems apart is that a separate treatment unit located after the septic tank actually treats the effluent before discharge to the drainfield (Figure 2-13). The septic tank and leachfield perform functions similar to a conventional system, except different types may be used. The additional treatment step enables advanced treatment systems to achieve consistently high results. This arrangement of treatment components in sequence, is referred to as a “treatment train.”

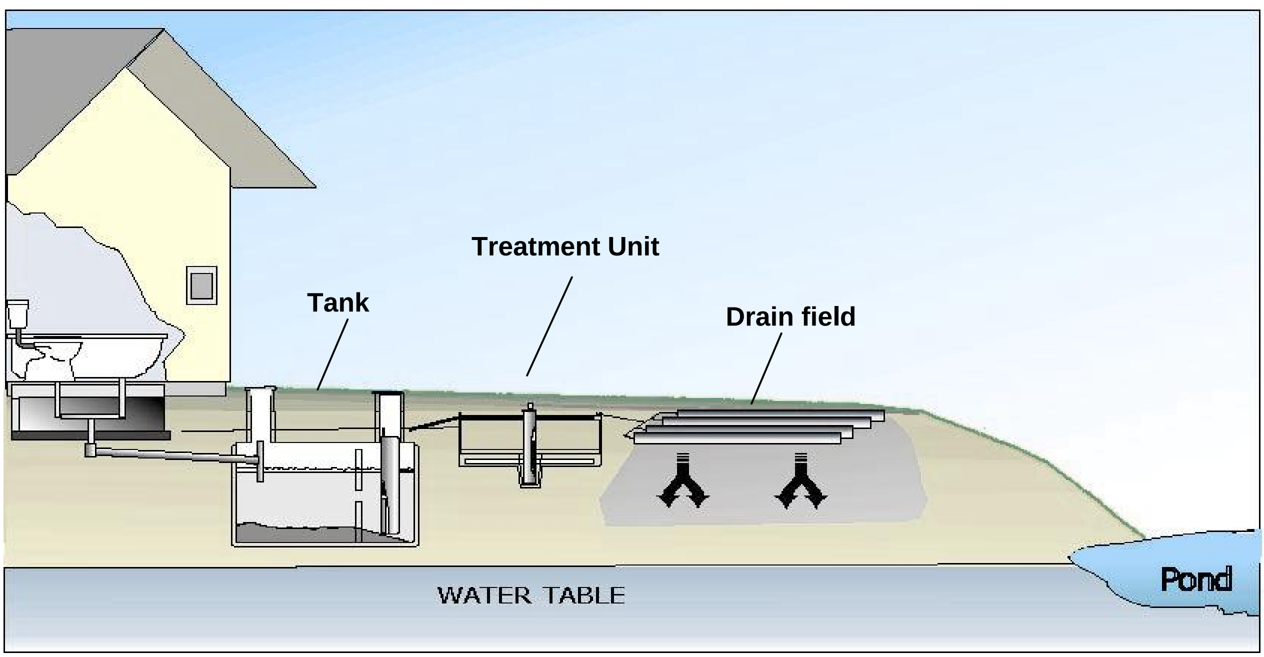

Figure 2-13
An Example of an Alternative and Innovative System Treatment Train

Reasons to Use Alternative and Innovative Systems

As site constraints increase, alternative and innovative technology becomes more cost-effective than conventional systems. Since conventional systems are not designed to remove nitrogen, advanced treatment may be required in nitrogen-sensitive coastal waters. In other cases, advanced treatment may be needed to protect groundwater resources or phosphorus-sensitive freshwaters.

On new lots or existing lots with failed systems and limited space, conventional technology will not physically fit. Therefore, an alternative and innovative system with the benefit of drainfield size reductions will likely be the system of choice. Many regulatory programs recognize the higher levels of treatment achieved in alternative systems and award drainfield size reduction benefits to many of the advanced treatment systems. As a result, advanced wastewater treatment systems may be preferred due to the convenience, reduced cost, and space savings with a smaller drainfield, not necessarily because of improved wastewater treatment to local water resources. An important note is that enhanced removal of biochemical oxygen demand (BOD) and total suspended solids (TSS) may make a smaller drainfield size feasible, without advanced treatment of nutrients or bacteria. Under regulatory programs where drainfield reductions are not allowed, economic and space benefits may not be realized, making use of an advanced treatment system a less attractive option.

In high water table situations where a raised fill system would typically be required, advanced treatment systems can be used to avoid impacts of fill systems, preserve the natural and architectural character of the neighborhood, and protect water quality more effectively. In this situation, shallow drainfields or bottomless sand filters may be used for final wastewater dispersal to the soil as an alternative to fill or mound leachfields.

Alternative systems employ components that help achieve consistent treatment performance. The reliability of this performance depends in large part upon required operation, maintenance, and management. All systems require varying levels of operation and maintenance to ensure system longevity. Unfortunately, many conventional onsite wastewater system users are accustomed to doing nothing to their systems. This disregard often reflects poorly upon alternative technology because even reasonable expectations may seem excessive when compared to total system neglect. Publicly owned sewage collection and treatment systems employ active operation, maintenance, and management that is transparent to the users, yet paid for by system-user fees. Without a doubt, alternative systems require more operation and maintenance than conventional systems, but the full spectrum of wastewater systems require management. System users and regulatory managers need to agree to do their parts to ensure that proper maintenance and operation occur; otherwise, there will continue to be a lopsided argument against the use of alternative technologies because of perceived excessive costs for operation and maintenance.

Because different components of the treatment train are interchangeable, the overview that follows is organized by

- Tanks for advanced treatment systems
- Types of treatment units
- Alternative drainfields

Examples that are included throughout the manual show the combinations of components typically used. These examples introduce technologies commonly used to support more compact design, protect critical resources, and overcome site constraints for repairs. Systems that require large land area, such as constructed wetland treatment systems, are not generally cost-effective in areas with expensive land prices and are not included here. The examples shown have generally been used for individual homes but can easily be designed for multiple homes as cluster systems.

Tanks for Advanced Treatment Systems

Concrete and fiberglass septic tanks are generally used for advanced treatment systems. Polyethylene septic tanks may be used if structural issues are addressed. Other features include:

- Two-compartment tanks are often used. These tanks typically have a pump in a protective screen vault that filters wastewater before it is pumped to the advanced treatment unit.
- Separate pump chambers may be used as needed.
- Flow equalization tanks may be used for shared or large systems. These are simply tanks that accept and store effluent following the septic tank and before the treatment unit. They help to moderate peak flows and provide a way to collect flow from different sources before treatment.
- Watertight tanks, which are generally required by most regulatory codes, are important for all systems, but they are absolutely essential with alternative and innovative systems.

Types of Treatment Units

A variety of treatment units could be substituted in a treatment train to maximize treatment of particular contaminants in the waste stream. The type of treatment unit selected depends on the treatment objectives—that is, the contaminant to be removed and the level of removal desired.

Types of treatment units include:

- Media filters for advanced treatment of nitrogen or pathogens
- Aerobic systems
- Special use alternatives

Additional treatment components, such as ultraviolet disinfection, can be added as needed.

Media Filters for Advanced Treatment of Nitrogen or Pathogens

Several different types of filter beds with various media have been used to reliably treat wastewater to a high degree. The oldest type of media filter bed, long serving as the industry standard, is the single pass sand filter, which has been used for both water and wastewater treatment for more than 100 years. Although generally not considered a nitrogen reduction system, single-pass sand filters are a proven technology for reducing pathogenic organisms. Regional variations to the single-pass filter have used other solid granular media such as crushed glass and bottom ash (a byproduct of coal-fired power plants). The use of glass media was isolated to the northwestern United States and western Canada and is used on a limited basis today, whereas use of bottom ash is still used in some Appalachian Mountain states where coal-fired power plants are common.

Absorbent media has been substituted for the non-absorbent granular medias mentioned previously to encourage more efficient movement of wastewater and gases in the filter bed itself. Absorbent media use promotes better treatment performance and helps reduce a system's footprint to enable it to fit into tight areas for system repairs. The absorbent media filters used in a single-pass mode include peat (introduced first in the industry) and open cell foam. Textile media, another more recent absorbent media, is used in recirculating filters.

In media filter systems, the general treatment train starts with the effluent being collected in a septic tank. The effluent is pumped to the top of the filter and distributed over the media surface. Regardless of filter type, the media provides surface area for bacteria and other microorganisms responsible for treating the wastewater as it trickles down through the media. The filter bed is never saturated with water and the presence of air promotes establishment of favorable microorganisms.

In single-pass systems, the treated effluent is collected at the bottom of the filter bed and usually dosed to the drainfield for final treatment and dispersal (Figure 2-14). Single-pass filters generally excel in pathogen removal. In recirculating designs, the partially treated effluent trickles down through the media, is collected in the bottom of the filter, and recirculates between the tank (either septic tank or separate recirculation tank) and the media filter several times before final discharge to the drainfield. In this recirculation process, a combination of aerobic treatment in the media filter and anaerobic conditions in the tank are required steps to convert nitrogen to N_2 gas. Recirculating sand filters have been used successfully for several decades and are generally accepted as a decentralized nitrogen-reduction technology. In some states, certain recirculating media filters are approved for nitrogen reduction, whereas certain single-pass filters are approved for pathogen-sensitive areas. Check with county or state regulators to determine which media filters are used and for what applications in specific areas.

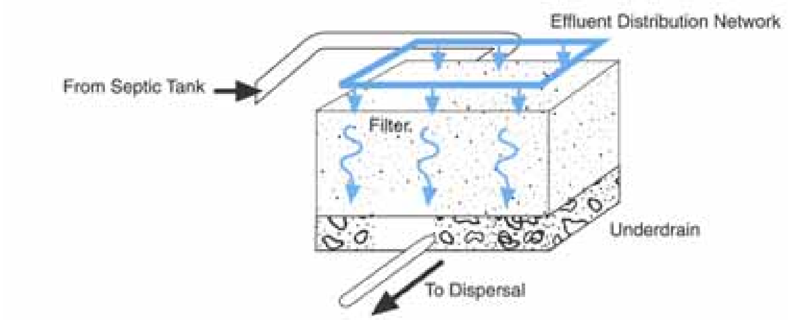

Figure 2-14
A Single-Pass Media Filter

Most media filters use a programmable timer to dose small and uniform amounts of wastewater to the filter surface. Some media filter designs do not employ time dosing, but apply wastewater to the filter surface by either gravity or pressure dosing through the use of preset float switches. Typically this latter "on demand" approach poses a higher risk to treatment failure and reduced filter longevity. Storing peak flows and timing doses of wastewater helps minimize filter overload and keeps the system working twenty-four hours per day to treat stored wastewater.

The use of alternate and more readily available medias help address the issues often associated with sand (or any other granular material), such as:

- Availability of good quality media
- Cost of transport
- Quality control during installation
- Filter modularity
- Cost of installation

Generally, modular prefabricated and prepackaged media filters such as peat, foam, and textile systems have advantages over other media filters that must be constructed entirely on site (Figure 2-15). Those advantages, which should produce more affordable systems, are:

- Easier transport
- Quicker installation
- Higher installation quality control

The challenge, however, for these newer filters is trying to match the long-term treatment performance, low levels of operation and maintenance, and general robustness of sand filters.

Figure 2-15
Examples of Media Filters: Peat Filter (top-left), Single-Pass Sand Filter (top-right), Foam Filter (bottom-left), and Textile Filter (bottom-right)

Aerobic Systems

Aerobic treatment units (ATUs) rely on air injection systems and blowers to create an oxygenated (aerobic) environment to help bacteria break down organic material. Usually there is at least one additional stage in the treatment process that enables solids and bacteria to settle out of the wastewater so that cleaner wastewater is distributed to the drainfield. This aeration process produces an effluent lower in TSS and BOD, with some limited reduction in bacteria. These are primary advantages of ATUs over conventional systems. In some states, drainfield size reductions or vertical separation distance benefits may be awarded for using a particular type of ATU. Check with regulatory officials about which technologies are permitted and any reductions that may apply in specific areas.

The injection of air into the ATU agitates the wastewater so solids are kept in suspension and mixed with the bacteria to digest the organic material. Usually there is a step in the process where any settled solids and bacteria are returned back to the aerobic portion of the tank for mixing and additional treatment. There are three basic operating modes for ATUs:

- Suspended-growth
- Fixed-film reactor
- Sequencing batch reactor

All three types have a solids (trash) removal step as the first process in their treatment trains, either designed as a discrete compartment or separate tank positioned before the aeration step. Here large solids are removed so that they do not hamper the aeration process

In a suspended-growth ATU, bacteria are free floating (suspended by the aeration process) in the main chamber (Figure 2-16). The last chamber is the zone where solids and bacteria settle out and are returned back to the aeration chamber by either a port on the bottom or by a recirculation pump. Proper aeration, mixing, and return are critical for adequate operation and treatment. Clarified treated wastewater from the aeration chamber is piped to the drainfield. This type of ATU is likely to have bulking problems, where clumps of bacteria and some solids do not settle to the bottom of the unit, but stay suspended and tend to clog the outflow pipe to the drainfield.

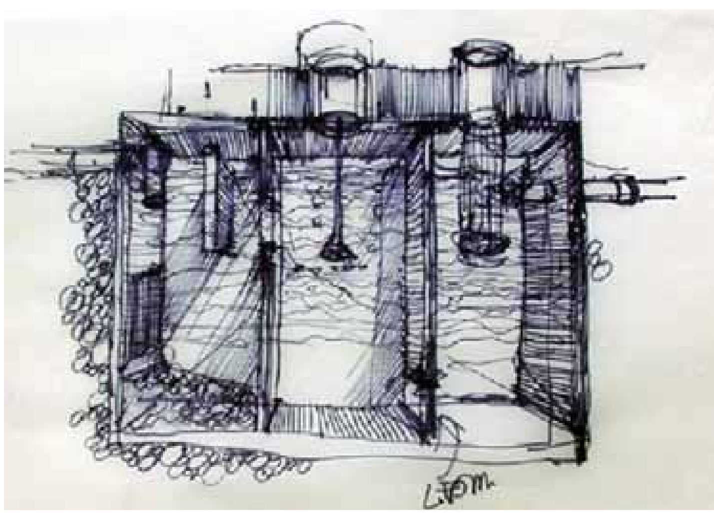

Figure 2-16
Suspended-Growth ATU

A fixed-film reactor ATU has bacteria growing on a surface medium suspended in the tank where the air is injected (Figure 2-17). The medium that the bacteria grow on can be made of a variety of materials including plastic, fabric, styrofoam, or even gravel. Organic matter decomposes in this chamber and a separate chamber is used for settling and clarification. Treated wastewater flows from the settling chamber to the drainfield for final dispersal. Fixed-film reactors usually don’t produce bulking or require a return mechanism, but they tend to be more expensive than suspended-growth systems.

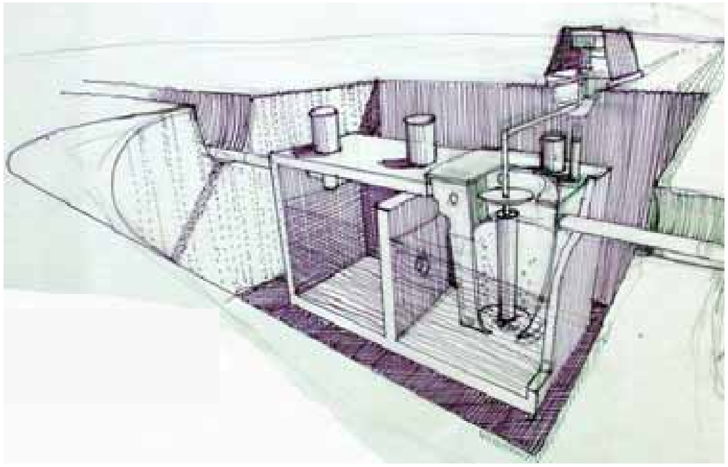

Figure 2-17
Fixed-Film Reactor ATU

In a sequencing batch reactor (SBR) ATU, filling, aerobic decomposition, settling, return, and discharge processes all take place in a single reactor (chamber or basin) in one complete cycle (Figure 2-18). Incoming wastewater mixes with sludge remaining from the previous cycle during the filling step. Air is injected into the wastewater and mixed during the decomposition cycle. After the settling stage the treated wastewater is discharged to the drainfield. This process tends to be more consistent, but since it has more moving parts and requires a controller, it has a higher potential for mechanical, electrical, or operational failure. Although this type of ATU may be used for individual onsite systems, this process is more commonly used for large-flow cluster systems.

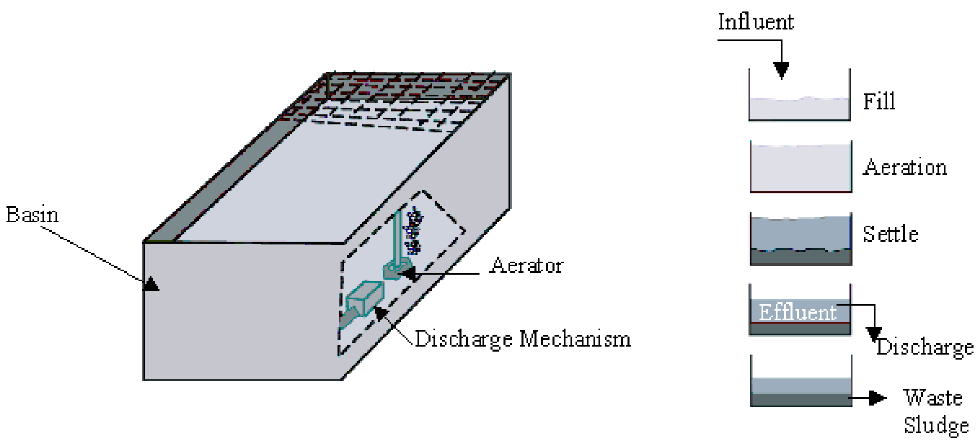

Figure 2-18
Sequencing Batch Reactor ATU

Some fixed-film and sequencing batch reactor type ATUs are approved for nitrogen and phosphorus reduction, whereas others, including the suspended-growth varieties, are used primarily to reduce TSS and BOD levels. Check local or state regulatory codes for nutrient approvals for specific areas. ATUs that do not incorporate time dosing in their treatment trains will not be able to store peak surge flows from a building and pose an inherently higher risk to treatment failure and drainfield clogging or overloading. Most ATUs have fairly small footprints, that provide the advantage of fitting in tight spaces because the treatment unit itself may be located within the septic tank. Generally, they have a somewhat lower initial capital cost than other technologies. However, their operation and maintenance costs tend to be higher than other technologies, especially where electricity costs are high (because the blower motors run continuously). In addition to the cost to operate them, noise from blower motors may be an issue for some homeowners or neighbors to consider. Lifecycle costs should factor in all expected costs, including long-term operation and maintenance costs, before a particular system is selected for a site.

Special-Use Alternatives

Special-use alternatives can include composting and incinerating toilets, which might be used in certain situations, either by homeowner choice in the case of composting toilets, or on a difficult site in the case of incinerating toilets. Both of these systems treat only the black water (feces and urine) component of the waste stream. In each case a separate gray water septic system is needed to treat the other wastewater, which increases costs and makes these options less attractive. Although incinerating toilets may be used for repairs, composting toilets are difficult to retrofit and are more suitable for new construction. Both of these technologies require a reasonable amount of lifestyle adjustment and with composting toilets, active management of the composting process. This added effort may be beyond the level of involvement that most homeowners expect to devote to their systems. Perhaps the most common application of composting and incinerating toilets has been for seasonally-used vacation homes or cottages, where flows are typically isolated to short periods of time.

Additional Treatment Component—Ultraviolet Disinfection

The treatment train approach to system design is flexible, which enables additional components to be added as needed. One unit, now being used more commonly when separation distances to wells are inadequate, is the ultraviolet light disinfection (UV) unit. A UV unit is normally included in a pump chamber following treatment and before final discharge to the leachfield. These units have proven effective in eliminating bacteria. A high level of BOD and TSS removal is required, however, before a UV unit can be included as a component of a system. In addition to regular maintenance and replacement of lamps as needed, an adequate alarm system needs to be employed to safeguard against lamp outages or power interruptions.

Alternative Drainfields

Alternative drainfields used with innovative technologies will fit into the landscape, treat wastewater far more effectively, and last longer than a conventional drainfield. There are two drainfield options typically used that are both pressure dosed for uniform wastewater distribution. Shallow pressurized drainfields, which are placed in the upper soil layers for maximum wastewater treatment by natural soil processes, are located about 8 to 12 inches from the ground surface and can be used when the water table is between 2.5 and 4 feet from the ground surface. Shallow drainfields (a variant of low-pressure pipe type drainfields) are used in many regions of the United States.

Figure 2-19 shows a shallow narrow drainfield being installed. Pressurized flow lines are shielded with 12-inch polyvinyl chloride (PVC) pipe cut lengthwise, with at-grade inspection ports located at regular intervals. Shallow drainfields are typically placed 8 to 12 inches below the ground surface to take advantage of biochemically active upper soil layers for microbial nutrient removal and plant uptake.

Figure 2-19
Installation of a Shallow Narrow Drainfield

Figure 2-20 shows a shallow narrow drainfield following a recirculating media filter. The drainfield is visible as the area with greener lawn, also showing additional nutrient uptake by plants. In this area the drainfield helps protect local drinking water wells and coastal pond water quality.

Figure 2-20
Shallow Narrow Drainfield Following a Recirculating Media Filter

Figure 2-21 shows a shallow narrow drainfield that serves a restaurant and retail/office complex that generates 2,700 gallons per day of wastewater. The lines shown are ready to be covered with 12-inch native backfill.

Figure 2-21
A Shallow Narrow Drainfield That Serves a Restaurant and Retail/Office Complex

Bottomless sand filters have been used to treat raw septic tank effluent in several west coast states with good success. In Rhode Island, bottomless sand filters provide a raised bed for final wastewater treatment and dispersal of advanced treated effluent (which must meet BOD and TSS standards of 30 mg/l each). These systems are easily installed with little site disturbance and maximize separation distance to groundwater. As a result, they are often ideal for repairs where water tables are near the surface and where small lot size restricts other options.

The raised bottomless sand filter system shown in Figure 2-22 serves a single-family home, and was installed as a repair to a failed cesspool. This older bottomless sand filter design serves as a final treatment and dispersal zone. The bottomless sand filter system shown in Figure 2-23 serves multifamily and commercial use in a village center.

Figure 2-22
Raised Bottomless Sand Filter Following a Recirculating Media Filter (single-family home)

Figure 2-23
Bottomless Sand Filter Following a Recirculating Media Filter (multifamily/commercial use)

Shallow narrow drainfields and bottomless sand filters are both alternatives that can substitute for the raised gravel fill system discussed earlier and provide much better treatment with minimal site disturbance. The typical separation distances to boulders, land slopes, and trees and shrubs that apply to conventional drainfields are usually relaxed with these options, which provides greater flexibility in siting.

In some cases, conventional gravity-fed drainfields are used with advanced treatment. In addition to more site disturbance, a real water quality concern is that highly treated wastewater is likely to leach quickly through the soil without build-up of a microbial mat to slow effluent for better treatment. As a result, rapid infiltration over a small footprint can increase the risk of groundwater contamination locally. Mixing and matching alternative technologies in a treatment train to achieve a desired treatment level or standard is easy; however, the technologies must compliment whatever components come before and/or after it.

Alternative Collection and Treatment for Cluster Systems

This section includes information about alternative collection and treatment for cluster systems, including:

- Large flow systems
- Collection systems
    - Gravity sewer
    - Grinder pump pressure collection
    - Septic tank gravity and pressure collection

Large Flow Systems

Advanced treatment systems can be sized to treat waste from clusters of two or three homes or an entire neighborhood while still using a soil-based leaching system for final treatment and dispersal. Cluster systems that use advanced treatment systems can achieve high levels of treatment and recycle effluent to the same watersheds, thereby replenishing groundwater supplies and maintaining stream flows. In contrast, most conventional centralized collection and treatment systems typically discharge directly to surface waters without these benefits, often transferring wastewater to a downstream subwatershed or an entirely different basin from the original source of the water supply. As with any soil-based leaching system, attention must be paid to careful site evaluation and soil suitability, although onsite leaching systems are being successfully used for large flow cluster systems.

Selecting the right type of treatment system for a large flow cluster system is highly specific to the site. The key factors to consider include:

- Development density
- Treatment level needed to protect local resources and overcome site constraints

- Land area and siting constraints
- Overall life cycle cost considering both construction and long-term maintenance

With decentralized cluster systems, the wastewater treatment technologies identified previously can be evaluated, often using zones that can be phased in over time and modular treatment units to accommodate larger flows. In general, at flows of 10,000 to 50,000 gallons per day, large recirculating sand filters and modular technologies may still be used, but pre-fabricated mechanical treatment units may also become cost effective (H R Consultants, 1998; University of Minnesota Extension Service, 1998). Examples of pre-fabricated units available from various manufacturers include:

- Fixed activated sludge treatment systems
- Trickling filters
- Rotating biological contactors
- Sequencing batch reactors
- Membrane filtration systems

Engineered treatment units can be specifically designed to treat certain types of contaminants such as BOD, grease, and nutrients. Treatment technologies such as membrane filtration systems are capable of reducing nitrogen to levels as low as two to three mg/l. Site design considerations also come into play in selecting the appropriate type of system to meet specific challenges. For example, some treatment units such as rotating biological contactors are typically housed in a garage or barn. Others, such as the sequencing batch reactor, can be located underground using little space but requiring deep excavation.

A review of local and county approvals for cluster systems can provide insight on the approved systems most commonly used and presumably cost-effective for a particular area. A review of the Rhode Island Department of Environmental Management (RIDEM) wastewater permit applications for large-flow alternative treatment systems (design flow 1,000 gallons per day or greater) for the period 1995 through 2003 indicates that the media filters and fixed activated sludge units described previously are most commonly used for systems in the 1,000 to 5,000 gallon per day range. These smaller systems comprise 67 percent of all large-flow alternative wastewater treatment system permits issued for this period. Many of these are modular, which enables system sizing to accommodate present needs and the ability to incorporate additional units as needed. These smaller systems are commonly paired with alternative drainfields, using either shallow trench designs or bottomless sand filters for final wastewater treatment and dispersal. In the 10,000 to 40,000 gallon per day range RIDEM applications show that recirculating sand filters and self-contained treatment units are commonly used, including fixed activated sludge systems, trickling filters, sequencing batch reactors, and rotating biological contactors. At larger flows a variety of alternative or conventional soil-based leaching systems may be used, including pressurized shallow trenches, conventional drainfield trenches, flow diffusers, and lagoons.

The maximum size cluster system installed in Rhode Island has been in the 40,000 gallon per day range. Elsewhere in New England, cluster systems of 20,000 to 80,000 gallons per day are more common, with a few approaching 200,000 gallons per day. (personal communication, Keith. Dobie, F.R. Mahoney & Associates). At flows of 100,000–200,000 gallons per day and greater, advanced treatment systems supporting water reuse and recycling may become feasible.

Several commercial centers, resorts, and stadium complexes have been built in New England that take advantage of cluster systems to generate high-quality wastewater that is stored and reused internally for toilet flushing, thereby reducing both water demand and wastewater leachfield requirements. Although recycling systems have been used more extensively in arid areas, summer water shortages and growth pressures, combined with growing demands for clean water are making reuse and recycling systems increasingly cost-effective even in the humid Northeast.

Collection Systems

Collection systems are not considered a treatment system, but rather a way to collect and transfer wastewater to a treatment unit from one or more discharge locations.

Gravity Sewer

The conventional wastewater collection method used by most sewered communities is a network of large diameter pipes that use gravity flow (Figure 2-24).

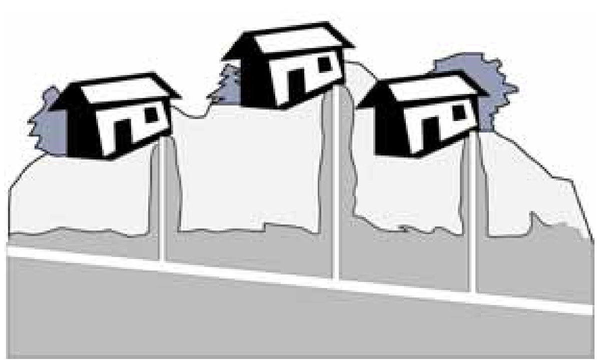

Figure 2-24
Gravity Sewer Collection System

Excavation costs are high because of the size of the lines, the great depth often needed to maintain gravity flow, and the necessity of placing manholes at regular intervals. Pump stations are used at intervals to pump up to a higher point where needed. Sewer lines are prone to leakage and must be maintained and sealed as needed.

Groundwater infiltration is often a greater concern than effluent leakage from the pipe. Groundwater that flows into cracked or poorly sealed pipes diverts groundwater to the treatment plant, using up valuable capacity. Just as importantly, groundwater diversion lowers water tables and can seriously impair stream habitat and water quality. According to EPA, (1997) wastewater collection and treatment using conventional gravity sewers is generally more cost-effective when lines are concentrated at about 100 houses per mile, where a good business and industrial base exists, and where distance to a main sewer line is within five miles.

Grinder Pump Pressure Collection

Pressure collection includes small-diameter pressurized lines that are used to convey wastewater to a central treatment facility. The lines generally follow topography, which eliminates the need for deep excavation to maintain gravity flow. Instead of a septic tank, each house has a tank that houses a grinder pump (Figure 2-25). When the tank fills, the pump grinds the waste into a slurry which is discharged to the pressure line.

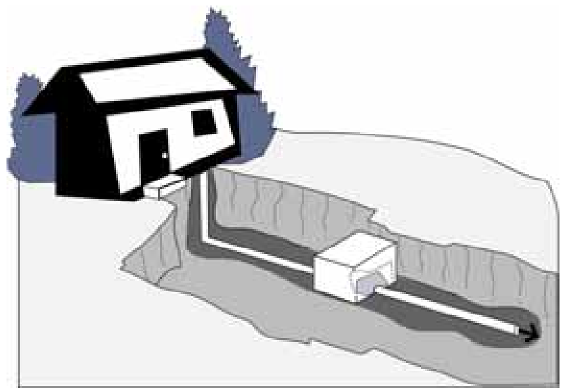

Figure 2-25
Grinder Pump Pressure Collection System

Grinding solids tends to wear out components, so grinder pumps generally have higher maintenance needs than effluent pumps. Larger prefabricated treatment units, such as those described previously, often use this method rather than separating solids with a septic tank at each site. Where large flows include high-strength commercial waste, blending wastewater flows from various sources can keep overall waste strength low, which improves treatment efficiency. Because solids are not retained in a septic tank, treatment units that use this method will generate relatively large amounts of sludge, which must be separated, dewatered, and disposed of regularly.

Septic Tank Effluent Gravity and Pressure Collection

Septic tank effluent gravity (STEG) tanks trap and retain solids at the point of discharge and transfer by gravity flow relatively clear effluent to the next treatment stage (Figure 2-26). Septic tank effluent pump (STEP) tanks do the same thing but instead pump the effluent because the treatment unit may be at a different elevation where gravity is not feasible. Both of these methods can have the benefit of moving only relatively clear effluent and keeping solids in tanks for additional decomposition and processing.

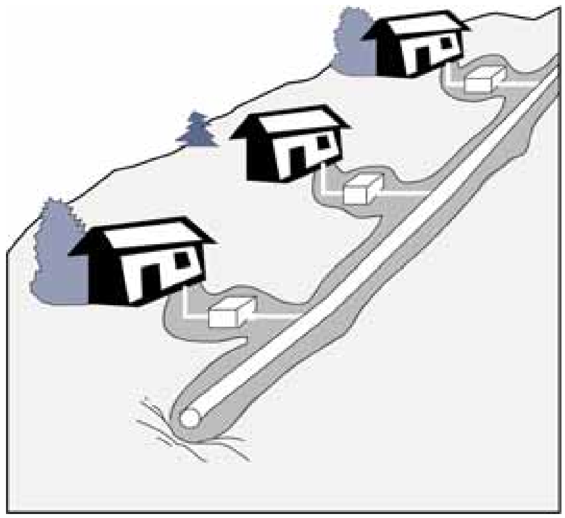

Figure 2-26
Septic Tank Effluent Gravity Collection

Effluent pumps tend to have comparatively low maintenance needs. This on-lot solids decomposition reduces the total pounds of organic material that ultimately needs to be processed at the wastewater treatment unit. With small cluster systems, segregating flows using individual tanks provides better control in pretreating waste and solids removal, often at a lower energy cost. However, responsible septage management and the inconvenience of individual tank pumping must be shouldered by homeowners or responsible management parties.

Depending on the flow, more than one building could be connected to the same STEG or STEP tank, and these tanks can flow to a variety of treatment options, ranging from conventional to advanced technologies. These collection systems are commonly used with cluster or larger systems, save space, and are a cost-effective means to move wastewater from one point on the landscape to another. According to the University of Minnesota Extension Service, (1998) cluster systems served by STEP or STEG collection systems tend to become more cost-effective than individual systems where flows range from 5,000 to 15,000 gallons per day.

Selecting Wastewater Treatment Systems for a Community

New or improved decentralized wastewater technologies are emerging regularly, and for many decision makers the number and variety of alternatives can be bewildering. Making wastewater treatment choices can be a complex process, particularly when choices affect where and how a community will develop. Consequently, the selection of wastewater management technologies for a community, a neighborhood, or even an individual lot should be part of a broader community planning process.

This section lays out a framework for choosing the most appropriate wastewater treatment systems. Given the complexities involved in public deliberation, this section is not designed as a cookbook formula leading to a certain set of solutions. Instead, a simple framework is provided that is intended to guide decision-makers in identifying key issues to be considered at different scales, be it the whole community, the watershed of an important waterbody, or an individual site.

General Considerations for Choosing a Treatment System

For the uninitiated, choosing the most appropriate treatment system for a site can be a mind-boggling chore. Usually, watershed (macro-level) and individual site (micro-level) factors need to be assessed before a decision is made. The micro-level factors are all the normal site-specific characteristics that the design professional determines and assembles into a permit package that is sent for regulatory review.

The macro-level factors, such as watershed susceptibility to nitrogen or pathogen inputs are somewhat abstract concepts to many septic system designers. Until fairly recently, not many regulatory programs nationwide had established watershed treatment zones or standards that needed to be met. The considerations were only required in isolated locations. As a result, the watershed level system selection factors, which really are the first decision step, may not be well understood by some wastewater professionals in various locations across the county.

An excellent guide for communities facing wastewater treatment decisions is the University of Minnesota Extension Service’s *Small Community Wastewater Solutions* (Olson et al., 2002).

The following checklists are intended to provide a quick reference to help with system selection. These factors are presented in a summary format, because elaborating on them would go well beyond the scope of this document. The checklists are grouped as

- System cost considerations
- General system considerations

System Cost Considerations

Certainly one of the overlying factors to consider is system costs. Design, installation, operation, and maintenance costs all need to be factored over a given life cycle before a decision is made on system selection. Remember that some technologies may have a lower initial capital cost and look attractive from that perspective, but may have much higher operation and maintenance costs. Over the life cycle period, these systems actually may cost far more than some others. Table 2-1 summaries estimated system costs and is intended to serve only for general planning purposes.

Table 2-1
Estimated Treatment System Costs

Estimated Treatment Costs Per Residence[1]			
Treatment Option	**Design and Installation**	**Annual Operation**	**Total Cost***
Conventional system	$5,000–$8,000	$100–$200	$7,000–$12,000
Mound or fill system with minor filling	$7,000–$12,000	$100–$400	$9,000–$20,000
Mound or fill system on difficult site	up to $30,000	$100–$400	$20,000–$38,000
Aerobic tank	$8,000–$15,000	$500–$800	$25,000–$30,000
Single-pass sand filter with shallow drainfield [3]	$8,000–$20,000	$200–$500	$22,000–$24,000
Fixed activated sludge system [3]	$15,000–$25,000	$600–$800	$22,000–$36,000
Peat filter with shallow drainfield [3]	$15,000–$24,000	$300–$500	$22,000–$27,000
Recirculating media filter with shallow drainfield [3]	$18,000–$21,000	$300–$400	$25,000–$28,000
Ultraviolet light	less than $1,000	$135	$3,700

*Note: Total cost assumes a 20-year life cycle and average design, installation, and operation costs. Costs may be more or less based on location. Total cost does not take into account interest or other financing expenses.

[1]Costs are highly site-specific and vary nationally. Estimates are based primarily on the Northeast and Great Lakes regions.

[2]Unless specified, includes a trench or other conventional drainfield.

[3]Drainfield is shallow narrow pressure-dosed alternative design.

Sources:
University of Minnesota Extension Service and College of Agricultural, Food and Environ-mental Sciences. *Innovative Onsite Sewage Treatment Systems*. University of Minnesota, 2001.

University of Rhode Island Cooperative Extension. 2003. *Alternative and Innovative System Matrix Review*. Onsite Wastewater Training Center. Kingston, RI. www.uri.edu/ce/wq

Environmental Protection Agency. *Onsite Wastewater Treatment Systems Manual*, Table 5-8, Section 5-31. February, 2002.

General System Considerations

General considerations for choosing a treatment system include:

- Regulatory issues and constraints
- Legal and administrative costs

- Difficult site conditions for excavation of collection lines
- Factors that reduce the cost of shared systems
- Waste type, strength, and quantity
- Lot size and usable space
- Site suitability
- Site design
- System design (owner-level)
- Site alteration
- Site limitations

Regulatory Issues and Constraints

- In general, state and local regulations may not support the use of alternative treatment technologies, or one entity may allow them while another does not.
- Local zoning regulations may require approval for a wastewater treatment system within setback distance from wetlands and surface waters.
- Regulatory agencies may have established standards for both small-scale alternative systems and larger package plants. Regulations may also be in place for water reuse and reclamation.
- Innovative technology systems being considered must be allowed by state or local regulations.
- If allowed, the particular technology approved for use might require a variance application (which involves time delay and additional cost). Other conditions of approval may be expected, such as monitoring requirements.
- If not allowed, the manufacturer or distributor may have applied for approval of the technology. Once reviewed, there may be a favorable decision or it could be rejected.
- An appropriate management program needs to be in place to assure that required operation, maintenance, inspection, and monitoring occur.

Legal and Administrative Costs

Retrofit situations where a group of homes or businesses will be connected to one new cluster system are more complex than new development proposals. Where tie-in to a new system is voluntary, the challenge of reaching an agreement that all can support can be particularly difficult. Legal agreements are required to outline responsibilities and liabilities of parties that may be sharing a system. Issues to be addressed include:

- Property ownership and liability
- Cost of easements, if applicable

- Joint ownership of components on a treatment lot and maintenance agreements for tanks and drainfields
- Lines that cross other properties not served by the system and all properties' ownership status must be established
- Costs involved with crossing roads, such as easements or other approvals for lines installed in right-of-way areas
- Clearance from other utility lines (call responsible party for verification)

Difficult Site Conditions for Excavation of Collection Lines

- Ledges that require blasting
- Shallow water table (need to de-water trench and/or avoid construction during seasonal high water table or high tide if located in a coastal area)
- Favorable grades from homes to dispersal sites
- Need for a wetland permit (may not be required for onsite repairs in some areas)

Factors That Reduce the Cost of Shared Systems

- Reduced design flow—Individual systems must be designed to accommodate high-peak flows. However, with shared systems not all households are likely to generate maximum flow simultaneously, allowing peak flows to be spread among several users and reducing maximum design flow.
- Economy of scale—Substituting one larger shared treatment unit for individual systems can be more cost-effective, but each case must be analyzed given local conditions and costs.
- Ease of establishing maintenance contracts.

Waste Type, Strength, and Quantity

- High-strength wastewater—High BOD and grease (multifamily structures may tend to be higher strength even where occupancy is low, possibly because the number of kitchens remains the same even when a unit is occupied by only one or two people. Average occupancy is generally about 2.5 persons per dwelling unit.
- Commercial or business—May have a high waste strength for nitrogen.
- High flow or variable flow—There may be an opportunity to reclaim or reuse treated wastewater.
- Seasonal and rental properties—Potential for reduced treatment efficiency and rapid wastewater movement in a drainfield with system startup each spring. Heavy use leads to a risk of overload.

Lot Size and Usable Space

For community systems, publicly-owned land may already be available, which eliminates land acquisition costs. Larger developed lots may be suitable for a repair or even cluster systems.

- Adequate space is necessary to repair a failing system.
- Adequate space for alternate leachfields for future use in case of failure is also necessary.

Site Suitability

- Depth to water table and other limiting layers
- Potential for water table rise above soil redoximorphic features
- Soil permeability—Slow, restrictive “hardpan” layers, or excessively permeable soils may be present
- Location with setbacks from wetlands and surface waters

Site Design

- Site accessibility—Ease of access for routine maintenance by inspector and access for pump trucks
- Existing obstacles—Boulders, sheds, gardens, or swing sets
- Homeowner aesthetic concerns

System Design—Owner-Level

- Ease of installation for new or repair system
- Design and construction costs
- Operation costs
- Inspection and maintenance costs
- Maintenance frequency
- Component longevity
- Overall system reliability

Site Alteration

- Site alteration may be necessary to install the system. Consider the extent of disturbance, excavation, and/or filling. If filling is required, consider the height of the fill and if a steep or gradual slope will be required. If a retaining wall is used, consider what material will be used and if it will be landscaped with stone or vegetation, and what will be the appearance.

- Trees may need to be removed or may be subjected to damage during construction of a conventional system.
- Filled systems in high water table sites often modify drainage patterns and increase runoff to neighboring properties. Consider if poor drainage and localized flooding are concerns.

Site Limitations

- High water table—The water table on a site could increase the risk of system hydraulic failure or treatment failure
- Proximity to public and private wells
- Proximity to shoreline areas of streams and wetlands
- Proximity to high velocity zones
- Ledge or large boulders present on the site could require more machine and labor time

The Process of Making a Wastewater Treatment Decision

To make a decision at a community level is a public process that requires energy, time, and expense. Far more than a technical engineering exercise, choosing a wastewater treatment system requires a community to work out a number of sociopolitical and economic issues. One important need is to build support for better wastewater management in the community. To accomplish this, the community needs to agree on a motivating factor or incentive.

Motivating factors that drive communities to spend time and resources to address wastewater treatment needs include:

- Protecting high-quality resources—Some research suggests that messages focusing on what might be lost without action are more powerful than messages dwelling on impaired conditions.
- Restoring impaired waters—When working to improve wastewater management to restore degraded waters it is important to make the case that resources are restorable and that recommended improvements have a good likelihood of achieving success. When waterbodies are known to be degraded for long periods of time, the public may have acquired the impression that the resource is too far gone and not worth repairing. In addition, residents may have accepted the fact they cannot swim or shellfish in a nearby pond, or that they must rely on bottled water and no longer see that as a major inconvenience.
- Protecting public health from serious failures. Making improvements protects your property and family’s health from neighboring systems that may be failing.
- Complying with state or federal mandates to remediate failures.
- Allowing full use and enjoyment of property; for example, have visitors, wash laundry at home.
- Maintaining and strengthen property values.

- Bringing properties up to modern standards, especially where state or other nearby towns are also taking action to bring substandard systems up to code.
- Being Fair—Most residents may already be taking proper care of septic systems on a regular basis. Maintenance and upgrade requirements will primarily affect the minority that may not currently be taking proper care of their system.

Community Interest and the Will to Reach Agreement and Work Together

One of the main ingredients in finding a community solution to failing systems in a neighborhood or business district is the willingness of individual property owners to reach agreement on a solution. Without a strong motivation, such as a state or federal order to correct a problem, it may be difficult for a group of landowners to reach an agreement on shared wastewater improvements that are strictly voluntary even when incentives include financial support and better protection of private wells. Full agreement on the part of all landowners may be a prerequisite for project approval.

Even if only a majority vote is needed, it may be difficult to force all reluctant homeowners to abandon their individual systems and connect to a community treatment system. Because of the time and effort required to develop a community solution, it is typically much easier for a community to simply establish a wastewater management program that requires septic system owners to inspect and maintain their systems and repair or replace failing systems and cesspools as needed. This minimalistic approach minimizes local bureaucracy and staff effort and leaves it up to landowners to find a solution on their own. The disadvantage of this independent approach is that overall costs are likely to be higher. Over the long term, the cost of maintaining individual systems is also greater, with less local oversight possible over many maintenance contractors.

The community social and political dynamics can have a direct influence on a community coming to a consensus decision. A small, close-knit community is more likely to be able to reach consensus on a wastewater solution than a commuter suburb with high resident turnover. Similarly, landowners of rental properties and seasonal dwellings can be difficult to reach and organize.

Managerial Capacity of Local Government

Small communities that are just beginning to consider establishing a wastewater management program or communities where there is a low level of management by the town should start small and focus on:

- Addressing critical areas where remediation is needed. Select a project where public support for corrective measures is strong.
- Initiating new development projects where developers will finance system construction cost and set up a responsible management entity. A municipality may charge initial impact fees and/or assess a regular utility fee to cover town oversight costs, including the development of a tracking program to oversee maintenance and staff time involved to ensure compliance and conduct spot-checks of system maintenance. Select a site in a priority area for new compact

development, where benefits of preserving open space for significant natural, scenic or cultural features will generate benefits and provide a good example.

- Establishing a demonstration project by applying for grant funds. Install the project as a retrofit to remediate failure. Make the demonstration site available for tours and educational programs. Where possible, use a public facility to expand outreach potential.
- Establishing what level of management is possible. If the level is low, focus on retrofits, and keep the number of new advanced treatment systems low and manageable until management capability is established.
- Charging fees to cover oversight costs where advanced treatment is used.
- Placing a moratorium on the use of advanced treatment systems for new development until a local management program is in place, including regulations for site suitability to include:
  - Minimum depth to water table
  - Wetland buffer protection measures
  - Stormwater management controls

Community Technical Advisors

Change is difficult to accomplish for most communities. Embracing new wastewater technologies is not always easy for communities, regulators, designers, and homeowners alike. Human nature leads people to fall into comfortable routines and to try to stay with tried and true technologies. Designers may choose fill systems over advanced treatment systems or may become familiar with one or two types of advanced technologies and favor those. Therefore, it makes sense for town staff, volunteer board members, and the community in general to become educated and to learn about the different wastewater treatment options, and to obtain more than one professional estimate or opinion. Communities should also look at what other communities have already done and learn from their hard work.

3 A CREATIVE VISION: THE PLANNING AND DESIGN SCENARIOS

For the last few decades, people all over the country have been working on solutions to the problem of suburban sprawl. These solutions begin with better design, often combined with planning that promotes protection of open spaces and revitalization of traditional town centers. Planning and design journals are full of ideas for “neotraditional town planning,” “sustainable design,” and “smart growth.” The design scenarios that follow are designed to make these ideas more tangible by showing how they could be applied in real-world situations to solve local problems with architectural and site planning solutions that reflect local traditions. The land use alternatives were originally prepared for the Rhode Island Department of Environmental Management, under the South County Watersheds Technical Planning Assistance Project, and published as part of the *South County Design Manual* (Flinker, 2001). In this manual, the future development scenarios are expanded to show how alternative onsite wastewater treatment systems can be used to make these more compact designs practical and environmentally sound options for unsewered communities.

Introduction to the Case Studies

The *South County Design Manual* was built around five different sites chosen to represent a wide range of landscape types and typical planning situations encountered by rural and suburban towns (Figure 3-1 and Figure 3-2).

Revitalizing Main Street

Rebuilding an Historic Village

Figure 3-1
Making a New Rural Neighborhood

Each of these hypothetical case studies takes an actual site and shows how it would most likely be developed in today's market following current zoning and other regulations. A more creative development alternative for each site was also drawn up to demonstrate how the same or an even greater amount of development could be accommodated while preserving important resources. The results graphically illustrate that growth does not have to be detrimental to the character and livability of small towns. Indeed, with careful planning and creative regulation, investment in new development can be harnessed to rebuild downtowns, retrofit declining commercial strips, and create wonderful new neighborhoods surrounded by protected open space.

Figure 3-2
Creating a New Town Center

Building a Rural Economic Center

These creative community design ideas require equally creative solutions to the practical aspects of traffic and pedestrian circulation, parking, architecture, water supply, and, of course, wastewater management. In order to show how alternative wastewater management technologies can support sustainable community design, the five scenarios that follow have each been the subject of further analysis to determine alternative ways to treat wastewater. This analysis includes a discussion of wastewater treatment issues for each site, with a recommended alternative as one of the possible options for the site. In each case, conventional sewage treatment is simply not an option, either due to lack of a municipal sewage treatment facility in a community, cost of extending lines, or the desire to reserve sewers for a central service area. There is also generally not enough development potential to support a major new community sewage treatment plant. However, as shown in the discussion that follows, a combination of individual, small-scale shared systems and small community systems can be used to achieve great results from both a design and treatment perspective. To link these hypothetical projects with real world innovation, each of the wastewater scenarios is followed by several actual projects that illustrate implementation of the design concepts and wastewater technologies.

The cost of using advanced treatment systems can be affordable, as demonstrated by their increasingly widespread use in both new construction and redevelopment projects. One of the costs that cannot be overlooked is the expense of developing management structures that will ensure advanced treatment systems are properly maintained. Whether local management oversight is town-wide for all onsite systems or focused on a small number of land development projects using innovative technologies, it is essential that local or county governments have a means to ensure that systems are properly maintained. Having maintenance programs and other supporting programs, such as training and certification for designers and installers and appropriate regulations specifying treatment standards, will ensure that community and homeowner investments are protected along with public and environmental health.

Making the Connection Between Local Resource Planning and Wastewater Treatment

The alternative development scenarios presented in this section are hypothetical, but the setting is an actual location characterized by diverse and sensitive water resources. These include:

- Groundwater aquifers that provide the only source of drinking water to the region. Deep sand and gravel aquifers underlie the study area where groundwater is held in the pore spaces among glacial outwash deposits. This type of aquifer yields a reliable and high-quality groundwater supply, but is highly vulnerable to contamination (Figure 3-3).
- A recreational river system that also supports regionally significant unique aquatic habitat, and adjacent coastal ponds—important nurseries for fish and shellfish but highly sensitive to nitrogen (Figure 3-4 and Figure 3–5).

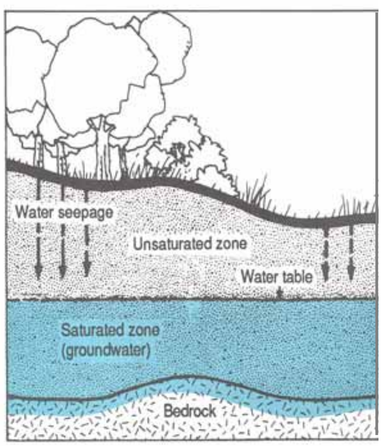

Figure 3-3
Groundwater Aquifer

Figure 3-4
Pawcatuck River—A Recreational River System that Supports a Unique Aquatic Habitat

Figure 3-5
Coastal Ponds Adjacent to the Pawcatuck River

In the past, making decisions about the type of wastewater treatment system to use was typically dictated by conditions of the site and immediate area rather than the larger aquifer or watershed setting. Suitability for onsite wastewater treatment focused on the hydraulic capacity of the site, that is, the amount of wastewater that could be safely discharged to a particular site given its permeability and the land area available for a leachfield. If horizontal setbacks from wells and surface waters, and vertical separation distances to groundwater or bedrock could be maintained, then water quality was considered adequately protected.

These site-specific factors are still valid today. However, it is now known that minimum standards are not always adequate under all situations depending on the capability of soil to treat wastewater and sensitivity of local water resources to contaminants. As a result, updated national guidelines for onsite wastewater management emphasize a watershed-based approach that takes a broader view of resource protection needs (USEPA, 2002). In the case studies that follow, watershed and aquifer scale treatment needs were considered based on the location of the project within a local sub-watershed or groundwater recharge area, municipal resource protection goals for the site, and other environmental characteristics or constraints.

Pollution Risks From Onsite Wastewater Treatment and Other Sources

Decisions about wastewater treatment options for the case studies consider existing water quality and pollution risks based on available reports and monitoring data. Septic systems threaten wells and surface waters locally in densely developed historical villages, in areas where septic systems are located on problem soils, and where homes are clustered together along shorelines. In dense, unsewered areas, septic systems are estimated to contribute up to 75 percent of the nitrogen inputs to groundwater. Nitrogen-sensitive coastal areas are at higher risk, with onsite wastewater treatment systems considered a major threat to aquatic health. Some ponds are impaired and closed to shellfishing due to high bacteria levels. All are considered in declining health due to nutrient enrichment.

With future development, pollution risks are expected to remain at about the same level, but the sources are likely to shift from agricultural fertilizers to septic systems, underscoring the need for proper siting and maintenance of these systems. Wetland and shoreline riparian areas have been identified as important zones for pollutant attenuation, including denitrification of nitrogen in shallow groundwater, which emphasizes the importance of protecting these areas from future growth.

Existing Wastewater Management Measures

In the case study area, state government sets minimum standards and regulates siting, design, and installation of onsite wastewater treatment systems. Local governments are responsible for ensuring proper maintenance of onsite wastewater treatment systems. A few of the larger towns have adopted mandatory septic system inspection and maintenance ordinances that require regular septic system inspection, maintenance, and repair as necessary, and phase out of cesspools. Establishing local wastewater management programs can be a lengthy process however, and most of the smaller communities are still developing wastewater management plans and do not yet have functioning management programs in place.

Municipal sewer systems are unavailable in all case study sites and onsite treatment is the only option. In addition, new discharges to surface waters are prohibited by state regulations, so onsite dispersal using either conventional or alternative leachfields on suitable soil is also required. Advanced treatment systems are permitted by state regulation, using technologies reviewed and approved by a State Technical Review Committee. Applicants are required to show proof of a maintenance contract with a qualified system maintenance provider. Tracking renewals of such contracts and overseeing maintenance work is considered the responsibility of municipal governments. Under the EPA voluntary guidelines for management of decentralized systems (EPA, 2003), cluster systems serving one or more buildings would ideally be managed using management models 4 or 5. Using this approach, a responsible management entity (RME) would be designated to operate and maintain the system. Operating permits would be issued to the management entity to provide needed assurance that appropriate maintenance is performed. At the highest level of management, the treatment facility would be owned by the responsible party, similar to a community wastewater treatment facility.

Evaluating Alternative Options

Making a decision about the type of wastewater treatment technology to use on a particular site can be a daunting process. Ultimately, the decision needs to address several factors to ensure that the best technology is being used that is also affordable, protects homeowner investment, and safeguards public and environmental health. Some factors considered in selecting wastewater treatment technologies for a site are:

- Treatment performance requirements
- Soil and site conditions
- Space and access limitations
- System robustness, reliability, and risk
- Initial capital and life-cycle costs
- Aesthetics
- Capacity of the local or county government to oversee maintenance

Although no one particular factor usually determines the actual system selected for a site, treatment performance requirements at the town, county, or state level often help define what type of treatment process is needed to achieve a desired performance level that is protective of public health and the environment. For instance, not all technologies are capable of or categorized as nitrogen-removal systems, so the short list of approved nitrogen-removal technologies may include only three or four systems. All factors collectively point the decision-maker to the best system for the site.

Making New Rural Neighborhoods

This case study examines making new rural neighborhoods.

Existing Conditions Before Development

This study area is made up of a mix of open meadows and large forested parcels together with a series of historic mill villages that line an old state highway (Figure 3-6). Like many rural areas, there is no single dominant element that generates its rural character; rather, it results from a great variety of natural and historic cultural landscapes within a relatively small area. In this scenario, natural resources include streams, ponds, and wetlands, and several large tracts of undeveloped woodland. Cultural resources include village centers, agricultural landscapes, and historic mill sites.

Figure 3-6
The Study Area for Making New Rural Neighborhoods

These resources are linked together by several types of corridors:

- Streams connect wetlands and waterbodies into an ecological system supporting diverse communities of plants and animals
- Rural roads link farmsteads and meadows into a continuous agricultural corridor
- Old farm and logging roads make an informal network of recreational trails that link existing protected lands with village centers

Current zoning for the area requires a two-acre minimum lot size as seen in the frontage lots shown to the lower-left and lower-right in Figure 3-7. Historic lot sizes are either much larger, like the farmstead shown in Figure 3-7, or much smaller than two acres, as shown by the aerial view of one of the mill villages in Figure 3-8, where lot sizes are as small as 5,000 square feet.

Figure 3-7
A Farmstead Lot in the Study Area

Figure 3-8
An Aerial View of One of the Mill Villages in the Study Area

Like many rural areas, the diversity of uses and development densities have created a rich visual environment. Much of the land has remained open and in active management for timber harvesting or agriculture, and there is room for both wildlife and people.

Under current zoning, most of the study area would be developed at a density of two acres per unit (Figure 3-9). Areas with poor soils, steep slopes, and difficult access are not shown as developed: even so, this uncoordinated large-lot development pattern pollutes waterbodies, fragments wildlife habitat, and destroys scenic vistas. Any hope of maintaining existing visual character or quality of life would be lost.

Figure 3-9
The Study Area Developed at a Density of Two Acres per Unit (Conventional Development Scenario)

The rigid standards of conventional zoning make little sense in such a varied landscape, where suitability for construction varies widely from parcel to parcel. Relatively few large lots are available close to village centers, which ironically have the best infrastructure, road access, and services. The end result is that it is easier to subdivide the large farms in the countryside, in part because these have the room and free-draining soils necessary for individual septic systems. In order to make money at these densities, developers tend to favor construction of large single-family houses on cul-de-sacs (Figure 3-10), which are more likely to produce a profit to offset high per-unit construction costs.

The result of this process is a virtual monoculture of suburban house lots that fit in neither with the rural landscape in the countryside nor the traditional streetscape of the villages. This outcome destroys the character and sense of place of both environments. Just as problematic, this narrow range of products no longer meets the needs of many existing residents, and caters to an increasingly small segment of the larger marketplace, especially as the regional population continues to age and households shrink.

Figure 3-10
Examples of Large Single-Family Houses on Cul-De-Sacs

Creative Development Scenario

The creative development scenario uses the idea of "conservation development" to accommodate the number of units allowed by current zoning while preserving 50 to 75 percent of the land available for development on each parcel (Figure 3-11). By siting new development in the most suitable areas, site disturbance is minimized, wetland buffers are enhanced, and permeable areas are retained to recharge groundwater. Protected farmland and other open spaces connect into continuous greenways that form meaningful expanses of protected habitat.

Figure 3-11
The Study Area Developed Using Conservation Development (Creative Development Scenario)

What makes this creative development scenario possible are flexible zoning rules that keep the overall two acres per unit density while enabling smaller or narrower building lots. What makes it work is a design process that goes beyond the usual engineering to address the visual character of the proposed development and how it fits into its context. This design process starts with a detailed analysis of natural and cultural resources and designs the development around the open space, rather than the opposite. The method for analyzing site features and selecting conservation areas and building sites has been clearly laid out by Randall Arendt and others (Arendt et al., 1994; Arendt, 1999). More in-depth, step-by-step directions are also described in *The Rhode Island Conservation Development Manual,* which provides more in-depth guidance using a ten-step process for planners, developers, and local officials (Flinker and Millar, 2002).

If each subdivision project follows this “conservation design” approach, then the development process itself gradually creates a permanent town-wide open space network (Figure 3-12). In addition, many towns and counties are beginning to provide guidance for these efforts with plans that identify key open space resources and suggest town-wide open space corridors.

By following these plans, a developer can avoid sensitive resources, contribute to town goals for open space, and enhance the value of building lots. Thus, while individual house lots may be smaller than two acres, each homeowner shares in the views, character, and recreational potential of the protected open space that surrounds his or her property.

Figure 3-12
An Example of a Subdivision That Follows the Conservation Design Approach

Within each project, the design process takes advantage of the character of the site and its surroundings to create a more attractive and livable neighborhood, which may take the form of a rural hamlet, a shady road through the woods, or a quiet lane on the edge of an existing village. In each case, building is done with the character of the site rather than paving over it.

Wastewater Treatment Alternatives for Making New Rural Neighborhoods

In this rural setting, low-density zoning protects groundwater aquifers and surface waters while allowing residential development compatible with existing agriculture. Preserving large areas of active farmland, intact forest, and open scenic views are priorities for the communities in this region. Relatively large two-acre lot sizes provide flexibility in accommodating onsite wastewater treatment systems using either conventional or alternative technologies. The different types of landscapes in this large rural district lend themselves to a number of development and wastewater treatment options. The choices are shaped by site conditions, environmental sensitivity, the amount of land to be preserved as open space, and conversely, how closely houses are sited together. Because the type of subdivision built under the alternative future rural neighborhood design scenario could vary widely, three different wastewater treatment options are described. These range from the lowest development intensity and level of management to the highest, and include:

- **Option A**—Conservation design using managed conventional systems to protect open space and individual wells
- **Option B**—Preserving farmland by locating individual wastewater treatment system leachfields in common open space
- **Option C**—Cluster wastewater treatment systems

Option A—Conservation Design Using Managed Conventional Systems to Protect Open Space and Individual Wells

The simplest and most widely used strategy for new unsewered development is to site buildings in the most suitable locations for wastewater treatment using the conservation design methods described previously. Careful site analysis is needed to identify conservation areas to be protected and suitable areas for siting homes and leachfields, roads, and other improvements. At an average density of two acres per dwelling unit, lot sizes can be safely reduced to one acre while still protecting individual wells if soils and site conditions are favorable. Of course this concept also assumes that good site design and other management practices are used to protect any nearby wetlands and surface waters. This approach can save 50 percent of the parcel as permanently protected open space while also reducing site disturbance. Ideally, a local wastewater management program would be in place to ensure these systems are regularly inspected and maintained

In this example, one new subdivision in the future scenario is used to illustrate a small portion of the site planning process (Figure 3-13).

Figure 3-13
New Conservation Development Subdivision in the Alternative Future Design Scenario

For the initial site suitability analysis and conceptual design, a rapid screening-level review was conducted using computer-generated maps available through the Rhode Island Geographic Information System (GIS). The purpose of this analysis is to:

- Identify the characteristic features of the site and regional greenways to be set aside as open space
- Locate suitable areas for buildings, onsite wastewater treatment, and stormwater management
- Create a design layout that fits into the landscape with minimal site disturbance

The parcel boundary was first outlined and overlaid on digital topography. The subwatershed encompassing the site was delineated, as shown in red in Figure 3-14. Wellhead protection areas and aquifers were also identified, with none located in the study vicinity. Soils, wetlands, vegetation, viewscapes and many other features were mapped. To identify site suitability for onsite wastewater treatment and stormwater infiltration, soils were categorized by soil hydrologic groups—a measure of the potential for water to infiltrate or runoff—and also by seasonal high water tables (shwt) depths (Figure 3-15). Wetland soils are mapped in red; other slowly permeable wet soils are shown in yellow and orange, as shown in Figure 3-15. The location of preservation areas, stormwater infiltration and storage areas, building and onsite system locations and road layout was then designed based on natural and cultural features.

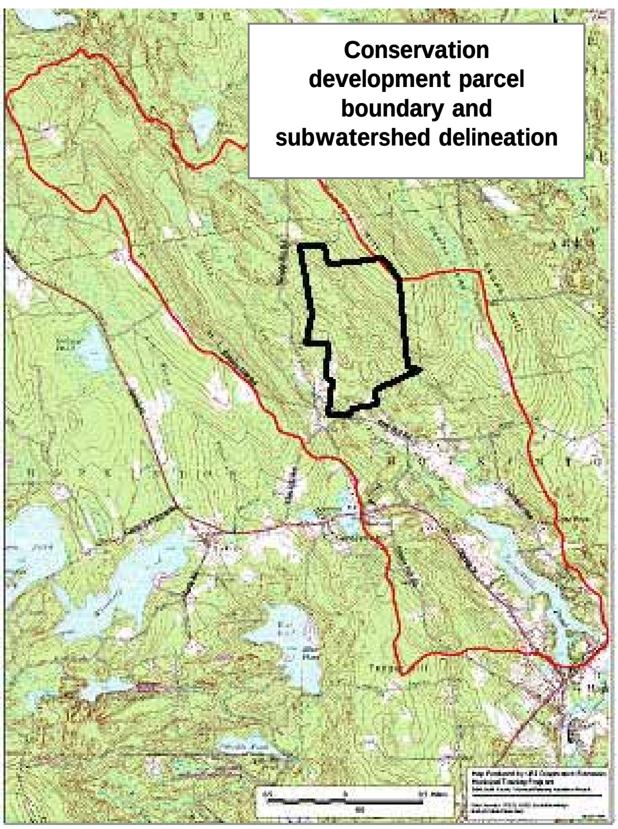

Figure 3-14
The Parcel Boundary with Topography and the Local Watershed Boundary Encompassing the Site

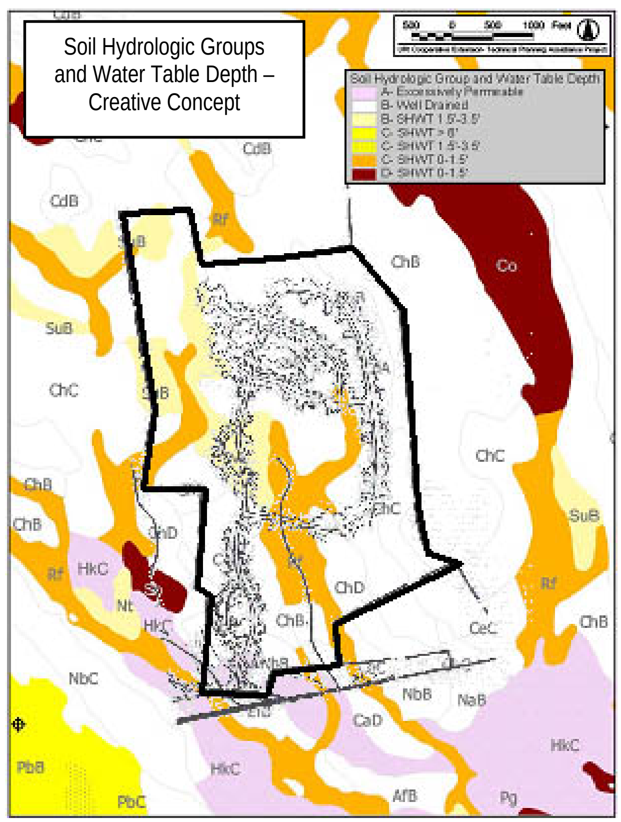

Figure 3-15
The Proposed Design Overlaid Over Soil Types

Results show that the site is located in the watershed of Locustville Pond, a recreational lake where nutrient enrichment is a concern, partly as a result of dense shoreline development. The key pollution control goals are to protect onsite private wells and avoid any additional runoff and nutrient (phosphorus) inputs to the downstream pond. In this project area, the zoned two-acre density is considered to be sufficient to protect water resources using conventional wastewater technology, provided onsite systems are located on suitable soils. To avoid further nutrient enrichment of Locustville Pond, a high level of pollution prevention is needed, with careful erosion control and stormwater management to maintain pre-development conditions. Site design would focus on limiting site disturbance and keeping impervious area to less than 10 percent, avoiding steep slopes, and maximizing wetland buffers as water quality treatment zones.

The resulting preliminary layout shown in Figure 3-15 preserves critical scenic and environmental features while maximizing suitability for onsite treatment. In this rural site, a combination of good site design, stormwater management using low-impact techniques, and managed conventional systems located in suitable soils is a practical, low-cost option. Since the town has not yet established a local wastewater management program, low-technology solutions are the most practical for this community. From a watershed perspective, regular inspection, maintenance, and upgrade of all systems in the watershed, especially older systems clustered along shoreline areas, would be the first step in further reducing pollution risks. Integrating current stormwater controls and wetland protection measures for new construction and redevelopment would also be important.

A community wastewater management program with public education and routine maintenance and upgrading of substandard systems would enhance protection of private wells (including shallow dug wells still serving older homes), reduce nutrient inputs to surface waters by targeting substandard and waterfront systems, and prolong system life, thereby protecting homeowner investment in the long-run. This approach corresponds to EPA's voluntary management guidelines following Model 1, where communities notify homeowners of the need to inspect and maintain onsite systems, and also Model 2, where homeowners with advanced treatment systems located on difficult sites would be required to have maintenance contracts for routine system inspection and care (USEPA, 2003).

Conservation development is simply a collection of methods to promote good design. Perhaps no other approach is so effective in reducing pollutant loads, conserving natural areas, saving money, and increasing property values. According to the Center for Watershed Protection (Schueler and Holland, 2000) better design seeks to accomplish three goals at every development site:

- Reduce impervious cover
- Increase natural lands set aside for conservation
- Use pervious areas for more effective stormwater treatment, often referred to as "low-impact" stormwater management

Figure 3-16 shows an example of a low-impact stormwater management technique. The techniques is a landscaped bio-infiltration are, also known as a “rain garden”, that stores and infiltrates runoff from a commercial building.

Figure 3-16
An Example of Low-Impact Stormwater Management

A thorough site analysis enables development site goals to be addressed from the start, focusing on low-impact nonstructural stormwater strategies. These strategies include, for example:

- Reserving permeable soils for groundwater recharge
- Micro-managing runoff near the point generated
- Disconnecting rooftop runoff from drainage systems
- Diverting runoff to vegetated areas for storage and infiltration
- Using small bio-infiltration areas and swales throughout the site

The goal is to mimic the predevelopment hydrology of the site to keep similar patterns in the volume of stormwater runoff. Conventional stormwater controls, even those designed for stormwater treatment, control only the rate of runoff, which results in a dramatic increase in the total amount of runoff and greatly reduces recharge to groundwater.

Figure 3-17 shows how fields and extensive stone walls were preserved by siting houses in a forested area at the back of the parcel using conventional septic systems. More than 50 percent of the property was preserved, including the original farmhouse (left). The stormwater drainage system was sited unobtrusively in the open field (right).

Figure 3-17
An Example of Conservation Development in Kingstown, RI

The basic steps for designing residential, commercial, and mixed-use developments have been clearly laid out in a number of publications. This process begins first with community planning to envision future growth, layout open space networks, and amend zoning ordinances to support flexible design options. Conservation development follows a four-step design process that focuses heavily on site analysis. The steps are to:

1. Identify conservation areas to be preserved and suitable locations to be developed
2. Locate house sites
3. Align streets and trails
4. Draw in lot lines

   (Arendt, 1999).

The Rhode Island Conservation Development Manual (Flinker and Millar, 2002) expands this basic process in a more detailed 10-step guide for developers and planners. Resources for conservation design are included in Chapter 5, *Resources for Applying Creative Design*.

Option B—Preserving Farmland by Locating Individual Wastewater Treatment System Leachfields in Common Open Space

Using a different site within the same rural neighborhood, this case study illustrates a range of wastewater treatment alternatives for a slightly more compact subdivision designed to protect active farmland. In this future scenario (shown in Figure 3-18 and Figure 3-19) new homes are clustered at the edge of an agricultural field. Using a circular road pattern, homes are centered around common open space, providing views from most homes and space for recreation.

Figure 3-18
New Homes Clustered at the Edge of an Agricultural Field

Conventional Onsite Systems with Leachfields in Common Open Space

Assuming soil conditions are good for onsite wastewater, a simple, a low-tech approach would be to use conventional systems for each home with a septic tank located on individual lots, but with leachfields positioned in the open space held in common ownership by all members of the development's homeowner association.

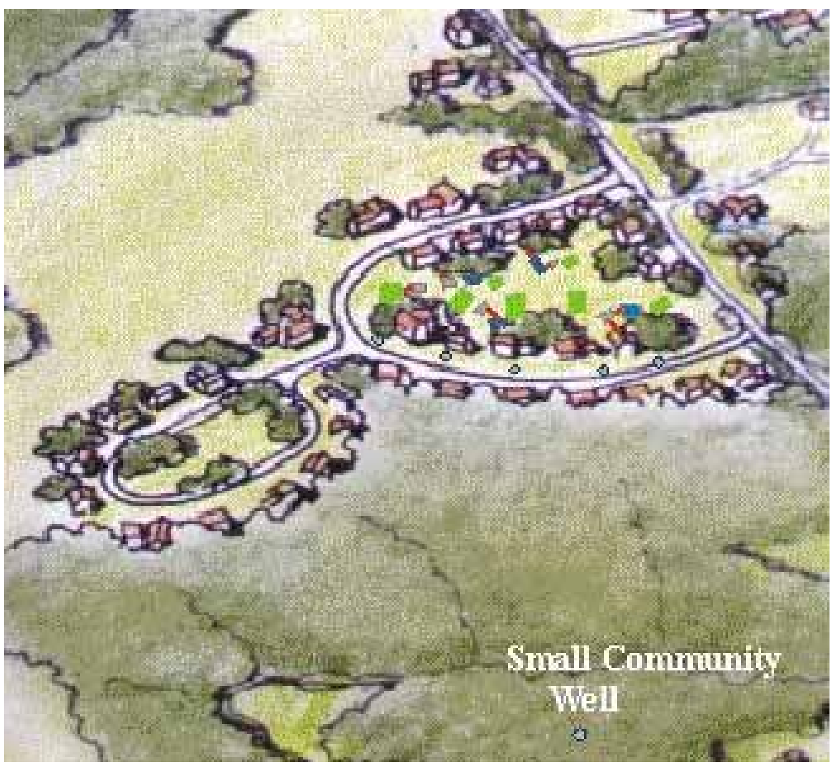

Figure 3-19
Option B—Locating Individual Wastewater Treatment System Leachfields in Common Open Space

Advanced Onsite Systems with Leachfields in Common Open Space

To enable more compact placement of new homes, Option B, as shown in Figure 3-19, also locates drainfields in the central common open space but uses advanced treatment systems to further reduce lot sizes to approximately one-half-acre. The overall density remains two acres per dwelling unit. To calculate the number of permissible lots, wetlands were excluded from the density calculation. Although the new neighborhood is hypothetical, protecting groundwater quality and the downstream freshwater resources are real priorities in this location within the Pawcatuck River watershed. A variety of time-dosed packed bed media filters, configured in either a single pass or recirculation mode could be used for these lots to achieve nutrient and pathogen treatment. Where permitted, this technology would also enable the maximum deduction in system and drainfield footprint size.

The high levels of treatment achieved with individual advanced treatment systems on each lot would assure maximum longevity of drainfields and protect homeowners' long-term investments. Use of shallow pressure-dosed drainfields would enhance nutrient and pathogen removal in upper soil and safeguard water quality. Advanced treatment reduces risk of well water contamination provided careful attention is paid to drainfield and individual setbacks, a horizontal distance that typically ranges nationally between 75 to 100 feet. Potential impacts from multiple leachfields may still be a concern, even though well setbacks are met, especially on marginal soils. In this case use of pathogen reduction technology such as bottomless sand filters as a drainfield option or ultraviolet light disinfection units after the advanced treatment systems would provide a high level of pathogen removal and lower contamination risk to wells. Where effluent movement from multiple leachfields is not a serious concern and site conditions are optimum, an argument could be made that advanced treatment could adequately protect wells that are closer than the regulatory setback standard. Indeed, for repair situations to existing homes, many regulators give well setback variances as a last resort. For new construction, however, maintaining full setbacks provides an extra measure of safety in case of inadequate treatment due to lack of maintenance, technology failure, or unfavorable site conditions such as elevated water tables with prolonged rainfall.

A homeowner association enforced wastewater management program would ensure that components of the advanced onsite wastewater treatment system are maintained as needed. Local oversight would still be needed to ensure that system maintenance is done properly and that contracts are renewed annually. According to the EPA voluntary management guidelines, the recommended level of management for these advanced onsite systems would be either Model 2, with required annual maintenance contract renewal, or Model 3, with operating permits issued to ensure performance annually (USEPA, 2003).

Advanced Onsite Systems with Leachfields in Common Open Space and Public Well

To overcome individual well setback issues, another variation for this site would be to establish a small community well to serve the subdivision rather than relying on individual wells (shown in foreground of Figure 3-19). The public well could be located in the adjacent wooded buffer area and still maintain the greater than 400-feet setback from leachfields to public wells. This option significantly expands operation and maintenance needs for the homeowner's association or other owner of the public well. The system owner would be required to demonstrate financial and managerial capacity to operate and maintain the well for the long term. These obligations would include complying with water supply monitoring and reporting requirements. Funds are typically held in escrow for future water supply system repairs and upgrading.

Option C—Cluster Wastewater Treatment Systems

An alternative small community treatment system, or cluster system, for this example site is shown in Figure 3-20. Each home would have its own septic tank (A) where solids would settle out and relatively clear wastewater would flow to a recirculation tank (B). A pump located in the recirculation tank would dose small amounts of wastewater to a recirculating media filter (C). Wastewater would recirculate between the media filter and the recirculation tank before final dispersal and treatment in the pressure-dosed shallow narrow drainfield (D) located in the commonly owned open space. Other treatment technologies, such as fixed activated sludge, can also be used for this location as a substitute for a media filter.

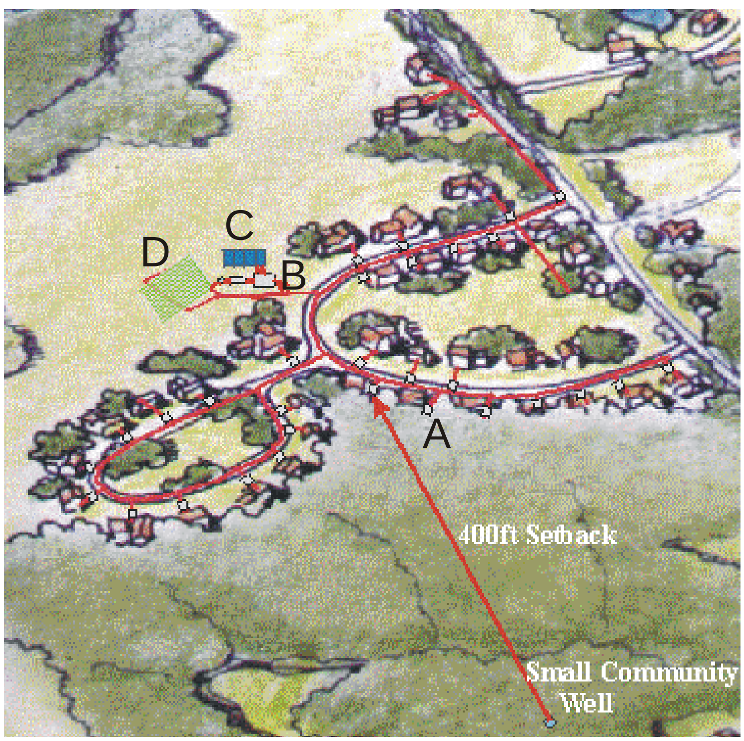

Figure 3-20
Schematic of a Small Community Collection and Treatment System

This alternative may enable more intense use of the property and support more compact siting within the new subdivision to preserve more farmland (Figure 3-21). A centralized treatment unit further removes operation and maintenance concerns from the homeowner to a designated management entity.

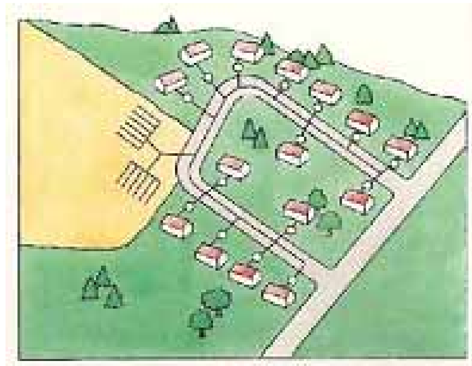

Figure 3-21
An Example Diagram of a Cluster Wastewater Treatment System

For some homeowners this treatment option begins to match the convenience and water use capacity of conventional sewers; however, public awareness is still needed to promote water conservation and proper system use at each home.

With proper design and landscaping, the treatment unit and drainfield could also be located in the central common space area provided setbacks are maintained and access for maintenance is maintained. Public use of the treatment area would also mandate a high level of maintenance oversight to guarantee proper system operation at all times.

Creative Land Use Opportunities with Cluster Systems

Locating a cluster system in this rural site opens up other possible options to meet community wastewater treatment needs. For example, existing homes in the vicinity that may have substandard or failing systems could be allowed to tie into the system. This shared solution is potentially more cost-effective than repairs or system replacement individually, especially if site conditions are difficult.

Another land use option would take advantage of the wastewater capacity of a shared system to increase density beyond the two-acre average by buying development rights from another property and using them here. This trading scheme for development capacity, known as transfer of development rights provides a mechanism to shift development from one part of a town or region to another area. Generally the “receiving zones” where development credits are used to increase density are located in planned growth areas that are less environmentally sensitive than “sending zones” where credits are sold to protect land. In this case development rights for critical open space land could be purchased and directed here to increase density within the new development supported by the cluster system.

The farmland on this site would already be protected by concentrating development at the allowable density, so the land protected by transfer of development rights could be located anywhere else within the town or district. This method is used in the New Jersey Pine Barrens to protect critical aquifers while directing development to appropriate urban growth areas.

Environmental Concerns with Increasing Density

A fundamental principle of the smart growth movement and environmental planning is that concentrating development within a parcel or larger watershed can reduce environmental impacts when compared to spreading the same amount of development throughout the larger area. This principle assumes that:

- Sound planning to select growth centers that have or will have appropriate infrastructure
- The increased density is part of a larger town or regional plan balanced with protection of open space reserves
- Compact development sites are not located in environmentally sensitive areas

If development in environmentally sensitive areas is unavoidable, development standards that go beyond minimum measures are used to control pollution risks. In addition, good site design and best management practices are used to reduce localized impacts from compact development. Addressing these concerns is paramount for unsewered areas, especially where local wells or other critical environmental resources occur and in marginal areas with development constraints. When using advanced treatment systems to meet wastewater needs, special care is needed to ensure other development impacts are addressed, with special attention paid to good stormwater management and protection of wetlands and riparian buffers for their habitat value and water quality function.

Factors to consider for protection of local water supplies and other critical water resources include:

- Whether the onsite or cluster system will be located within a wellhead protection area. Siting a new public well will result in creation of a new wellhead area that may also encompass wastewater treatment systems.
- The minimum setback distance to a public well is commonly 200 to 400 feet or more from a wastewater treatment system, rather than the 75 to 100 feet used for private wells. This inner radius should be fully protected.
- Large cluster systems have greater setbacks to wells and surface waters. Horizontal setbacks may be three times greater, resulting for example, in a 1,200-foot setback to a public well from a large cluster system. Greater horizontal setbacks and vertical separation distances to groundwater must be addressed in site design.
- Large flow systems are defined as those exceeding a certain design flow, such as 2,000 gallons per day. In critical areas, local governments may want to include smaller systems having for example, 1,000 gallons per day as large flow systems and establish siting and performance standards for these intermediate systems.

- Large flow systems often require additional hydrogeologic investigations to ensure proper system function and adequate protection of local water resources. Additional studies may include, for example, any or all of the following:
  - Groundwater mounding study to determine if wastewater loading will elevate groundwater levels below the leachfield and compromise the required separation distance between the bottom of the drainfield and the groundwater table.
  - Wet season water table monitoring to determine fluctuations in water table height and duration that may not be indicated by standard site evaluation methods.
  - Rate and direction of groundwater flow to evaluate the movement of effluent. Wastewater plumes generated by leaching systems are known to remain concentrated for long distances, up to 300 feet, with limited dispersal (USEPA, 2002).
  - Wastewater effluent plume analysis using particle tracking to estimate the concentration of effluent at the edge of the property, a nearby well, or other sensitive receptor. A commonly used standard to protect groundwater supplies and surface waters is to allow no more than 5 mg/l in the wastewater plume at the sensitive location. This is the EPA drinking water action limit, a precautionary level set to avoid increasing nitrogen to the 10 mg/l maximum contaminant level.
  - Estimated nitrogen loading to the groundwater from the parcel as a whole. Additional inputs from fertilizers and other sources may be included in the calculation. To prevent degradation of groundwater supplies or nitrogen-sensitive coastal waters, some jurisdictions have established maximum nitrogen loading limits on a per acre basis. In coastal areas, these are usually based on a watershed assessment that considers all sources. The state of Washington has adopted an anti-degradation provision for groundwater supplies that specifies that community onsite systems shall not increase the nitrogen concentration in groundwater more than 2 mg/l above background concentrations (Bailey, 1996).
  - Integrating standards for wetland and shoreline buffer protection and stormwater management can control the environmental impacts of building on marginal land. Stormwater runoff controls should include maximum impervious cover standards (10 percent or less on average for sensitive watersheds, higher for impacted areas) and requirements to treat and infiltrate runoff. In critical watersheds both the rate and volume of flow should be maintained to mimic pre-developed conditions.

Design, Operation, and Maintenance Considerations for Cluster Systems

Wastewater treatment scenarios using advanced onsite and cluster systems are more complex than the traditional conventional septic tank and gravity flow drainfield approach. However, the level of wastewater treatment far exceeds that of a conventional system. The additional components and treatment units that insure advanced wastewater treatment add a level of complexity that requires designers, installers, and operation and maintenance providers to have a familiarity with the technology.

Proper training and certification for these practitioners before they engage in alternative and innovative system work is required in many locations throughout the United States, which clearly helps to produce better design, installation and operation and maintenance practices.

One of the main advantages in using a cluster system is cost savings to the individual system users because the system design, initial capital equipment and installation, and operation and maintenance costs are shared. With larger subdivisions using a shared community approach, the system could be expanded in phases as the development phasing also expands. Generally, the design flow for shared systems can be reduced, because not all of the connected homes will be generating peak flows at the same given time. As an added precaution, many larger shared systems may include flow equalization tanks to minimize peak flow problems.

Operation and maintenance for all systems is essential. Maintenance of single family residential alternative systems is not particularly difficult or expensive, ranging from $125 to $300 per year with maintenance scheduled for once or twice annually on average. However, operation and maintenance costs can vary greatly depending on system complexity and energy requirements. Systems requiring four or more visits annually and with high power needs can be much more costly to maintain. Typically, the risk of upsets is low with managed individual systems, and a problem on any one particular lot does not usually compromise the function of adjacent systems. In contrast, a major component problem on a shared system that is poorly managed can affect all the users tied into that system.

Larger shared community residential systems require much more frequent maintenance because wastewater flows and strengths are more variable, and there is greater inherent risk of system upsets that could affect treatment performance and longevity. For larger cluster systems daily maintenance checks may be necessary. However, if less complex technologies are used, such as sand filtration for instance, regular maintenance can sometimes be done by non-specialized personnel, with monthly (or more frequent checks if necessary) conducted by experienced wastewater treatment system operators. When selecting treatment technologies, the level of system complexity and maintenance needs is an important consideration and long-term cost factor.

Real-World Supporting Examples for Making Rural Neighborhoods

Real-world supporting examples provided in this section include:

- Island Residential Compound—Using advanced onsite and cluster systems to support mixed use while protecting coastal waters
- Portsmouth Abbey School—Using a cluster system to maintain multiple use of limited open space
- Shannock Woods Cluster Subdivision—A cluster system supporting compact design to minimize land disturbance and protect groundwater
- Trims Ridge, Block Island—Using separate conventional onsite systems with drainfields located in common areas to preserve open space

Island Residential Compound—Using Advanced Onsite and Cluster Systems to Support Mixed Use While Protecting Coastal Waters

This residential compound, located on Block Island, 12 miles off the mainland, is a good example of how the use of alternative and innovative decentralized systems can enable sustainable mixed-use development at the outer edge of a well-established village but located in a fragile coastal zone. This compound has six structures on the parcel that are occupied by different family members but owned by one person (Figure 3-22). The existing structures were positioned on a dune-like coastal feature between the Atlantic Ocean on one side and a poorly flushed coastal estuary on the other that is both nitrogen- and pathogen-sensitive. In addition, a small freshwater pond occupies much of the lot on the ocean side of the parcel. Soils on the site are sandy and do not provide adequate treatment to protect shellfishing in the estuary. Municipal drinking water serves the structures, which consist of one year-round occupied home and five buildings that get active summer use as an artist's gallery, kite shop, and seasonal rentals.

Figure 3-22
Block Island Residential Compound

The site is on the outside boundary of the town's central village sewer district; however, sewer extension was not feasible due to town and state regulatory restrictions (Figure 3-23). A key factor in the town's decision not to extend sewers was a very real concern about opening the area for intense development, including new construction on substandard lots of record with high water tables and high flood zones. Because of the location in a sensitive coastal area, sewer extension would also have required approval by the state coastal management agency.

Decentralized advanced wastewater treatment systems were considered the best solution to protect public health and water resources while still allowing more intensive use of the high-value property. The conventional septic system approach would have required raised leachfields that needed extensive filling and regrading due to the high water table and slopes, which would change the whole character of the site without removing nitrogen.

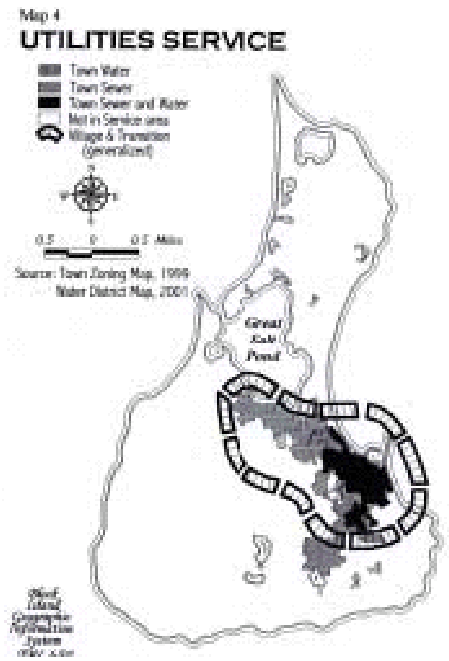

Figure 3-23
Block Island's Sewer and Water Service Districts, as Adopted in the Town Comprehensive Plan

Under the town's wastewater performance standards, nitrogen-reducing systems are required for this area because of its proximity to the coastal pond and sandy soils with shallow water table. This narrowed down the technology choices to those systems capable of removing 50 percent total nitrogen (state nitrogen reduction standard). Recirculating media filters were selected, with final treated effluent dosed to shallow drainfields for additional removal of nitrogen and bacteria. On this island community, everything comes on and off the island by ferryboat. The owners of these systems realized a cost savings by selecting modular, factory pre-packaged treatment units with small footprints, which saved space and ferry costs.

Because the property is under single ownership, this approach offered flexibility in using a cluster system. Cluster systems can certainly be used with individual owners provided all parties are amenable and legally binding maintenance agreements are written and attached to property deeds as part of municipal land evidence records. Based on site conditions, four alternative systems designed to handle flow from the six structures were selected as the simplest and most cost-effective solution. Two of the homes have individual systems. The other four homes were grouped into pairs, with each set having one shared system. In each case the pair of houses were close together with nearby land suitable for a shared leachfield. Each house using a shared system has its own septic tank but favorable grades enabled gravity flow to a common recirculation tank, which then pumped effluent to a larger, shared treatment unit, followed by a shallow narrow drainfield similar to the individual systems (Figure 3-24).

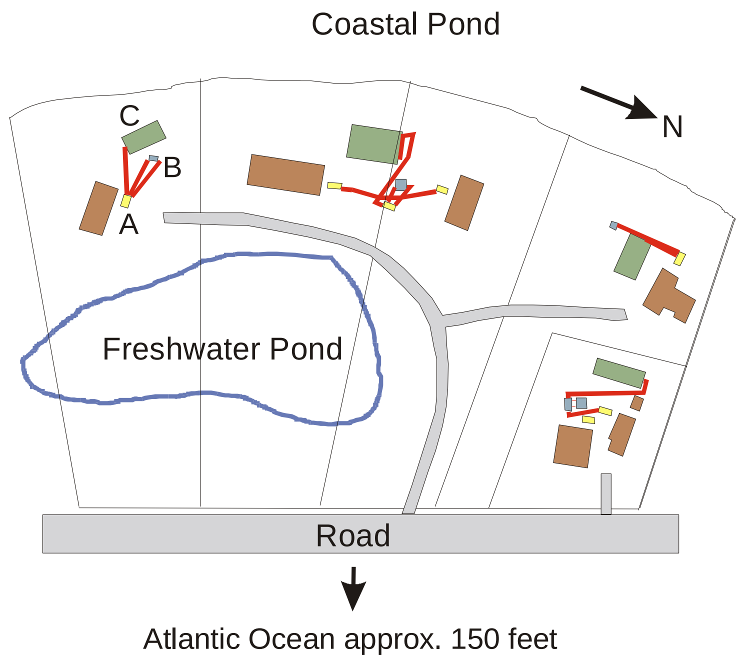

Figure 3-24
Site Plan of the Island Residential Compound

Wastewater from the homes flows into a septic tank (A) where effluent is recirculated to a media filter (B). Final treated effluent is dispersed to a shallow narrow drainfield (C).

Although one larger community system serving the entire site may have been technically feasible, the combination of individual and paired units was considered more practical for several reasons. Disadvantages with one large treatment system included:

- Increased costs of wastewater collection lines
- Higher cost of larger treatment units and drainfields
- Increased complexity for installation and maintenance
- Need to contract with a maintenance provider experienced with larger units

From an environmental perspective, a large drainfield would have been located closer to the coastal pond, creating a single discharge point with less opportunity for dispersal throughout the site and uptake through natural processes. In addition, multiple systems enable flexibility for changes in flow with seasonal use, with some units closed during the winter months while others remain in use year-round.

Portsmouth Abbey School, Portsmouth RI—Using a Cluster System to Maintain Multiple Use of Limited Open Space

Advanced decentralized wastewater treatment systems can permit multiple use of leachfield areas and also accommodate large flows on difficult sites. This case study illustrates how the use of a 12,000 gallon per day cluster wastewater treatment system at this private high school in Portsmouth, RI enabled multi-use of an athletic playing field for both wastewater treatment and a school sports program. The Portsmouth Abbey School is located on Aquidneck Island, a developed island within Narragansett Bay. Site features include a topography of gently rolling hills and silty soils that are slowly permeable with seasonal shallow water tables and occasional ledge outcropping. With a well-established infrastructure, the school had limited space available for a drainfield repair.

The site is served by public water but the town is completely unsewered. Faced with poor performance of conventional septic systems on difficult soils, the Abbey School decided to investigate replacing one of several existing systems serving the site with an advanced system that would function more reliably, last longer, and ultimately be more cost-effective. The system that needed replacement consisted of a conventional septic tank with shallow concrete leaching chambers located in an athletic field. This system received only sanitary wastes (no kitchen grease), eliminating the need for additional pretreatment or high-flow storage.

The water quality protection goals for this site were to:

- Ensure system hydraulic function on a site with difficult soils
- Reduce wastewater strength so shallow drainfield dispersal could be used (encouraging additional nutrient removal)
- Reduce bacteria for maximum protection of public health in a high-use area

The site drains to well-flushed areas of Narragansett Bay and is outside shoreline buffers, shellfish beds, and other sensitive habitat, minimizing the need to reduce nitrogen to extremely low levels.

The design engineer chose a recirculating media filter constructed in two separate cells to enable routine maintenance without disrupting use. The two-cell design fits into the topography at two grade levels following the natural slope, with minimal regrading. The media filters are followed by a shallow narrow drainfield for final dispersal (Figure 3-25).

Figure 3-25
The Portsmouth Abbey School Recirculating Media Filter (left). The Athletic Practice Field With the Shallow Narrow Drainfield (right).

With limited available space, the shallow narrow drainfield was located in an athletic field. As required by state regulations, the shallow narrow drainfield lines need inspection and maintenance ports to ground surface, but those would have interfered with athletic activities and been a hazard to the players. After considering several options, the designer decided to bury the inspection port covers just below the ground surface with turf grass, and attach small metal plates that can be located with a metal detector at the time of routine maintenance. Although the playing field is not an ideal drainfield location, it is a workable solution that enables full use of the area as a practice field. The life expectancy of the shallow drainfield, because it receives highly treated wastewater, is expected to be much greater than a conventional drainfield.

The system was selected for its relatively low cost compared to more highly engineered pre-fabricated treatment units, and the maintenance requirements are relatively simple and easily provided by trained local maintenance providers. Remote telemetry was added to the system controls, with a computer used to track routine system function. A maintenance contract is in place for regular maintenance every six months or as needed. The school maintenance staff performs routine maintenance such as monitoring daily water use, observing the number of pump cycles using remote computer software, and checking the effluent filters monthly and cleaning them as needed. The existing leachfield was also kept in place so that in the event of a power failure, the flows can be diverted back to the leaching chambers. Multiple and redundant safety features added fairly minor costs to the project, but provided safeguards in case problems arise to protect public health at this multi-use site even with difficult site condition

Shannock Woods Cluster Subdivision—A Cluster System Supporting Compact Design to Minimize Land Disturbance and Protect Groundwater

The Shannock Woods Cluster Subdivision illustrates how a 7,200 gallon per day alternative treatment system can be used on a cluster development to minimize hillside clearing, soil erosion, and scenic impacts, yet still achieve a high level of wastewater treatment to protect drinking water in a highly permeable aquifer recharge area.

This new 16-lot cluster subdivision, resting on 24 acres, contains 20,000-square-foot-lots in a one-acre zoning district (Figure 3-26).

Figure 3-26
Plan of the Shannock Woods Cluster Subdivision

Fifty percent of the site is preserved as open space, and each lot has a private well. Soils on this site tend to be excessively permeable sands and gravel and water tables are generally deeper than six feet. Drinking water well contamination, because of excessively permeable soils, was a concern. Steep slopes pose a particular challenge to septic system design, and excessive erosion and scenic impacts are other major concerns due to hillside clearing (Figure 3-27).

Figure 3-27
Wooded Hills Near the Shannock Woods Subdivision

The cluster subdivision option was selected by the designer and landowner to avoid steep slopes and minimize site disturbance. The town planning board initially rejected a conventional subdivision layout because it was deemed as too intensive for the site given steep slopes and other concerns noted previously. The technology selected for this site provided a high degree of treatment and minimized risks to private wells. Centralizing the treatment components and drainfield area drastically reduced the minimum land area needed for the individual lots and kept site disturbance to a minimum while enabling the same number of lots to be built.

To reduce site disturbance and avoid erosion in the sloping terrain, building envelopes were designated for individual home sites. The width of the entrance roadway was also reduced to avoid loss of trees. The treatment objective in this groundwater recharge area was to protect nearby wells from pathogens and high nitrogen concentrations. As a result, a recirculating media filter removing at least 50 percent of the nitrogen was selected. The treatment train for this site consists of septic tanks located on individual lots. Effluent flows from these tanks by gravity to two 5,000 gallon recirculation tanks (see Figure 3-26—A). Wastewater is recirculated between the recirculation tanks and the recirculating media filter designed for 7,200 gallons per day (see Figure 3-26—B). Each recirculation tank doses two of the zones in the filter. Final treated effluent from the media filter is dispersed in a shallow narrow drainfield (see Figure 3-26—C) where additional pathogens and nitrogen removal can be expected through natural processes.

Trims Ridge, Block Island—Using Separate Conventional Onsite Systems with Drainfields Located in Common Areas to Preserve Open Space

This older creative development plan dates back to 1980 and is still a good example of using separate conventional onsite wastewater treatment systems to preserve open space by locating the drainfields in common areas adjacent to each lot. This ten-acre development plan preserved historically significant agricultural fields in a beautiful coastal watershed, and provided an aesthetically pleasing cluster subdivision of ten single-family homes.

The site is located adjacent to Trims Pond, which is nitrogen-sensitive. The homes are arranged in pairs with shared double-bay garages at the lot line (Figure 3-28).

Figure 3-28
Trims Ridge Units with the Shared Double-Bay Garages

Lot size was reduced from one acre to one-fourth acre. The selected wastewater treatment method over twenty years ago for this site was conventional septic systems. This conventional technology does not adequately address nitrogen removal, but the innovative placement of septic systems and homes enables more compact and flexible design (Figure 3-29).

Figure 3-29
A Birds-Eye View of the Trims Ridge Cluster Subdivision Showing Lot Lines

This design preserves an impressive 75 percent of the site as open space. A central well located in the common open space supplies all units. The original network of stone walls crisscrossing the site is mostly intact, and all units have a water view (Figure 3-30). A gravel road, consistent with others in the area, minimizes stormwater runoff and maintains rural character. All the homes are buffered by native species plantings. A broad naturally occurring buffer to Trims Pond was maintained, and the cluster residents share a single boat dock.

Figure 3-30
Trims Ridge Cluster Subdivision Viewed for the Main Paved Road

Revitalizing Main Street

This case study focuses on revitalizing a small town's main street.

Existing Conditions Before Development

Settled in a dense band of structures lining Main Street, this historic village contains a remarkable collection of historic homes, commercial buildings, brick mills, and churches. Visually, this has created a delightful variety in size, shape, and architectural styles, held together by the unifying theme of Main Street (Figure 3-31).

Figure 3-31
An Aerial View of an Historic Village's Main Street

Functionally, this town is still a 19th-century village, with home, school, church, commercial, and government uses in close proximity. This structure creates an eminently walkable community, with a high degree of livability and a strong sense of place. Shops and businesses tend to be small and locally-owned, relying on personal service rather than cheap prices to attract customers. The scale of these businesses is ideal for the Main Street location, where they have the flexibility to fit into existing storefronts (Figure 3-32), or reuse historic structures (Figure 3-33).

Despite the attractions of village centers like this one, growth can be stifled by small lots, lack of parking, and aging infrastructure. Too small of a village to support a municipal wastewater treatment plant, the homes and businesses are dependent on individual onsite septic systems, many of which cannot support the increased flows that would result from the growth of a thriving town center.

Figure 3-32
A Store Front on Main Street

Figure 3-33
An Historic Structure on Main Street

As a result, main streets in small towns can remain in suspended animation for years. Meanwhile, investment is siphoned off to other areas of the town, often on the highway strip outside of the village, or in new industrial parks near the interstate.

Conventional Development Scenario

Many factors conspire to produce the scenario illustrated in Figure 3-34. Zoning requirements for minimum lot size, frontage, and setbacks make it hard to expand on existing lots. Requirements for off-street parking and limits on building coverage can make it even harder to build anything without tearing down existing structures and consolidating lots. Lacking a municipal wastewater system, any change of use can require expensive upgrades to individual systems. Some uses, like restaurants, may be driven out of the village if the lot is too small to install a suitable wastewater treatment system.

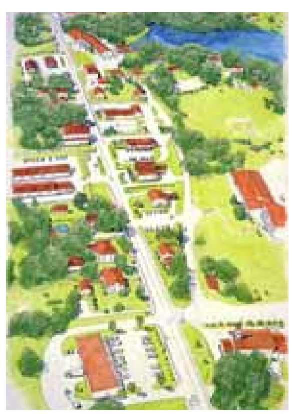

Figure 3-34
Conventional Development Scenario

While this has slowed development to some extent, it is only a matter of time before the rewards to developers outweigh the costs of wholesale replacement of existing buildings. New development is likely to be driven, not by local residents, but by corporations looking to expand franchise gas stations, mini-malls, and fast-food outlets (Figure 3-35). The result will be development that does not relate to the existing village in either scale or appearance, which tends to favor automobile access over pedestrians, and which virtually ensures the loss of much of the fine architecture that remains in the village.

These pressures also encourage businesses such as self-storage units that contribute economically to the town but offer little to the character and livability of Main Street (Figure 3-36). With low overhead and minimal needs for wastewater treatment, this can seem like a perfect choice for the small local business owner who cannot get approval for a more traditional Main Street use.

Figure 3-35
An Example of Conventional Development Driven by Corporations—a Fast-Food Outlet

Figure 3-36
Businesses Such as Self-Storage Units Offer Little Character to Main Street

Creative Development Scenario

In the Creative Development Scenario, the village is revitalized with new homes and businesses carefully designed to fit in with the historic character and pedestrian scale of the village (Figure 3-37).

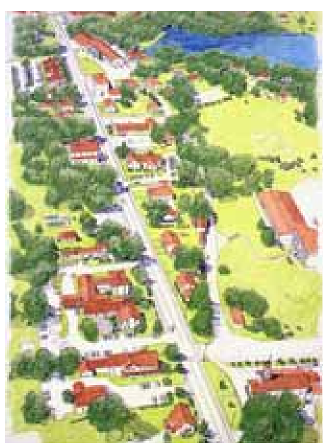

Figure 3-37
Creative Development Scenario

Rather than tearing down existing buildings, additions are placed to the rear in compatible architectural styles. Larger uses are accommodated by connecting existing buildings together. Meanwhile, careful planning provides the convenient vehicular access and ample parking demanded by growing businesses.

Shared curb cuts between parcels reduce conflicts between cars and pedestrians and improve the appearance of the streetscape. Driveway connections cross lot lines, minimizing curb cuts and enabling customers to drive to adjacent businesses without pulling back onto Main Street. Placing drive-through windows at the rear of the buildings enables a function necessary for the success of many modern businesses, while keeping the street side pedestrian-friendly.

Parking is distributed throughout the village in small lots at the sides and rears of structures. This is convenient for customers and helps to reduce the apparent amount of asphalt. Cooperative agreements between landowners provide for connections across lot lines. The alleys enable customers and service vehicles to travel between businesses without pulling back onto Main Street. Sharing of parking lots is also encouraged, with residents using lots at night that during the day serve neighboring businesses.

This comprehensive approach to providing for parking and vehicular access results in a much more efficient use of space, enabling Main Street to be renovated for the comfort of pedestrians. A “streetscape master plan” provides for improvements to sidewalks, the addition of benches and trash receptacles, and pedestrian-scale street lights that encourage people to walk between uses. Overhead wires are buried, and a comprehensive landscape maintenance plan provides for the care and replacement of street trees. This public investment inspires private investment in storefronts, sidewalk cafes, and events that take advantage of a revitalized Main Street environment (Figure 3-38).

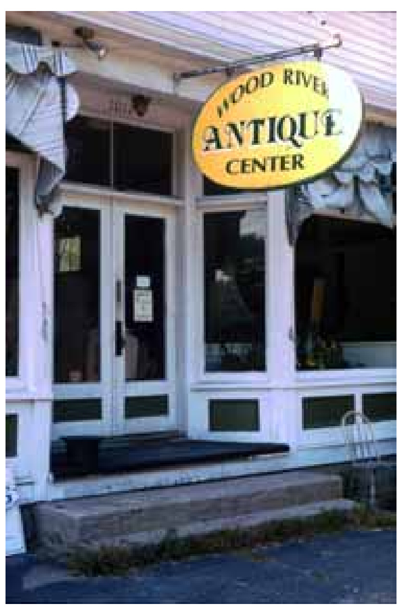

Figure 3-38
An Example of a Private Storefront

A detail of the creative development scenario illustrates many simple techniques for encouraging growth without destroying the character of an historic village center (Figure 3-39). The existing condition of this site includes three houses on individual lots. In the creative scenario, two of these houses are renovated and joined with a wing that contains the modern functions and equipment—including a drive-through window—necessary for a Main Street business such as a bank.

Figure 3-39
Detail of the Creative Development Scenario

Parking is distributed around the side and rear of each structure, and curb cuts are minimized through the use of shared driveways. The building in the center of has been expanded and renovated to accommodate a restaurant, which shares parking with the neighboring businesses during the busy evening hours. Service access and storage is kept to the rear.

Whether a local business or a national chain, banks, restaurants, and other businesses are asked to fit into the character of the village rather than replacing historic structures with corporate architecture. While perhaps more expensive than developing a standard company building, this approach promotes good community relations and creates a memorable experience for visitors (Figure 3-39). If other issues can be resolved, such as access, parking, drive-throughs, water supply, and wastewater service, many firms will jump at the chance to be on Main Street where the people are, rather than on the edge of town.

Figure 3-40
An Example of a Fast-Food Restaurant in Freeport, Maine

Wastewater Treatment Options for Revitalizing Main Street

This case study zeros in on a portion of the alternative future Main Street scenario that includes a 5,000 to 6,000 gallon per day shared system serving a 75-seat restaurant, a branch bank office, and four small business offices all located in one large building complex. As with so many existing villages, space at this site is at a premium; however, the presence of public water is a tremendous benefit and makes the project feasible. Enough land is available to support the components necessary for an alternative wastewater treatment system. At this density the conventional technology approach would be limited to concrete leaching chambers located under the parking lots to get maximum drainfield sizing, which is not recommended due to poor treatment potential.

Keeping Local Diners and Restaurants by Accommodating High-Water Users

One of the most difficult challenges facing traditional village centers is accommodating high wastewater flows from restaurants. Fast food chains typically rely on take-out, throw-away packaging, and pre-processed foods, which keeps water use low. Sit-down restaurants require much more water for cooking and dishwashing. Here wastewater flows are typically estimated to be 75 gallons per seat each day compared to 35 gallons per seat for a fast food restaurant. In addition, restaurant waste is high in BOD, TSS, and grease. Special design is needed to deal with this high-strength waste, especially when space is limited.

The wastewater treatment issues in this case study center on protection of the nearby Pawcatuck River, which flows 400 feet behind the bank and restaurant, roughly parallel to Main Street.

Although the river segment through the village is impaired for swimming due to elevated bacteria—runoff and septic systems are considered responsible—a public access is located just downstream and maintaining water quality is vital. In this setting advanced treatment is considered preferable for improved treatment of bacteria and phosphorus, and also to minimize site disturbance and reduce risk of system failure, under the following circumstances:

- Large flow systems.
- System repairs or new systems on lots of record within 150 feet of the river and tributary streams and wetlands.
- High water table soils.
- Small lots requiring excessive filling and alteration to accommodate a conventional system, especially where scenic and historic character would be affected or where stormwater diverted from raised systems would cause nuisance flooding to neighboring properties and leachfields.

Advanced treatment systems that use shallow drainfields provide the flexibility needed to accommodate wastewater flows from this future scenario restaurant /office complex while also improving phosphorus removal in upper soil layers. The first priority for all high-flow, high-strength waste is to ensure good pre-treatment.

Using a typical treatment train for restaurant waste, wastewater from the restaurant kitchen in this case study would flow through three two-compartment 3,000 gallon grease traps as shown in Figure 3-41 (A) and then flow into a septic tank (B) serving the bathrooms in the restaurant. This combined flow from the grease traps and bathroom septic tank would flow by gravity into a 2,000-gallon flow equalization tank (C). This equalization tank would help store peaks flows of wastewater, provide a fairly even flow, and eliminate the risk of peak and low flow upsets on treatment processes in the treatment unit (D). The selected treatment unit would have to be a small-footprint system capable of handling large flows while also producing high-quality wastewater. In this case study a sequencing batch reactor was chosen (D). The septic tank for the bank and office portion of the building would flow directly into the sequencing batch reactor. Final treated effluent would flow to a 2,000-gallon drainfield pump tank (E). Final effluent would be split by a sequencing valve and pressure-dosed to a shallow narrow drainfield (F), a raised bottomless sand filter (G), and an at-grade bottomless sand filter (H).

Figure 3-41
Advanced Treatment System

Real-World Examples Supporting Revitalizing Main Street

The next two examples show how alternative decentralized systems can support the charm of an historic mill village within the Blackstone River National Heritage Corridor. Chepachet Village, in the town of Glocester, RI (Figure 3-42) has an established wastewater management plan with an extensive education program, development of a septic system inspection/upgrade ordinance, a needs assessment, and a long-term wastewater management plan for the town that will accommodate existing uses and limited future economic development. Soils in the village area are dense glacial till with large rocks and boulders, with water tables at 1.5 to 4 feet during wet times of the year. Private and small public wells provide the only source of drinking water.

Figure 3-42
Chepachet Village

Antique shops housed in structures that were once textile mills line the Chepachet River (Figure 3-43).This tributary is part of the Blackstone River National Heritage Corridor. Failing septic systems are being replaced throughout the village using a combination of onsite and cluster systems.

Figure 3-43
Textile Mills Converted to Antique Shops
Line the Chepachet River

Small Multifamily Mixed-Use Shared System

The historical building shown in Figure 3-44 houses a real estate office, a pick-up dry cleaner, and an apartment. The green rectangular cover of the 600-gallon-per-day media filter serving these mixed uses is visible in the backyard as shown.

Figure 3-44
An Example of a Mixed-Use Shared Media Filter System

Another example site in this village (Figure 3-45 and Figure 3-46) is a single parcel with three structures on it:

- A barn containing a small retail plant and garden shop (no running water in barn)
- A three-bedroom main house consisting of two apartments
- A one-bedroom cottage

In addition to the retail plant display area on the northeast portion of the property, the lot also contains a fair amount of wetlands and wet, medium-textured soils. All these factors combine to produce a site with limited usable space for a septic system repair. The existing septic system consisted of a septic tank and failed bed-type drainfield.

Figure 3-45
The Main House and Cottage

To protect onsite wells and solve the wastewater challenges on this site, a recirculating media filter was used to provide a minimum of 50 percent nitrogen removal, followed by a bottomless sand filter designed to function in high water table soils while providing additional bacterial removal. Because all buildings were under single ownership, a shared system serving the main, multifamily house and separate cottage was designed. The same approach would have been recommended with parcels under different ownership but in most cases, agreement to cooperate on a shared system is purely voluntary. Legal covenants for system access and maintenance must be developed. Wastewater from both the main house and the cottage was collected by gravity flow to a common septic tank (Figure 3-45—A) where it is pumped to a recirculating media filter located on the high point of the lot near the road (B). Final treated effluent is pressure-dosed to the top of a raised bottomless sand filter serving as a drainfield (C).

Raised bottomless sand filters following advanced treatment systems save space and are a cost-effective drainfield option for sites that have shallow water tables, setback issues, and space limitations. In addition, a high level of wastewater treatment is assured in this type of treatment train. Figure 3-46 shows a schematic drawing of this mixed-use cluster system.

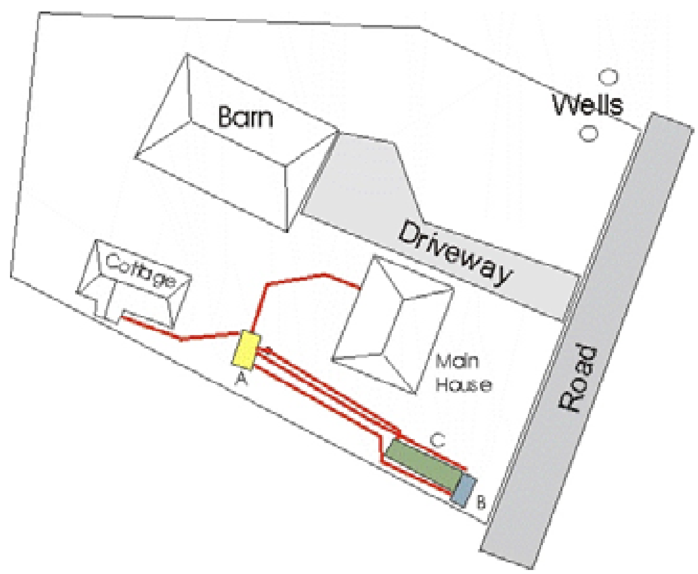

Figure 3-46
A Schematic Showing a Small Multi-Family Mixed-Use Cluster Decentralized System

Commercial Cluster System Supporting Main Street Businesses

This second Chepachet Village demonstration system solved the wastewater problems associated with several buildings owned by the same landowner. Flow to this system comes from a small restaurant, a small five-shop strip mall, a duplex apartment with four bedrooms, and a small doctor's office. The flows from the mall, duplex, and doctor's office are moderate residential-quality wastewater. The flow from the restaurant is high-strength wastewater despite efforts in the kitchen to reduce fats, oils, and grease.

Design flow to this system is 2,700 gallons per day; however, actual combined daily flow from these buildings is approximately 1,300 gallons. The main challenge for this system and any system involving a restaurant is managing inputs of fat, oil, and grease so that it does not get transferred to the treatment unit or drainfield and cause failure.

As Figure 3-47 shows, the system installed on this site first routes restaurant kitchen wastewater through a three-compartment 2,000-gallon grease trap (B) then combines this flow with wastewater from the restaurant bathroom facilities. This combined effluent then flows to a large septic tank (A2). Wastewater exiting the strip mall, duplex apartment, and doctor’s office all flow into separate septic tanks (A), and then directly into a recirculation tank (C). A pump recirculates wastewater from the recirculation tank to a recirculating media filter (D). Final wastewater is pressure-dosed to a shallow narrow drainfield (E).

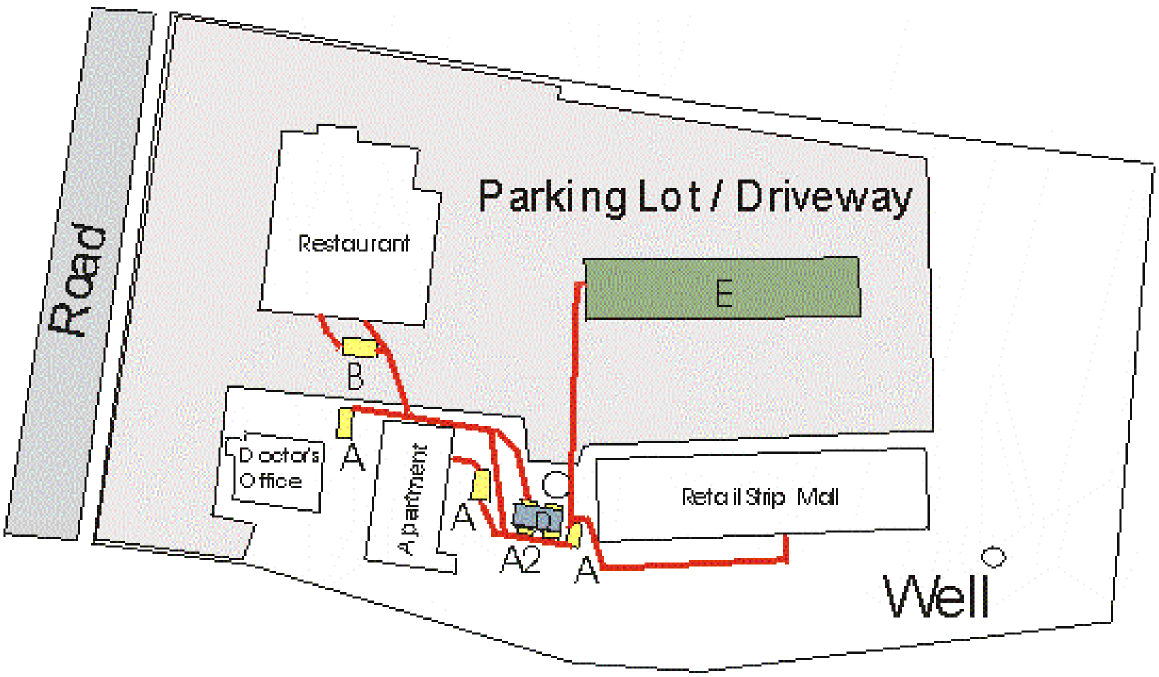

Figure 3-47
A Schematic of the Chepachet Village Shared Commercial System

Figure 3-48, Figure 3-49, and Figure 3-50 show the layout of treatment components and the completed drainfield for this cluster system.

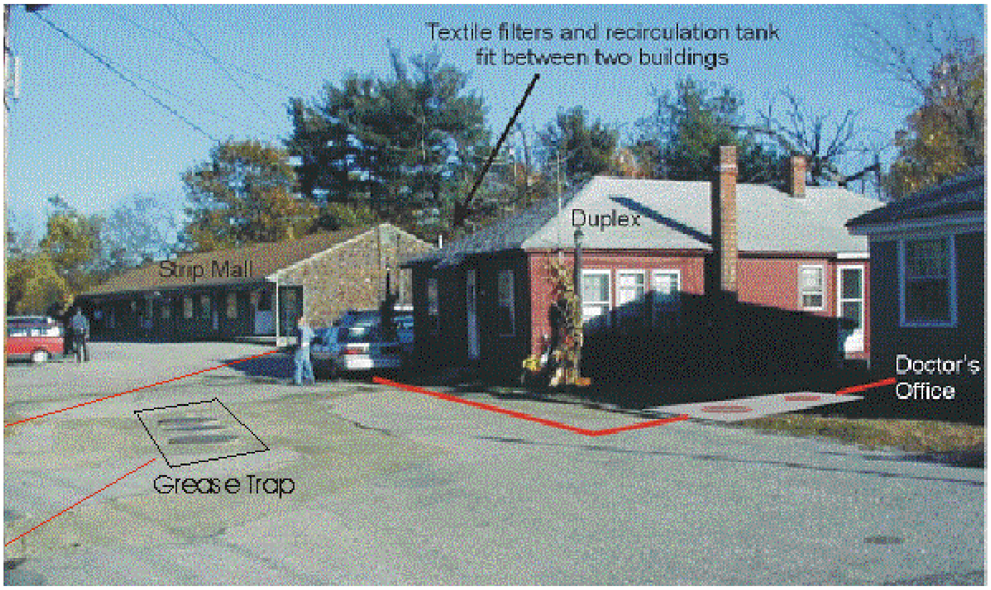

Figure 3-48
Layout View of the Chepachet Village Shared Commercial System Site

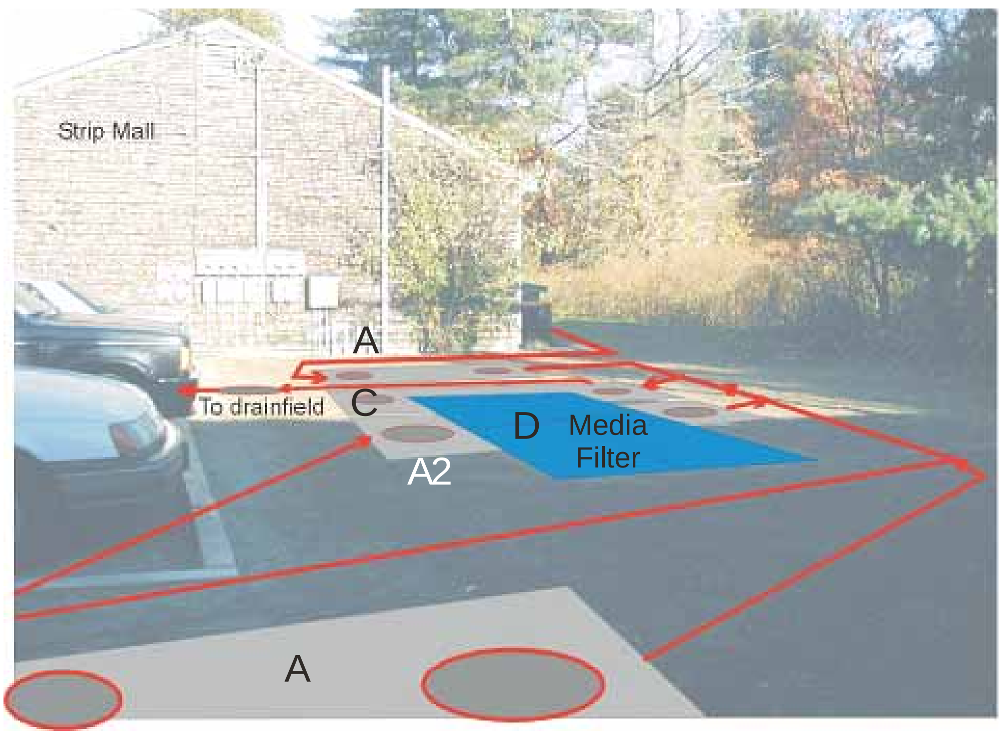

Figure 3-49
Layout of the Treatment Components at the Chepachet Shared Commercial System

Figure 3-50
The Completed Drainfield at the Chepachet Village Shared Commercial System Site

Wickford Village—Using Advanced Wastewater Technologies to Preserve an Historical Seaport and Restore a Coastal Fishery

Wickford Harbor is a 400-acre sheltered cove of Narragansett Bay in North Kingstown, RI (Figure 3-51). A working port since the 1600s, the harbor and surrounding Wickford Village is a thriving waterfront village of historic homes, gardens, and shops. Recreational paddling, boating, and shellfishing are popular in Wickford Harbor's many coves. The harbor provides a valuable nursery for fish, wading birds, and shellfish. It also supports one of the few remaining eelgrass beds in Narragansett Bay—an EPA-designated national estuary. This important underwater grass filters pollutants and provides essential habitat for shellfish. Because it is sensitive to pollution from runoff and septic systems, especially nitrogen, it also serves as a vital indicator of coastal water quality.

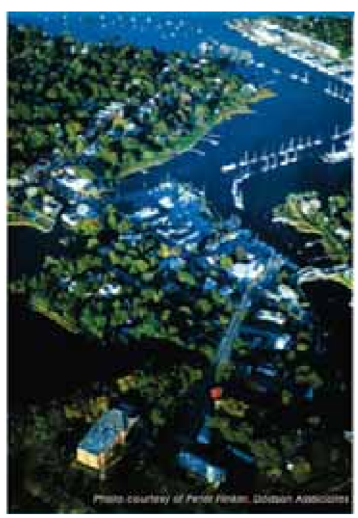

Figure 3-51
Wickford Harbor and Downtown Wickford Village

A Threatened Resource

Substandard septic systems in the densely settled village have long been a concern. Town officials had explored the possibility of a sewer connection to a nearby state-owned wastewater treatment facility servicing an industrial park, but decided against it due to the potential for greatly expanded growth. Although zoning standards control new construction and expansion within the village, town officials felt that if sewers were available, the pressure for zoning changes to allow more intensive use would be too great to resist, eventually leading to loss of the village's historic character (Figure 3-52).

Figure 3-52
Historic Wickford Village

The town chose to adopt a decentralized approach, promoting repair and upgrading of onsite systems, using advanced treatment where necessary to overcome difficult site conditions. With the driving factors of protection of sole-source aquifers and coastal waters, the Town of North Kingstown adopted a wastewater management program in 1998 that requires all homeowners to regularly inspect and maintain septic systems and report results to the town. The town water department and groundwater committee maintain an active public education program through water department newsletters and other publications, school programs, and local environmental fairs.

To evaluate the potential impacts of onsite systems and stormwater runoff on the harbor, the University of Rhode Island Cooperative Extension and Save the Bay, a nonprofit group working to protect Narragansett Bay, worked with the town to conduct a watershed assessment. They found high nitrogen loading to the harbor from watershed land use activities (Figure 3-53), with septic systems estimated to account for more than 80 percent of the sources. Nutrient enrichment caused overabundant growth in nuisance algae in the harbor (Figure 3-54). In addition, a review of building records and septic system permits concluded that at least 70 percent of village septic systems were likely to be cesspools or other substandard systems.

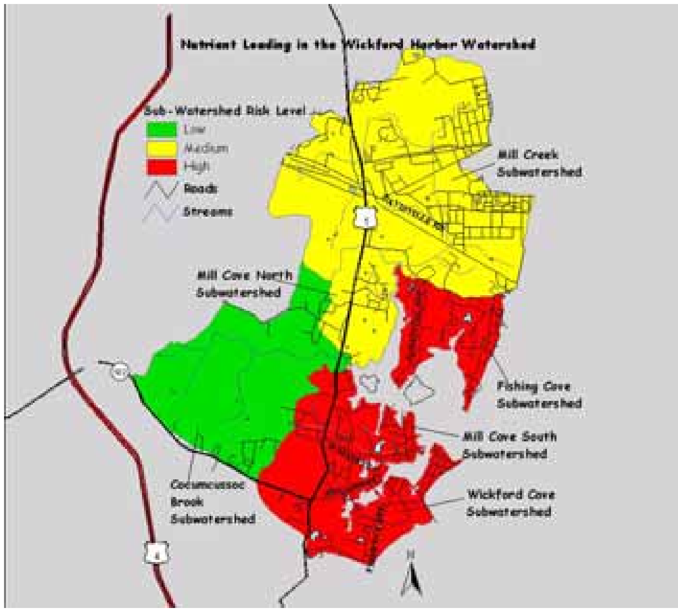

Figure 3-53
High-Risk Areas for Nitrogen Loading to Wickford Harbor

Figure 3-54
Overabundant Growth of Nuisance Algae
in Wickford Cove Caused by Nutrient Enrichment

Advanced Treatment Solutions for Sensitive Sites

Over the past several years, state regulators have approved advanced treatment technologies for general use and training and certification programs for wastewater professionals were instituted. As a result, alternative systems became more widely available and a growing number of homeowners and business owners in the village began upgrading substandard septic systems. Advanced treatment technologies provided the only repair solution for difficult sites that could not have accommodated a conventional system.

Figure 3-55 shows a waterfront home on Wickford Harbor had a failed septic system with a direct overflow pipe to the harbor. This system was replaced with an advanced wastewater treatment system in a 1997 demonstration project funded under the RI AquaFund Program. A single-pass media filter followed by a shallow narrow drainfield now serves this single-family dwelling located on the harbor shore. Advanced treatment reduces pathogen inputs to the harbor to protect shellfishing and swimming use.

Figure 3-55
A Waterfront Home on Wickford Harbor That Now Uses an Advanced Treatment System

Figure 3-56 shows members of the Rhode Island Independent Contractors and Associates and URI Cooperative Extension installing a pressure-dosed shallow narrow drainfield to maximize wastewater renovation in upper soil layers on a shoreline lot.

Figure 3-56
A Pressure-Dosed Shallow Narrow Drainfield Is Installed on a Shoreline Lot

Advanced Treatment Solution for a Difficult Village Site

Repairs in the Wickford Village Center can be challenging, especially where space is limited and new solutions must blend in with historical architecture. One of the focal points of the village is a corner block multi-use building with bookstore and other shops on the first floor and six one-bedroom apartments above (Figure 3-57). The back of the building is about 30 feet from harbor waters. An outdated septic system provided little treatment before discharging to the subsurface near the shore. The main treatment objective was to reduce nitrogen to restore eelgrass habitat. Pathogen removal in the treatment unit was considered less critical due to the opportunity for additional treatment in a bottomless sand filter. In addition, the immediate vicinity is closed to shellfishing due to boating and surface water runoff.

Figure 3-57
Mixed-Use Commercial and Residential Building in the Village Center

The amount of space available was so limited that several creative solutions were needed to site a new system with a design flow of 900 gallons per day, including:

- The only option was to locate the tank and treatment unit in the building basement.
- Because a tank would not fit through the door, a concrete tank was poured in place.
- A recirculating media filter was chosen because of its small footprint; however, the fiberglass media filter container needed to be unpacked, cut into three pieces to fit into the basement, and re-joined in place.
- Most of the basement installation work was done by hand.

The drainfield was designed to fit in a wedge-shaped alley alongside the building, using a 90-square-foot bottomless sand filter.

Views of bottomless sand filter used as a drainfield for the Wickford Village commercial and residential system are shown in Figure 3-58 and Figure 3-59. The sand filter is roughly 90 square feet in size, which is about all that could fit in the alleyway between the buildings. The property line is one foot off the right edge of the sand filter.

Figure 3-58
Bottomless Sand Filter Used as a Drainfield

Figure 3-59
Bottomless Sand Filter and Property Line

Figure 3-60 shows the rest of the system (septic tank and recirculating media), which is located in the building's basement.

Figure 3-60
Septic Tank and Recirculating Media Located in the Building's Basement

This type of repair represents an extreme situation that is more costly than a typical alternative system installation. In fact, in a village with many difficult repair sites, clustering homes together in small groups of cluster systems or collecting flow to a larger treatment unit may be more economical. This type of community solution requires a great deal more effort on the part of town officials and landowners. In addition, reaching community consensus on the preferred solution can be a long process. Allowing individual landowners to find their own solutions, perhaps in voluntary cooperative agreements with neighbors, may not be the most cost-effective solution, but can be the simplest to implement.

Developing Treatment Standards

The Town of North Kingstown encouraged homeowners in high-risk areas to upgrade to advanced treatment systems by providing partial grants for construction of advanced treatment systems (Figure 3-61). Applicants in critical harbor areas, along shoreline tributaries, and in problem soils were given priority. The second priority was given to systems in close proximity to tributary waters, and the remainder of the watershed designated as a third zone. In each case substandard systems on poor soils would have high priority for funding system upgrades.

The treatment priorities for grant funding could easily be developed into treatment standards for new systems and repairs in the Wickford Harbor watershed. Specifying the areas where nitrogen and/or pathogen treatment is needed to protect water resources and overcome site constraints such as high water table provides guidance to designers and homeowners on the type of technology that is most appropriate for a site. Often the most appropriate systems are also the most cost-effective, where systems designed for difficult sites can be expected to have a longer useful life. Treatment performance standards are typically adopted as zoning overlay districts. Because technologies are constantly evolving , a list of technologies capable of achieving a standard—such as 50 percent nitrogen removal, can be maintained in a separate list at the town hall.

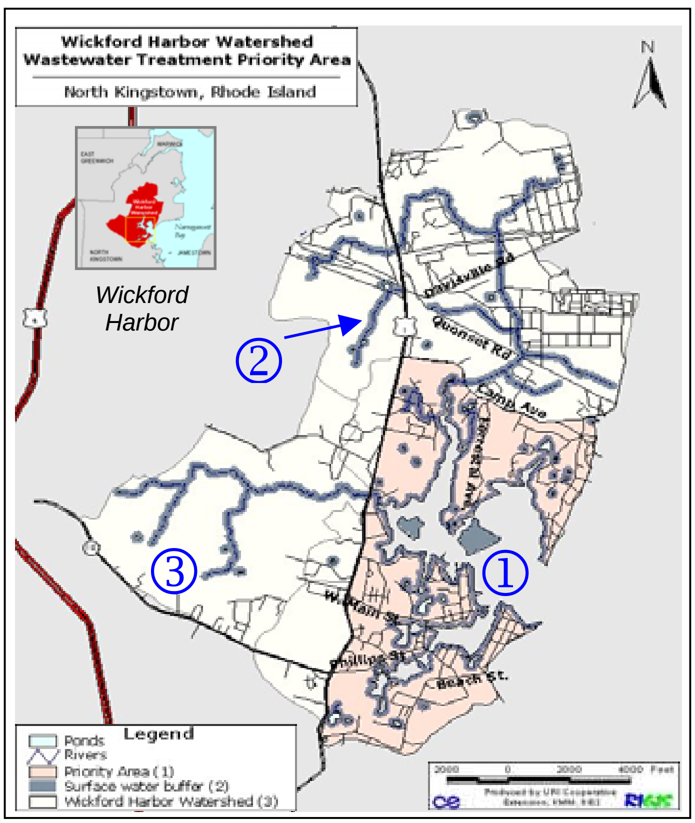

Figure 3-61
Priority Areas for Town Grant Funds for Septic System Upgrades Using Advanced Treatment Systems

Rebuilding an Historic Village

This case study focuses on rebuilding an historic village.

Existing Conditions Before Development

The real-life historic community (Figure 3-62) that is the focus of this case study straddles a river that once supplied power for mills that employed the community's residents. Now the village is quieter, the mills are no longer in operation, and residents go elsewhere to work. The village remains a nice place to live, in part because of the rich legacy of buildings, the sense of moving water nearby, and the feeling of community inherent in a place that is a bit off the beaten track.

Figure 3-62
An Aerial View of the Historic Village

One of the attractive things about the village is the hundreds of surrounding acres of undeveloped space—though all of this space is zoned for residential development (Figure 3-63).

Figure 3-63
The Village is Surrounded by Open Space

Like many mill villages, this one is split between two towns, and bisected further by both the river and a rail line. While this complicates efforts to prepare a unified plan for the area, it creates a situation where many groups are interested in helping to improve the area and to work cooperatively on improvements.

As shown in (Figure 3-64), the village is comprised of a narrow Main Street with houses close to the road. Designed around the mills and the river, roads and houses came afterwards, giving the village the complex, organic quality that always makes mill villages interesting places. But small lots and nearby water also complicate efforts to adapt old villages to new uses. Dependent on individual wastewater systems, many of the units are below modern standards and businesses struggle with a perceived lack of parking. A restaurant recently moved out of the village when a suitable wastewater system could not be designed for a small lot in the center of the village.

Figure 3-64
The Village Has a Narrow Main Street With Houses Close to the Road

Zoning requirements for half-acre lots and constraints on septic systems and parking make it difficult to develop new homes or businesses in the village center. Development continues in the countryside, however, where large parcels with good soils and easy access are subdivided first (Figure 3-65). Most businesses abandon the village center for the commercial zone out on the state highway. Here, small local shops have trouble competing with the larger regional chain stores. The cycle of disinvestments in the village center gets worse as people have fewer reasons to be there. The best that can be hoped for is that existing residents will be able to keep up their houses and the village remains a pleasant place to live—but they will have to work, shop, and seek entertainment elsewhere. Meanwhile, historic mill buildings and commercial structures are abandoned and eventually disintegrate.

Figure 3-65
Conventional Development Scenario

The development that replaces these older forms tends to follow a few simple models. Residential cul-de-sacs (Figure 3-66) reach out across the forested hills surrounding the village with one- or two-acre house lots. Commercial development, whether at the scale of a convenience store or supermarket, follows the basic strip mall model, with a large paved area in front for parking, beyond which is a simple slab-like building (Figure 3-67). Helping to drive both these patterns are zoning ordinances that require roads, lots, and buildings to be spread out, often with the purpose of preserving open space on each lot, but ironically resulting in all existing open space being irrevocably changed into sterile suburban lawns and remnant patches of forest. Further driving land uses apart are standards for individual wastewater systems designed to mitigate problems by lowering density rather than improving treatment.

Figure 3-66
Residential Cul-De-Sac Development

Figure 3-67
Commercial Strip Mall Development Model

Creative Development Scenario

Under the Creative Development Scenario, existing homes, streets, and businesses are carefully preserved as the seed crystal at the heart of a revitalized village center. Development is kept off the surrounding hills and instead channeled into carefully-designed extensions of the village and infill along existing streets (Figure 3-68). A mix of residential, small scale industrial, commercial, office, and residential is encouraged within existing buildings, as well as in new structures that fit the scale and character of the historic village.

Figure 3-68
Creative Development Scenario

A permanent greenbelt of protected open space is preserved around the village, over which views are maintained from many of the homes. Trails provide physical access to this surrounding open space, and sidewalks connect different parts of the village together. Thus, while individual lots may be small, quality of life remains high.

Meanwhile, outside the village center a new commercial node is created where Main Street intersects the state highway. Here, a master plan with design guidelines directs development of each lot so that attractive buildings front the road and screen out rear parking lots. Unified landscaping, pedestrian connections between buildings, and preservation of a key open meadow make this new commercial cluster an asset rather than an eyesore.

A close-up view (Figure 3-69) shows how new development can strengthen a village center, while providing the needed investment to rebuild streets, parks, sidewalks, and utilities.

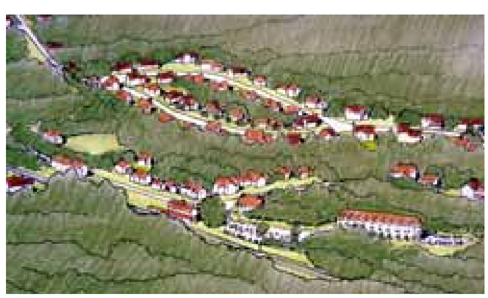

Figure 3-69
Close-Up View of the Creative Development Scenario

The organizing element of the community is its streets, which are designed just as much for pedestrians as cars. This concept includes:

- Designing comfortable, continuous sidewalks that connect people with all the places they want to go
- Replanting of trees and flowers to shade pedestrians and please the eye
- Returning to traditional design elements like porches, fences, and hedges that help to create a comfortable separation between the public street and sidewalk and private yard spaces

The resulting “streetscape” can become a shared community space that provides for circulation while unifying the visual character of the village. While the lots in the village are relatively small, the convenience of nearby services, the presence of neighbors, and ease of maintenance have a growing value in the marketplace. While existing village residents are often reluctant to see further development within the village, careful planning and design standards can reduce negative impacts while channeling investment to improvements that benefit everyone in the community.

Wastewater Treatment Options for Rebuilding an Historic Village

This main case study shows a hypothetical wastewater treatment option for a new development adjacent to an historic village. This example shows how the presence of municipal drinking water and the use of a small community collection and advanced treatment system help to:

- Expand an existing village center
- Make development at this dense level possible while minimizing sprawl
- Preserve outlying open space and valuable farmland
- Continue to foster a village appeal

The new homes and a few existing buildings with failed or failing septic systems are located in a portion of the village where surface topography enables gravity collection of wastewater from septic tanks at each structure. This technique helps lower the on-lot costs by approximately 35 percent and eliminates the need for pumps. The thirty homes are divided into four roughly equal districts, and each district has its own collection, treatment, and dispersal system. The main advantage of splitting the flow into several smaller systems as opposed to one large system is that risk potential of a catastrophic failure effecting all of the homes is lowered, yet the homeowners still realize the cost benefits associated with a shared system. In addition, the smaller systems can fit into tighter available space.

The conceptual design for this case study, as shown in Figure 3-70, depicts the district layout, the collection network, and the treatment trains for each district. The individual septic tanks (A) at each home achieve solids retention and settling, the recirculation tank (B) and recirculating media filter (C) lower wastewater strength, and treated wastewater is dosed to a shallow narrow drainfield (D) located in the commonly-owned open space.

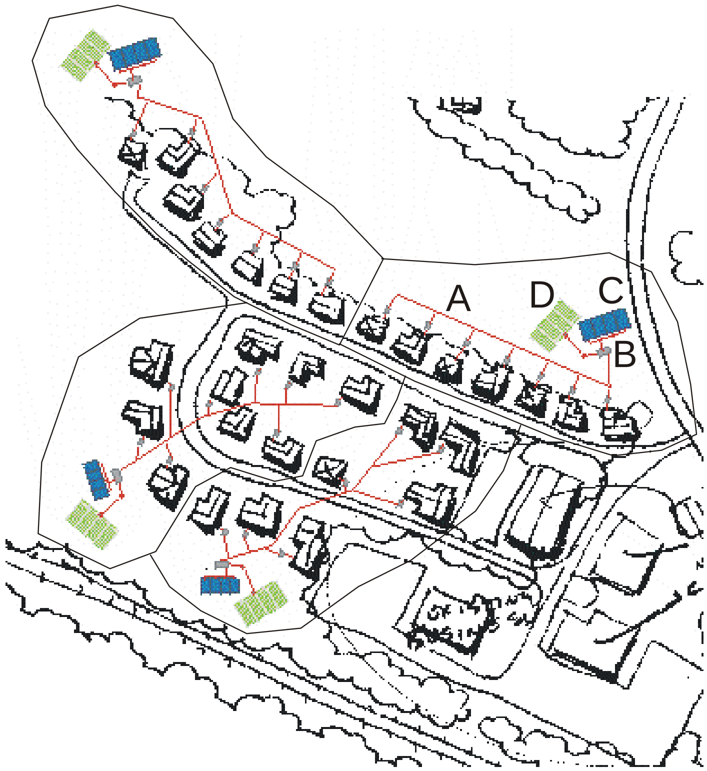

Figure 3-70
A Wastewater Treatment Option for an Historic Village

Alternative Wastewater Collection Demystified

The traditional method of collecting wastewater is to transfer both liquid and solid material in a large-diameter gravity sewer collection pipe to a low point on the landscape where either a treatment facility or a pump station is located. This collection method typically results in solids being transported long distances to a processing point. With a septic tank effluent gravity (STEG) collection system, the tank traps solids and only the liquid portion of the waste stream is transferred to the treatment location. Moving relatively clean water is easier, more efficient, and usually minimizes maintenance problems. In addition, size of transport pipe, depth of pipe burial, cost of materials and excavation, and ease of installation are all less or easier with STEG collection than with traditional large-diameter sewers. These factors translate into a less-costly treatment system. This approach also enables in-fill development in villages where lots may be large enough for a house and reasonable size yard, yet too small to adequately fit a septic system. With affordable alternative collection systems like STEG, wastewater from the in-fill and existing development can be transferred to a parcel where there is space available to treat and disperse wastewater.

With most treatment systems it is usually more efficient to treat solids and wastewater as close to the point of generation as possible. In the above example, the STEG tank is also the location where solids decomposition will occur. This solids storage and decomposition process places less treatment demand on the next treatment step and helps keep the amount of solids handling to an absolute minimum.

A wastewater management worker would simply probe the STEG tanks to monitor solids accumulation, clean the effluent filters on a periodic basis, and watch for telltale signs that would indicate if a household's discharge practices may be having a potentially adverse effect on the treatment system. If problems are detected, then corrective actions can be taken before they develop into major treatment problems. When solids (sludge and scum) levels in STEG tanks reach 35 to 50 percent of the tank working volume, then the wastewater service provider would schedule a pump out. Systems managed this way place less of an organic solids treatment burden on the municipal treatment plant receiving the septage.

If wastewater cannot flow by gravity, then a septic tank effluent pressure (STEP) collection system can be used. These collection systems function similarly to STEG, but wastewater is pumped to the next treatment process instead of flowing by gravity.

Real-World Supporting Examples for Rebuilding an Historic Village

Three real-world supporting examples for rebuilding an historic village are provided in this section. The examples are:

- Neighbors cooperating on a shared wastewater solution
- Conservation development to preserve open space
- A cluster system serving a new neighborhood

Neighbors Cooperating on a Shared Wastewater Solution

In this simple, small-scale supporting example, four neighbors found a solution to their failing septic systems by joining together to create one shared alternative system with a common treatment unit and drainfield installed on one of the larger backyards. This real-world alternative system approach met creative community design goals by helping to maintain the natural features of the neighborhood while revitalizing the wastewater infrastructure. Rebuilding older neighborhoods invariability means finding solutions for existing failed or substandard systems clustered on small lots. A treatment system serving new infill development or growth at the edge of an existing village might be able to tie in to existing homes if service, maintenance, and legal agreements can be arranged.

In many cases, however, treatment solutions for existing development need to be found separately. For instance, new construction timing may not meet immediate repair needs or connecting wastewater lines may be too distant or obstructed by wetlands or ledge. A major stumbling block for collective wastewater treatment for existing development is that all parties must be ready and willing to become part of the shared system, financially able, and capable of reaching agreements on liability and maintenance issues.

In this real-world example, the neighborhood consists mostly of one-fourth-acre lots with municipal water service. Soils in this area tend to be sandy with rapid permeabilities. Topography is fairly flat with high water tables approximately 3.5 feet below grade.

Existing septic systems in this neighborhood consist mostly of cesspools and steel tanks with old and inadequately sized bed type drainfields. These lots are located on a broad peninsula that extends into a large embayment that is sensitive to nitrogen inputs and seasonally closed to shellfishing. The conventional repair solution would have been a septic tank followed by a raised drainfield. This solution would have resulted in extensive tree removal, filling and regrading with little removal of nitrogen. With sandy wet soils, a risk of pathogen movement to coastal waters existed.

With tight lot zoning and problem lots so close together, this situation was a prime candidate for a small shared collection and treatment system. One of the homeowners faced with a failed system owned a double lot (one-half acre) that they wanted to remain as open space. This family was also receptive to using their extra lot as a treatment zone lot and having some neighbors partner on a shared system. This homeowner received a tax break from the city because the lot is no longer buildable.

The system selected consists of a 2,000 gallon per day recirculating media filter and a shallow narrow drainfield as a final treatment and dispersal zone. As Figure 3-71 shows, wastewater first flows into individual septic tanks (serving as either STEP or STEG tanks) at each of the four participating homes (A). Effluent only is transferred from these individual tanks through small diameter pipes, which required minimal excavating with light machinery, and minimized site and tree disturbance. The rest of the treatment system is located on the treatment zone lot. Wastewater from all the individual STEP or STEG tanks flows to a recirculation tank (B) located on the treatment zone lot. Wastewater recirculates from the recirculation tank to the recirculating media filter (C—outlined in blue). Final treated wastewater is dosed to a shallow narrow drainfield (D—outlined in green). Unlike conventional drainfields, the shallow narrow drainfield can be installed closer to trees and shrubs saving existing mature vegetation on the site. Currently this system is operating at approximately 70 percent of its design flow capacity.

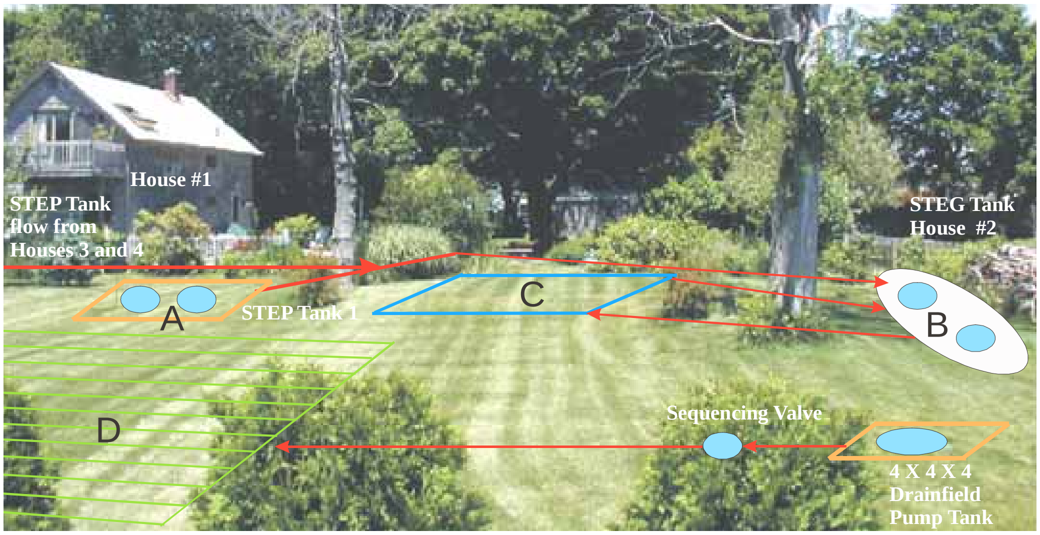

Figure 3-71
Shared Recirculating Media Filter System That Serves Four Homes

Conservation Development to Conserve Open Space

A real-world supporting example of using conservation development principles and an alternative collection and treatment system to preserve large amounts of open space is the Donovan's Farm project in Norwell, MA. The Donovan's Farm project began when the town decided to buy a 175-acre estate to preserve an historic farmstead and the surrounding meadows. A wooded portion of the property was slated for development to recoup some of the public investment and provide much-needed housing for seniors. Guided by a master plan and design guidelines, a 40-acre parcel was sold to a developer, of which only one-third was cleared to build the new village of 40 homes (Figure 3-72).

Figure 3-72
The 40 Homes at Donovan's Farm Are Gathered Along an Old-Fashioned Village Street

Houses are detached, with shared driveways, close together but surrounded by protected open space, through which trails will connect to a town-wide recreational system. As a result of a favorable housing market, the town was able to keep over 150 acres in permanent conservation, and provide some needed diversity in its housing stock, while making a profit on the project. Wastewater from all the homes is piped to a cluster treatment system that uses a pre-fabricated fixed film, sequencing batch biofilter. The wastewater is first collected in a dual-chamber septic tank, from which it cycles through a separate pump chamber and two treatment unit reactors. Once a batch of effluent has received the necessary amount of treatment, it is discharged to a drainfield (Figure 3-73).

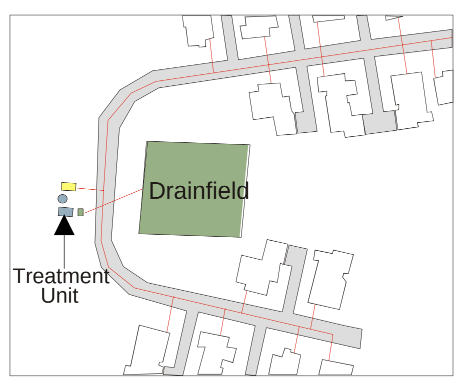

Figure 3-73
Layout of the Donovan's Farm Conservation Development

A Cluster System Serving a New Neighborhood

The Littles Hill new residential cluster subdivision in Georgetown, MA demonstrates how advanced treatment systems can support a new residential neighborhood that is an expansion of an existing town growth center. This development is relatively large, containing 45 four-bedroom homes that produce a total of 19,800 gallons of wastewater per day. The subdivision has clustered one-acre lots, with a two-acre average density, and public water (Figure 3-74). Fifty percent of the parcel was reserved as open space. The design allowed the houses to be constructed with less land clearing and tree removal to reduce erosion potential from some of the steeper slopes. With public water available, greater flexibility in local zoning may have enabled more compact siting on one-half-acre lots or smaller, further reducing land disturbance and avoiding steep slopes while preserving 75 percent of the parcel as permanent open space.

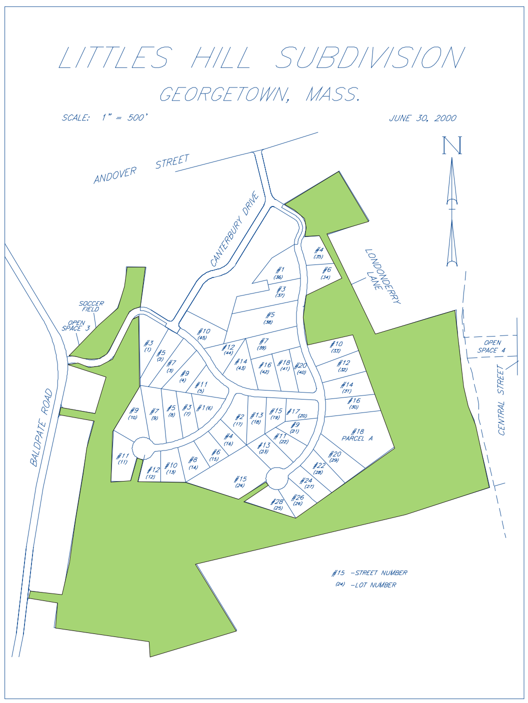

Figure 3-74
Layout of the Littles Hill Cluster Subdivision

With larger wastewater flows (typically greater than 10,000 gallons per day) more complex treatment units may become more feasible due to factors such as:

- Cost effectiveness
- Treatment efficiency
- System reliability
- Space requirements for treatment units
- Maintenance needs

The cluster system selected for this site is a pre-fabricated unit. All wastewater flow is collected in a septic tank followed by a flow equalization tank. The treatment unit is an aerobic rotating biological contactor followed by a secondary clarifier and a deep bed sand filter. Ultraviolet light disinfection for pathogen removal occurs before discharge to a subsurface leaching field of plastic chambers.

Community performance standards for the treatment system were set for BOD at 30 mg/l, TSS at 30 mg/l, and total nitrogen at 10 mg/l. A licensed plant operator, monthly monitoring of treatment plant effluent, and quarterly monitoring of groundwater wells are required under the development's regulatory permit approval. The structure containing the Littles Hill rotating biological contactor treatment unit looks like any other country barn and fits into the wooded landscape (Figure 3-75).

Figure 3-75
A Country Barn-Like Structure Houses the Treatment Unit

Creating a New Town Center

This case study focuses on creating a new town center.

Existing Conditions Before Development

The site is a sparsely settled area, wooded except for a truck stop and gravel pit. Like many areas near the interstate, it is zoned for a mixture of strip commercial, residential, and industrial uses, each separated into its own zone according to proximity to the highway. Figure 3-76 depicts a portion of this area along the state highway a quarter of a mile from the interchange (Figure 3-77). Existing development is scattered along the roadside adjacent to the site, including several small commercial and industrial buildings and the large truck stop that caters to traffic on the interstate (Figure 3-77).

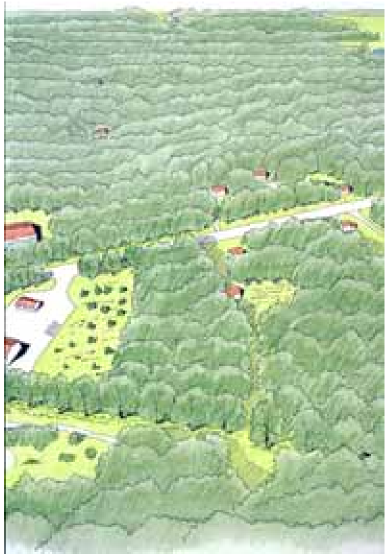

Figure 3-76
A Portion of the Case Study Site

Figure 3-77
The State Highway Interchange (above) and a Truck Stop Near the Interstate (below)

The town has identified the area as appropriate for economic development, which so far has resulted in preliminary plans for an office park opposite the truck stop. The area was also identified in the town's comprehensive plan as a good location for a town center. Such a center could combine town government offices and emergency services with other municipal uses such as schools. These uses are currently scattered across the town, which lost its original village center to a state reservoir project.

Issues of water supply and wastewater treatment weigh heavily on plans to develop the area. While full build-out of the district could support a municipal wastewater system, it will likely take decades before there are enough users to make such a system financially feasible. In the meantime, users will continue to build individual systems, which will likely force structures further apart and make it difficult to build at village-center densities. The town, meanwhile, lacks the funds to build a municipal system—especially when years could pass before enough tax-paying users materialize to support it.

Conventional Development Scenario

Guided by zoning which calls for a narrow strip of commercial/industrial development along the roadside, with residential districts behind it, development occurs in haphazard fashion as lots become available (Figure 3-78). With nowhere else in town to go, a variety of uses find their way here, with small-scale industrial and warehouse buildings ending up next to commercial, office, and retail structures.

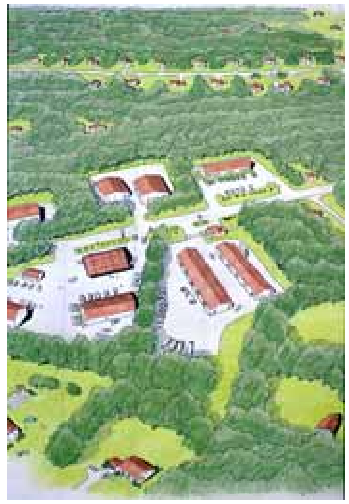

Figure 3-78
Conventional Development Scenario

The result is a chaotic pattern of development with no focus of activity other than the traffic on the highway. With one or two curb cuts from each lot, drivers must dodge cars pulling in and out from all directions. Eventually the situation becomes so dangerous and dysfunctional that the highway needs to be widened for extra turning lanes.

The result is an environment that works, after a fashion, for cars and trucks, but that is increasingly dangerous for pedestrians (Figure 3-79). Even walking between adjacent businesses is difficult, much less crossing the highway on foot. People living in surrounding neighborhoods cannot walk to businesses on the highway, so must drive just to get a gallon of milk. Ultimately, all of the businesses along the strip have a hard time competing against whoever shows up to build a more functional and attractive strip mall or supermarket just down the road (Figure 3-79). The result is a continuation of the boom-and-bust cycle typical of commercial strips. Worst of all from the town's perspective, one of the gateways to the community is lined with a chaotic gauntlet of parking lots, signs, and flimsy commercial structures.

Figure 3-79
A Commercial Strip Lined with Parking Lots and Signs (left) and Many Business Located in Strip Malls (right), Which Are not Accessible to Pedestrians

Creative Development Scenario

Traditional village planning principles are used to create a mixed-use village center organized around a town green extending on both sides of the state highway. By bringing buildings closer together, open land around the outside of the village can be permanently preserved as a greenbelt (Figure 3-80). Residential, commercial, and civic uses formerly separated by zoning are brought together into a walkable mixed-use center; shops, restaurants, and small office buildings line the town green with apartments on the upper floors. Single and multi-family dwellings line side streets.

Figure 3-80
Creative Development Scenario

Within the village, some of the most visible building sites are set aside for community buildings, which could include a library, emergency services, school, youth or senior center, or government uses. Other lots could be reserved for religious buildings. Flexible guidelines for building size, proportions, rooflines, fenestration, and materials establish a common vocabulary for the entire development. In keeping with the rural character of the town, the size and scale of buildings would be kept within limits.

The public space along the street is the center of activity and is carefully designed to create a physically comfortable and visually appealing experience for pedestrians (Figure 3-81). A “build-to” line is established to guide building setbacks, which creates a nearly continuous wall enclosing the street space. Broad sidewalks provide lots of room for walking and sitting. Traditional village landscaping is anchored by plantings of large shade trees in the central park and along the streets. Low shrub plantings soften lines of buildings and help screen parking lots.

Figure 3-81
Public Space Along the Street Is Pedestrian-Friendly

Open space areas also contain a comprehensive stormwater management system, where a series of ponds and constructed wetlands hold and treat runoff before discharging it back into the ground.

Circulation is organized by a simple loop road around the central green connected to an irregular grid of side streets. Many possible routes reduce congestion at any one point, enabling roads to be narrower. Parking is distributed around the village. On-street spaces provide short-term parking for patrons of shops and restaurants. Additional parking hidden around the sides of the buildings is shared by different uses, such as office workers during the day and residents and visitors at night and on weekends.

Wastewater Treatment Options for Creating a New Town Center

Wastewater options for new community growth centers can be as diverse as the mix of uses envisioned and their natural settings. This hypothetical case study is an ambitious, highly intensive use in a rural area that has limited drinking water availability. Although such a project would be possible in a geologic setting with high-yield sand and gravel aquifers, this site has glacial till soils where the typical drilled bedrock wells would produce lower groundwater yields. This case study still has utility in that it helps show some of the challenges that a community would face with water and wastewater infrastructure issues, while still trying to preserve as much open space as possible in the community forest greenbelt around the town center and in the traditional town green.

A variety of wastewater options were selected to depict what could be used for this town center project. One overriding goal in all of these options, however, is the emphasis on water conservation and treated wastewater reuse for landscape irrigation to help ease this community’s water quantity problem. Of course, when planning a new town center, the intensity of use, water demand, and wastewater generated can be scaled back to accommodate the site’s sustainable capacity. The most suitable areas can be set aside for necessary infrastructure including wells, stormwater storage and infiltration, and leachfields.

Water Supply

The town center mixed-use buildings housing shops, restaurants, and small offices with apartments on the upper floors would all need to be serviced by a community water supply system. Two basic water supply options exist:

- Extend municipal water quite a long distance from the existing service district (through a rural area zoned for low-density development) to the site. This option would provide enough water but at a high construction cost. The availability of public water is also likely to create great demand to change zoning to allow more intense development through the rural greenbelt surrounding this site. Without strong controls, this could easily generate linear sprawl-type growth along the water line.
- Construct an onsite public supply at a sufficient distance away from critical portions of the wellhead, or an off-site supply where aquifers may be higher yielding. In each case, a water storage tower will be needed to store water to accommodate peak needs, especially with low-yield wells. Provisions must be made for alternate backup sources when the system is shut down for maintenance. Construction of a new public supply is a major undertaking with permanent responsibilities for routine system maintenance and repair, replacement of major system components over time, source water protection, water treatment, monitoring, and reporting. In recent years, with detection of water-borne pathogens causing disease outbreaks in some areas, the trend has been toward more frequent monitoring requirements with increasingly stringent standards. Whether the new supply is a small well serving a block of retail shops or a new community well serving an apartment complex and office park, the water supplier must be able to demonstrate the financial and managerial capacity to manage the supply over the long term.

Wastewater Treatment

In this type of intensive development, where buildings have large footprints and are clustered closer together, individual treatment systems become more difficult to site and sharing treatment units becomes more cost effective. The options would typically range from constructing one large pre-fabricated treatment unit capable of handling all future development, to multiple smaller cluster systems serving different segments of the project. These smaller cluster systems could also be pre-fabricated units or simpler media filters with fewer mechanical parts.

This site is located within the headwaters of the Pawcatuck River system, an important habitat and recreational resource. Conventional treatment is considered adequate for low-density development and small-scale commercial development. Because this is an intensely developed site, with large flow systems clustered together, advanced treatment is considered essential to protect groundwater for public and private wells. Under these circumstances, performance standards should be established requiring significant nitrogen and pathogen removal. Technologies are available to reduce nitrogen concentration as low as 2 to 3 mg/l. With this level of nitrogen treatment and the incorporation of disinfection using ultraviolet light, water re-use is possible for flushing, thereby cutting total water use by at least 50 percent and reducing the size of drainfields needed.

A possible hypothetical wastewater scenario for the New Town Center is shown in Figure 3-82. This approach encourages a pedestrian-friendly new town center with associated landscaping and architectural features that create a distinctive sense of place. The scenario proposes a combination of media filters and pre-fabricated treatment technologies to keep treatment components to a reasonable size. This approach also offers more flexibility in placement and optimizes use of available space. In addition, it accommodates phased construction over the years based on the demand for use of the site and the health of the economy.

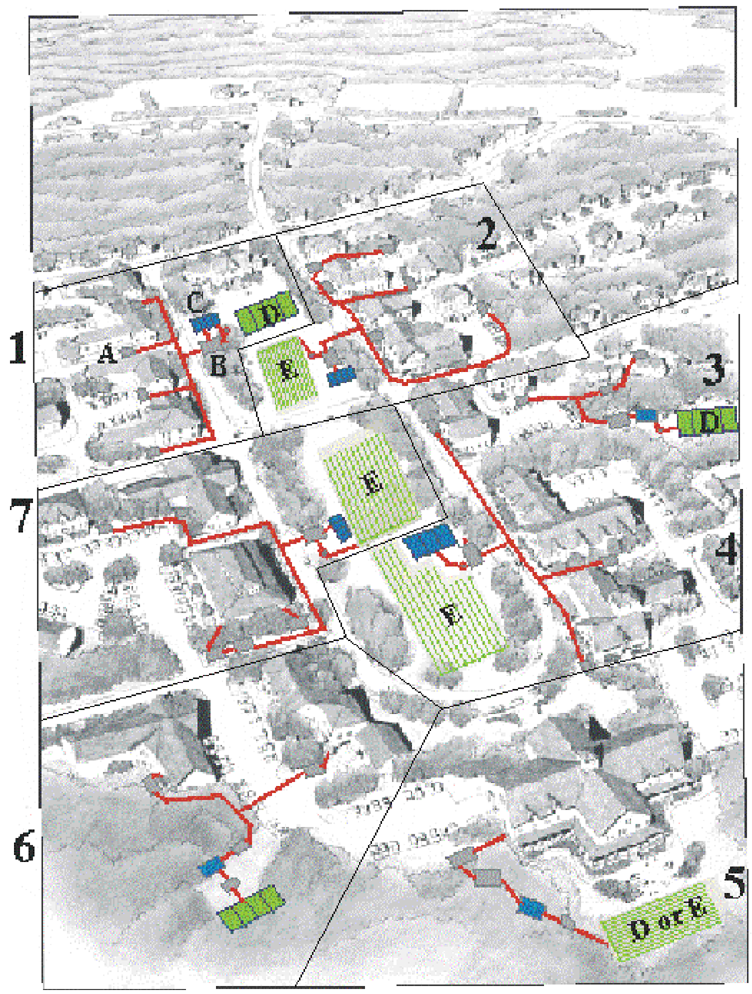

Figure 3-82
New Town Center Wastewater Plan

In this scenario, each building in the seven different wastewater zones (or districts) would have its own septic tank(s) (depicted as A in zone 1 in Figure). Technologies depicted in treatment zones 1 through 4 and 7 use recirculating media filters for advanced treatment. These recirculating systems, selected for areas with more available space, are less energy intensive than several other treatment options, and are generally simpler technology with lower operation and maintenance requirements. Systems in zones 5 and 6 use prefabricated treatment units such as sequencing batch reactor and fixed activated sludge technologies. These two technologies have fairly small footprints and fit more efficiently in locations that have limited available space.

In the case of the recirculating media filter systems, effluent from the septic tanks would flow to recirculation tanks (component B in zone 1), and recirculate to the media filter surface (C). The final treated wastewater would be dosed to either a shallow narrow drainfield (D) or to a drip irrigation field (E), where further reduction of nutrients (nitrogen and phosphorus) would likely occur. Some of these dispersal fields would be located in the community-owned open space in the town green area. The wastewater dispersed in these drainfields would eventually recharge groundwater in the same watershed where water removals are occurring via municipal and private wells.

In the zones 5 and 6 systems, wastewater from the septic tanks would flow by gravity to a flow equalization tank designed to store and meter out wastewater on a uniform basis. Effluent from the equalization tanks would flow to their respective systems for advanced treatment—in this example, the sequencing batch reactor (zone 5) and the fixed activated sludge system (zone 6). Final wastewater would be pressure-dosed to either a shallow narrow drainfield (D) if space is limited, or to a drip irrigation field (E) if more space is available.

Real-World Supporting Examples for Creating a New Town Center

Four real-world supporting examples for creating a new town center are provided in this section. The examples are:

- A new town center built from a strip commercial zone
- A new town center with a mixed-use assisted living and commercial complex
- A new residential village
- An outlet mall

A New Town Center Built from a Strip Commercial Zone

Located in the unsewered community of Mashpee, Massachusetts, Mashpee Commons is a renovated strip shopping center that was designed to look like a traditional New England town center with mixed commercial and residential uses (Figure 3-83). This real-world example shows what can occur when alternative wastewater treatment technology and the desire to redevelop and revitalize a portion of a community come together in a positive manner.

The project is located near the Mashpee River and estuaries—water resources sensitive to nitrogen inputs. A decentralized approach would need to reduce nitrogen loading to the Mashpee Estuary from the expected 80,000 gallon per day Commons project. In an effort to address other environmental issues, the Mashpee Commons was also designed to reduce dependency on cars, making a more sustainable center. The design makes it possible to walk or bike almost anywhere in the village, and there is easy access to mass transportation systems. The roads are narrow and the parking areas small in order to reduce impervious surface runoff, and the buildings are constructed with energy saving “green” technology. Approximately 65 percent of the land used in the Mashpee Commons will be open space.

Figure 3-83
Overall Schematic and Street Views of the Mashpee Commons Center

The system designed for this project consisted of a pre-fabricated cluster system. The treatment train includes septic tanks and flow equalizer tanks, rotating biological contactors followed by clarifiers, denitrifying units, ultraviolet light disinfection, and open sand infiltration beds for dispersal of final effluent.

A New Town Center with Mixed-Use Assisted Living and Commercial Complex

The town of Portsmouth, RI has proposed a revitalization project known as the “Town Center” district. Much like the hypothetical example leading this section, the goal of this project is to transform a linear, heavily traveled transportation corridor with conventional strip commercial zones into a more pedestrian-friendly business district with mixed residential, institutional, and governmental buildings.

Current travel corridors and a general view of the site is shown in Figure 3-84, paired with the proposed redesign with a more village-like network of roads, bikeways, and village-scale development with buildings set close to sidewalks and roads.

Since this community is completely unsewered, the use of advanced treatment technologies is necessary to support the much more compact village-style design proposed. Institutional and commercial business districts in particular are normally reserved for sewered areas. Actually building this plan means promoting a mixture of uses and allowing phased growth over time.

Figure 3-84
Portsmouth Town Center District Existing (left) and Proposed Future Conditions (right)

An example where a decentralized approach is already being used to meet these objectives is Aquidneck Place, an independent and assisted living facility located in the Town Center district (Figure 3-85—A and Figure 3-86). This facility represents the first phase of the project. Under a second phase, a commercial development is planned on an adjoining lot (Figure 3-85—B and Figure 3-87). This project efficiently combines use of two parcels, preserves an original farmhouse near the entrance of the property, and makes good use of advanced technologies to support institutional and commercial uses.

Figure 3-85
Plan for the Portsmouth Town Center District

Figure 3-86
Aquidineck Place

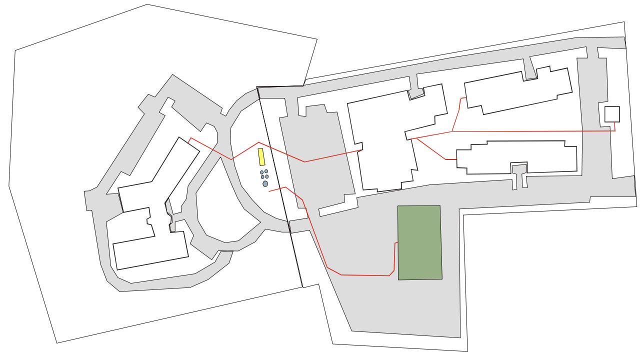

Figure 3-87
Plan View of Aquidneck Place

A modular pre-fabricated treatment unit was selected based on initial and life cycle costs. This trickling filter was designed to treat institutional wastes, which can be high in nitrogen, solids, and grease from kitchen facilities with erratic high flows. The system consists of a grease trap, a septic tank, two recirculating trickling filter units, followed by a deep sand filter. Final treated effluent is dispersed to drainfield trenches (concrete chambers). The system occupies a small footprint, with most of the components being self-contained, underground units with mostly lids visible at the surface (Figure 3-88). The various underground chambers of the system were dug all the way down to shallow bedrock. The drainfield, which will be shared with the commercial buildings, is located in an area that will become a parking area for the commercial center. Additional modular treatment units will be added to accommodate the second phase.

Figure 3-88
Lids Are the Only Parts of the System Visible from the Surface

The current system can handle up to 8,000 gallons per day. At the completion of the second commercial phase, a total of 20,000 gallons per day will be generated.

The area is served by public water, but because of the slowly permeable soils and nearby nitrogen-sensitive coastal waters, the treatment system was required to meet less than 30 mg/l BOD and TSS, and less than 10 mg/l total nitrogen. Monitoring results show that with incoming effluent concentrations of about 50 to 70 mg/l total nitrogen, the actual treatment performance is closer to 5 mg/l each for BOD, TSS, and total nitrogen (personal communication, Craig Lindell, Aquapoint, Inc.).

With a system of this size, redundant safety measures are critical. Control panels within the maintenance shed on the Aquidneck Place grounds regulate the majority of the system. The panels contain alarms that alert the operator whenever there is a problem. The system is hooked into the backup power generator for Aquidneck Place in case of a power outage. The groundskeeper for the residence checks the system daily and an experienced system operator performs routine maintenance and troubleshooting. As cluster systems become more widely used, more experience with different types of technologies is gained, and performance is better documented, maintenance requirements can be better documented to increase maintenance efficiency, which ultimately reduces operation and maintenance costs for cluster systems.

A New Residential Village

The Jackson Meadows cluster development, located in Marine on the St. Croix, Minnesota is a real-world supporting example of a new town center that clusters 64 homes onto 90 acres of a 300-acre parcel to enable the conservation of more than 200 acres as permanent open space (Figure 3-89).

Figure 3-89
Layout of the 64 Homes in Jackson Meadows

In doing so, this development illustrates how alternative treatment systems can

- Help make a compact development
- Minimize urban sprawl
- Save open space
- Provide high-quality wastewater treatment on a small-lot cluster development in an unsewered community
- Avoid the pollution risks often associated with conventional septic systems

The development is in the form of a village that looks like an old-style urban neighborhood complete with smaller homes, picket fences, alleyways, detached garages, and pedestrian walkways (Figure 3-90).

Figure 3-90
The Jackson Meadows Project

The design used a subsurface flow wetland treatment system as an alternative to conventional onsite septic systems. Two separate systems, divided by the natural topography of the area, are designed to recycle a total of 11,000 gallons per day of domestic wastewater. In Phase 1, wastewater is periodically dosed into a constructed wetland treatment cell. A dosing siphon will intermittently dose the treated water into a separate constructed wetland infiltration cell for additional treatment prior to dispersal into the subsurface soils. The wetland treatment system fits into the landscape that consists of restored prairie dispersed with wetlands to mirror the natural wetland potholes that once existed across the state (Figure 3-91).

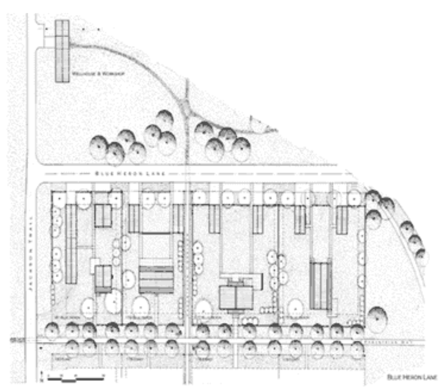

Figure 3-91
A Plan View of One Section of the Project

Although an excellent choice for this site and many other areas, constructed wetlands require more land than other technologies described in this manual. As a result, these systems may not be feasible where space is limited and where high land values make them less cost effective.

An Outlet Mall

Westbrook Outlet Mall is a 400,000-square-foot mall with no municipal sewer access (Figure 3-92). The development itself is designed more creatively than typical indoor malls, but is accessible only by highways. Although most town planners might label the development as sprawl, the true innovation in this development is the use of state-of-the-art wastewater treatment technology to conserve, recycle, and treat water, paired with a town center concept mall that has more pedestrian-friendly walkways and spaces. This concept demonstrates the wave of the future where onsite wastewater treatment systems are refocusing on wastewater recycling to make for more sustainable growth.

Figure 3-92
Westbrook Outlet Mall

The normal estimated wastewater discharge for an outlet mall of this size would be about 40,000 gallons per day. Because of the strict water conservation and reuse aspects of this system, the system was designed at 20,000 gallons per day, which in hindsight was quite close to the actual operating flow of 19,566 gallons per day. The use of recycled highly processed water back to the toilets for flushing alone reduced discharge by approximately 6,300 gallons per day, which reduces the drainfield size requirements and also reduces the load to the drainfield and environment. The use of ultra-low flush lavatory fixtures and reclamation of treated water save approximately 13 million gallons of water per year.

The project's design engineers selected a membrane filtration system to handle all the sanitary waste from the site's lavatory facilities and food court. Treated wastewater is recycled for use as flush water for toilets and urinals. The remaining tertiary quality effluent is discharged to a drainfield for final dispersal. Since this facility was constructed, several other new commercial and mixed-use developments in New England have started using similar technologies to recycle and reuse wastewater.

Building a Rural Economic Center

This case study focuses on building a rural economic center.

Existing Conditions Before Development

The actual study area is on the border of two communities, one rural and one more suburban, and is an important gateway to both towns (Figure 3-93). Currently zoned for half-acre to three-acre house lots, the site is now in agricultural use. For the more rural town, the site has the best access to major roads and represents a logical development area. For the more developed community, by contrast, the site is considered part of an agricultural greenbelt that should be protected from development. In any case, there is an obvious conflict between potential uses: good access and soil conditions make the site favorable for development; at the same time it is some of the last open agricultural land in the area.

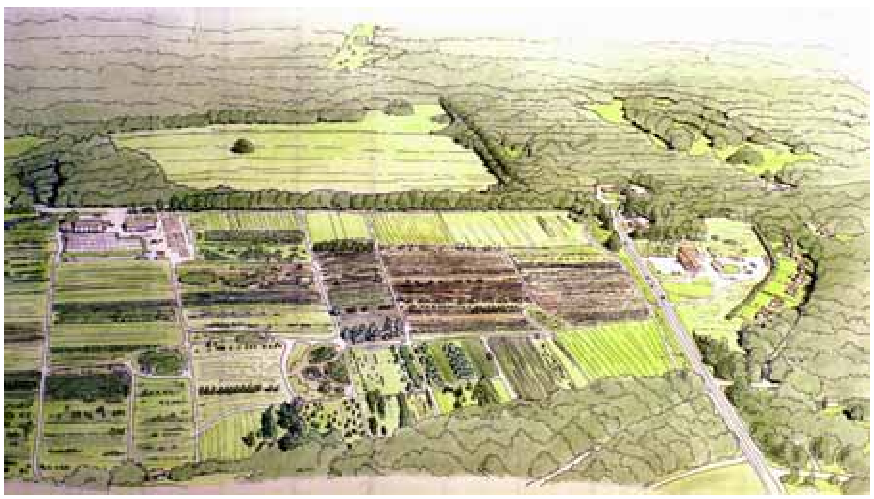

Figure 3-93
Building a Rural Economic Center Case Study Area

There is good access to potential development sites from two state highways (Figure 3-94) that intersect in one corner of the study area. The land is largely open and easily developed (Figure 3-95), with the largest portion in use as a wholesale nursery for trees and shrubs. Across the road, cornfields and woodlots retain some of the historic appearance of small farms that once characterized the region. Views of fields and woods are prized by residents of both towns, and while no one wants to see the area developed, there is little funding available for public purchase of open space. Meanwhile, landowners count on future sales of their parcels to support their retirement plans.

Figure 3-94
State Highways Provide Good Access to Potential Development Sites

Figure 3-95
Land Is Largely Open and Easily Developed

Conventional Development Scenario

Farmers planning to retire have few options here, since zoning allows only for residential development. With a one-half-acre minimum lot size in one town and three-acre lots in the other, the farmland is quickly filled up with subdivisions (Figure 3-96). Usually the frontage lots get sold off first, lining once-scenic rural roads with houses. Large-lot zoning, especially over three acres, can slow the subdivision process if values do not support the expense of road construction; but once lot prices reach a certain point, the road gets built and the farmland is lost forever.

Figure 3-96
Conventional Development Scenario

Faced with this situation, landowners push for wholesale zoning changes, often to permit large-scale commercial development. This option can be politically popular, as towns realize the fiscal impact of residential development on their tax base and look to commercial growth to support the cost of local schools and services. Continued farming is rarely part of the equation.

As in many areas on the suburban/rural fringe, the potential sales value of development lots is not high enough to support a high level of design or construction quality. Commercial centers tend to be cheaply-constructed, with little landscaping other than a paved parking lot (Figure 3-97 and Figure 3-98). House lots are usually sold to individual builders or future homeowners, so style and quality varies widely. In any case, other than a few foundation plantings, there is usually little leftover to improve the appearance of the street or lot landscaping. Diluted by the scale of the large lots, the improvements that are made are almost invisible.

Figure 3-97
An Example of a Cheaply-Constructed Commercial Lot

Figure 3-98
A Commercial Center with Little Landscaping

Creative Development Scenario

The overall goal of this hypothetical case study is to preserve large amounts of agricultural open space and maintain the sense of rural charm and natural land features, while still providing a vibrant rural economic hub. With at least 75 percent of the farmland in the study area permanently protected, growth is channeled into a new mixed-use village centered on the intersection of the two state highways. Office and commercial buildings take up the quadrant that is part of the nursery in the foreground of Figure 3-99. These buildings would be marketed to firms with a connection to the existing farm economy, such as small-scale food processing, direct marketing of fresh produce to consumers, and various farm management and support services.

Figure 3-99
Creative Development Scenario

One possibility would be a farmer’s market structure, which would serve as an agricultural small-business incubator—a place where local farmers can come together to sell their products with low overhead and flexible rates. This facility could also contain the large kitchen, storage, and refrigeration equipment needed for local farmers to experiment with value-added goods such as gourmet cheeses, pies, and preserves.

Across the street, business development is consolidated into a commercial core, with new residential streets rounding out the village on the outside. All the way around, a clear edge is established between village and countryside, which can never be further developed. While the character of the area would certainly change, the essential rural pattern of open space surrounding a compact, walkable village, would be retained.

Expanding traditional agricultural land uses to include this type of rural mixed-use commercial zone can add income to farm families faced with falling crop prices and rising taxes, land values, and development pressure. This scenario may help some farmers keep their land in agriculture and preserve the farmland that they, their neighbors, and visitors have come to love.

Wastewater Treatment Options for a Rural Economic Center

Wastewater infrastructure associated with this agricultural center does not have to be complicated or expensive, but it does need to protect public and environmental health and fit the intended uses and types of enterprises that will bring economic sustainability to the agricultural center. In this case study, several different types of businesses are likely to be occupying this site such as office space, gift and retail shops, a sandwich shop, and a small bakery/coffee shop. Several farmers share a cooperative facility to make value-added farm products such as cider, jelly, honey, and other specialty canned fruit and vegetables. This diverse mix of uses generates three types of waste that could be handled separately to better manage the different waste characteristics and variations in flow during operation and seasonally. The offices primarily generate sanitary waste, the sandwich shop and bakery generate high strength wastewater that requires special grease handling, while the cooperative food processing facility generates larger volumes high in BOD and TSS.

Deep well-drained soils on this site are favorable for onsite treatment, with plenty of available space for conventional septic systems. However, advanced treatment is preferable to avoid additional loss of active farmland and to protect groundwater. A small community well located in an adjacent woodlot supplies water to this site. The site is located partially within an upper watershed that drains to the Pawcatuck River with sensitive aquatic habitat downstream. Reducing stormwater runoff, maintaining natural hydrology with high infiltration, and maximizing protection of wetland and stream buffers are priorities. Using advanced treatment systems will reduce space needs to maintain wide undisturbed riparian buffers and provide flexibility in siting bioretention areas.

Wastewater treatment options for the site are illustrated in Figure 3-100, using three different systems. Treatment zone number 1 in the northwest corner of the site, which contains retail shops, bakery/coffee shop, and office space, is served by one system. The treatment train here includes septic tanks (A) at each of the four main buildings in this area; the bakery also has a grease trap. Wastewater from these tanks will flow by gravity to a dosing tank (B) that will dose septic tank effluent into a low-pressure small-diameter pipe drainfield (C) that is placed within 18 inches of the ground surface. As flows and uses begin to increase and retail and office space usage becomes more intensive, modular single pass media filters (D) will be placed before the drainfield taking advantage of buffers between the tilled farmland and the new development. This effluent will be dosed to the original drainfield. This phasing scenario enables easy expansion of the system as the income from the property increases.

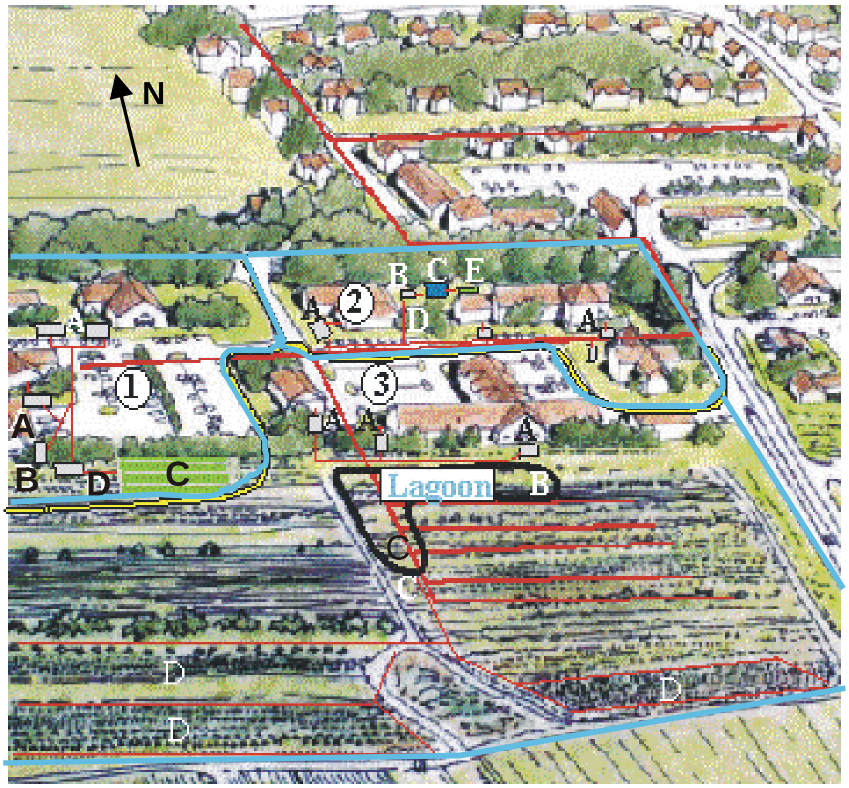

Figure 3-100
Wastewater Treatment Options

The retail, flower, antique, and gift shops and the sandwich shop located in the four buildings in the northeast corner of the site (treatment zone 2) will use a recirculating media filter. This technology was selected because space is limited in this area and the media filter will consistently produce high-quality wastewater that can be dispersed in a relatively small footprint. Each building will have its own septic tank (A) for solids settling. Effluent from these tanks will flow to a recirculation tank (B), which will recirculate wastewater to the surface of a media filter (C). A grease trap (D) handles flow from the sandwich shop. Final effluent will be dosed to an at-grade bottomless sand filter drainfield (E) located in the landscaped area between the development and the road.

The east central portion of the rural economic site contains the cider, jelly, honey, fruit and vegetable canning cooperative facility (treatment zone 3). At various times of the year different crops would be processed through the cooperative. A small amount of sanitary flow from the two buildings would be handled by conventional septic tanks and drainfields. All process water, which consists primarily of rinse water used in the cooperative's production process, would flow out of the two facilities into separate septic tanks (A) for solids removal. Wastewater would then flow by gravity to a lined process water storage lagoon (B) at the field edge. A pump house (C) at the south end of the lagoon would contain the pumps and equipment needed to irrigate horticultural plants, flowers, orchards, and vines (D) using drip irrigation emitters. Irrigation needs in the cold months would be low, which coincides with the exact time when production in the facility is lowest also, making outdoor wastewater recycling less feasible.

Real-World Supporting Examples of Building a Rural Economic Center

Four real-world supporting examples of building a rural economic center are provided in this section. The examples are:

- Other applications for small farms caught on the urban edge
- Vineyards
- Landscape irrigating with treated wastewater
- Rustic oceanfront beach cottages

Other Applications for Small Farms Caught on the Urban Edge

The agri-business center described previously is a particularly intensive project that may not always be feasible for other farms. For farmland caught at the edge of suburbia, many smaller scale options are available to generate additional income without selling the farm. These "urban farms" may only survive by abandoning traditional operations and marketing products directly to the suburban populations. For example, farms that may have raised dairy cows, corn, and potatoes for generations may shift to pick-your-own orchards, turf farms, and nursery shrubs and trees. Making the farm a recreational destination for nearby urban dwellers and new suburban residents is another often successful strategy. This strategy may include weekend hay rides, corn field mazes, and educational demonstrations. Fresh foods prepared on the premises, such as cider and doughnuts or ice cream, creates an added incentive to make the trip. In addition, summer farm stands may evolve and become fully enclosed, year-round markets selling a variety of produce, flowers, gifts, and prepared foods.

In each case, demands for more wastewater treatment will vary widely based on the scale of the use, type of food processing, and number of visitors expected. When the farm stand wastewater demands require more than just a few portable toilets, then the options described in the case-study example represent just a few of the possibilities that may be practical.

Vineyards

Sakonnet Vineyards is located on 50 picturesque rolling acres in the Sakonnet River watershed in Little Compton, RI (Figure 3-101). The location is a real-world example of using innovative treatment technology to expand an agricultural business that is located on a distinctive and attractive rural landscape that creates a sense of community and charm for the locals and visitors alike. The dense silt-textured soils at the vineyard are far better suited for grape production than for development or wastewater treatment. The vineyard presently produces over 30,000 gallons of wine per year and tours of the facility are a popular attraction that help to support local tourism.

At this production level, approximately 230,000 gallons of process water is generated. The vineyard would like to increase production to 50,000 gallons but is faced with more than 150,000 of additional gallons of process water. The vineyard had an existing lagoon that was too small for the winery's load of wash water, and subsequently the lagoon became anaerobic and odorous. The overflow from this lagoon drains to a ditch that flows to a wetland, which drains to a drinking water reservoir. Providing maximum settling of solids to reduce BOD and phosphorus inputs to the wetland was critical.

Figure 3-101
Sakonnet Vineyards

A new one-third acre aerobic lagoon was designed with an increased surface area and mechanical aerator (Figure 3-102). This lagoon has a storage depth between two and five feet and a total capacity of 320,000 gallons. This enlargement is sufficient to handle wastewater generated during harvest season and the following three months. The lagoon is used to irrigate crops. When processing volume is high and irrigation needs are low, spray irrigation is still used to disperse the processing water and provide final treatment and groundwater recharge. The lagoon can be emptied by irrigating approximately three acres of grass and woodland over a 55-day period.

Since the lagoon site is located near a wetland complex that drains to a public drinking water supply reservoir, this wastewater treatment upgrade is helping to protect drinking water quality for Newport County residents, recycling limited water supplies for irrigation, and sustaining productive agricultural open space.

Figure 3-102
Process Water Treatment Lagoon

Landscape Irrigating with Treated Wastewater

Since 1995, the town of Jamestown, RI has been using a portion of its municipal wastewater treatment plant effluent to landscape irrigate a town-owned golf course (Figure 3-103). Although spray irrigation of treated wastewater is used in more arid regions, it is not widely practiced in the humid Northeast. This example represents an interesting real-world example for areas that are generally considered water rich, and it emphasizes one community's goal to reach more sustainable development, build on local traditions, and maintain a respect for existing conditions.

Figure 3-103
Golf Course Fairway with Storage Lagoon Located to the Left

There is often pressure to locate golf courses in rural fringe areas, and although they are not exactly farmland, they do maintain open views and are a low-intensity land use. Some careful considerations are necessary when irrigating even treated wastewater to ensure public health protection. Treatment levels of nutrients and pathogens need to be closely monitored and disinfection technology needs to operate effectively. In this case, town wastewater treatment facility staff check contaminant levels in the effluent and work with golf course groundskeepers to irrigate only at night, no later than five hours before opening tee off, and not during high-wind periods. The nutrients in the treated effluent replace some of the traditional fertilizer inputs on this sustainable site.

Jamestown is an island community that is entirely dependent on rainfall to recharge limited groundwater supplies and small reservoirs. This wastewater irrigation system minimizes demand for pure water, reduces direct discharge of treated effluent to coastal waters, and replenishes groundwater to supply local wells and prevent saltwater intrusion.

Rustic Oceanfront Beach Cottages

The following support example deals with an actual location where a low-intensity seasonal recreation use directly abuts farmland and the open ocean. The R. C. Beach property in the Matunuck, RI coastal zone (Figure 3-104) is of extremely high value, and the real challenge on this site is to maintain the current land uses and avoid their loss to exclusive large-lot "mansionization."

Figure 3-104
The Current Landscape of Farms and Fields in the Matunuck, RI Coastal Zone

The site is a rustic seaside community where beach cottages are often handed down within families for generations. The site represents an affordable summer seaside resort for working class people that has low impact on the water resources and contains farmland and ocean views from the main road that are prized by all that travel there. The same type of waterfront development might be found clustered on freshwater lakes throughout the country. Because of the location in a sensitive coastal flood hazard zone, the challenge is to provide adequate wastewater treatment for summer needs without encouraging more intensive year-round use.

This summer resort colony consists of approximately 400 densely clustered cottages that date back to the 1950s, set behind a sandy beach directly on the Atlantic Ocean (Figure 3-105). Each cottage is privately owned, but land for each home site is leased from a single landowner.

Figure 3-105
Modest Summer Cottages at R. C. Beach Are Not Insulated for Winter Use

Located in a rural coastal plain that was once mostly dairy farms and potato fields, the upland edge of the property adjoins active farmland that is permanently protected through sale of development rights to the town (Figure 3-106).

Figure 3-106
The Edge of the Adjacent Agricultural Field at R. C. Beach

Town water is available during the summer, but only to a central office and five bathhouses scattered among the residences. In addition to showers, the bathhouses also have flush toilet facilities and dishwashing stations. Tap water is available at these locations for residents to fill potable water containers. Bathhouses are served by onsite systems that are thought to be outdated cesspools or seepage pits. Occupancy in this densely packed community ranges between two to four people per cottage, commencing in May and ending in October, with the heaviest use June through August.

Over the years, many homes have installed their own non-sanctioned shallow point driven wells and even flush toilets. Although most shallow wells are generally not used for drinking water there is a concern for public health with outdated bathhouse systems and an eclectic mix of substandard systems serving individual cottages. Other environmental concerns include risk of nitrogen and bacteria movement laterally to a nitrogen-sensitive coastal pond just west of the property and potential breakout of contaminated groundwater at the nearby sloping beach face. Groundwater flow studies would be needed to verify flow direction and depth, an additional expense that could be used towards advanced technologies.

Town water records for the bathhouses indicate only a total of 4,000 to 6,200 gallons of wastewater is generated per day in these five facilities. However, this does not address the amount of wastewater generated via the wells and makeshift septic systems at many of the cottages. With the installation of a new septic system it is suspected that water usage at most cottages will likely skyrocket. To account for this inevitable increase flows from these cottages were calculated at 150 gallons per day assuming an occupancy of four people per cottage (this could easily be exceeded on a holiday weekend), and a total flow of approximately 45,000 to 60,000 gallons per day. From a regulatory perspective this may represent a conservative estimate of flow, but until better values are derived, it offers a lower risk. The well-drained sand and gravel soils on this site can infiltrate large volumes of water. However, every available bit of open space is typically used for parking. Larger open areas near the bathhouses tend to have shallow water table, making them less suitable for large drainfields.

Before developing a final treatment option for this site, the landowner and town would have to determine whether it is preferable to keep existing flows minimal by retrofitting only the bathhouses and requiring existing substandard systems to be abandoned, or expanding a nonconforming use by serving wastewater needs for each cottage. Assuming total flows ranging from 45,000 to 60,000 gallons per day, the recommended treatment option would be to collect wastewater using onsite septic tanks and pump effluent to the adjacent farmland for collection and treatment. A recirculating media filter would provide nitrogen removal to help protect the nearby coastal pond, while also reducing the amount of farmland required for dispersal of treated effluent. Use of a shallow drainfield for final dispersal would also reduce loss of farmland while providing additional treatment of bacteria and nitrogen through natural processes.

Wastewater from the bathhouses would be collected using two tanks per facility. Under the full-service scenario, new tanks would also be installed to serve two to three cottages each, or a maximum of six bedrooms. Two separate effluent collection and treatment systems are proposed for this site—a west (phase one) system and an east (phase two) system. The dividing line is the main access road into the cottage site. This approach would keep the overall size of the treatment components and drainfields to a minimum to preserve farmland. Phasing installations of the two systems would provide an opportunity to determine actual flows being generated in phase one. This information would enable modifications to the design of phase two to either increase capacity or to shift some of the phase-two cottages over to the existing phase-one system and reduce the overall scope and size of the phase two system (saving additional farmland in the process).

For each of the two treatment systems, effluent collected from the septic tanks would flow by gravity or be pumped northward to the abutting farmland where it would flow into an equalization tank and recirculation tanks in series. Effluent would be time-dosed to a recirculating media filter for treatment, and then dosed to a large, zoned shallow narrow drainfield for final dispersal and treatment. See Figure 3-107 for a general concept plan and Figure 3-108 for a schematic of the collection system in the bathhouse area. The recirculating media filters and recirculation tanks would be zoned so that a portion of the system could be turned on during the beginning and end of the occupancy season where flows will be lower. As the season progresses to peak occupancy, more media filters would be activated. This scenario would aid the treatment process and keep overall operation and maintenance cost as low as possible.

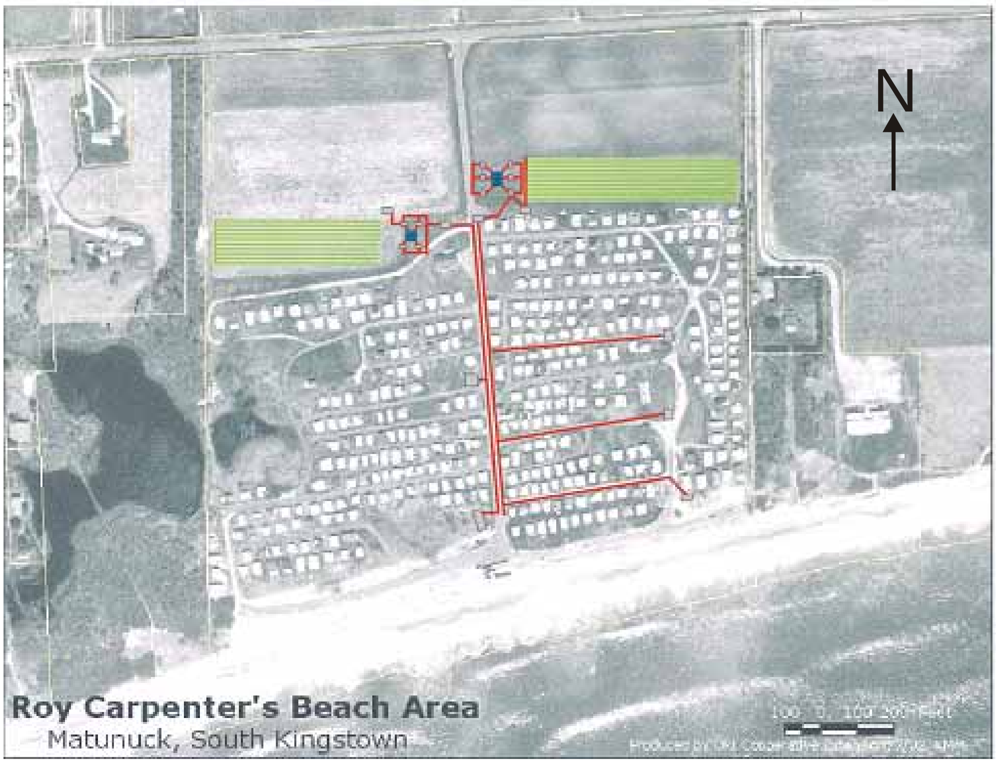

Figure 3-107
General Concept Plan of the R. C. Beach Cottages System

The conventional option for this site would be on-site leaching chambers where space is available or collection and pumping to the same farm field. Leaching chambers or drain lines would have required much more, if not all of the field to accommodate peak flows while providing very little protection to the groundwater or coastal ponds. Land application of treated effluent or shallow drip dispersal in the actively farmed portion of the site was not considered feasible. Although this may seem to be an ideal solution, using treated sanitary wastes would require a very high level of treatment to eliminate pathogens and ensure compliance with all standards at all times. In cases where treated wastewater is used for irrigation, regular monitoring and oversight is needed to ensure public health is protected, even if nursery crops rather than produce is grown.

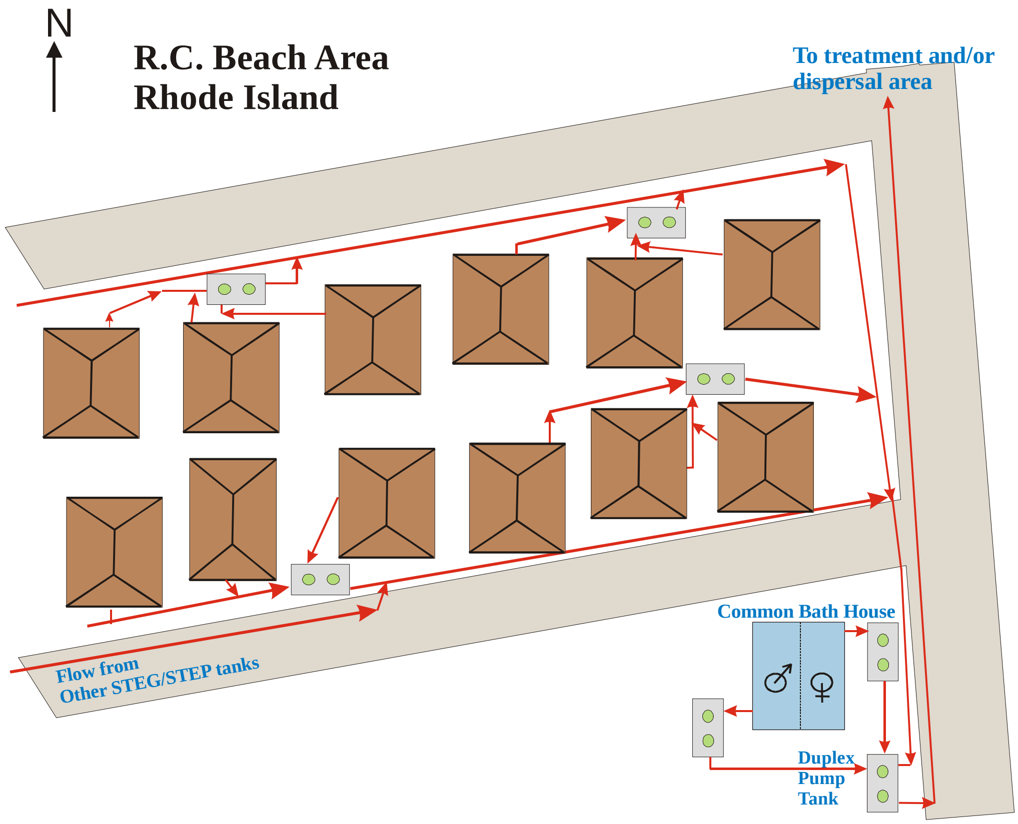

Figure 3-108
Conceptual Drawing of the Collection System at the R. C. Beach Cottages Site

Figure 3-109 shows a future hypothetical conventional development scenario for the R. C. Beach Cottage site. In this scenario, farmland views would be lost, replaced by buildings far larger than those shown in Figure 3-109.

Figure 3-109
A Future Hypothetical Conventional Development Scenario for the R. C. Beach Cottage Site

Figure 3-110 shows larger homes that are used more intensively year-round in a high-velocity coastal flood zone.

Figure 3-110
Larger Homes with More Intensive Year-Round Usage

4 ALTERNATIVE SYSTEMS FOR INDIVIDUAL LOTS

This chapter presents examples where design principles and alternative technologies described in the main community case studies are applied on individual lots. Use of alternative systems for individual lots supports the principles of creative community design by permitting compact development and in-filling, which minimizes sprawl and promotes pedestrian-friendly, distinctive neighborhoods. A community's character emerges from the sum of the look and feel of its individual lots. These real-world examples show how alternative systems permit a greater use of yard, buffers, and green space to maintain and enhance the sense of community within individual neighborhoods.

Case Studies of Alternative Systems for Individual Lots

Several of the case study systems were constructed as demonstration systems under an EPA-funded National Onsite Wastewater Demonstration Project-Phase II project in 1998. Since then, many other landowners have installed alternative technologies for either new construction or repairs in sensitive coastal areas and other resource protection zones. These examples explore selection factors related to treatment performance, environmental protection, and site constraints. Although site design and system selection are highly dependent on site conditions, checklists are provided as basic guides to system design on individual lots with factors to consider in evaluating use of individual versus cluster systems.

The reasons to select a particular system over another are many. They include:

- Space limitations
- Treatment requirements
- Reliability and risk of hydraulic failure or inadequate treatment
- Availability and ease of support from companies supplying treatment components
- Aesthetics
- Life cycle costs (not just initial installation cost) including maintenance, repairs, and energy costs over a several year period

In most examples presented here, the treatment objective was to protect pathogen- and nitrogen-sensitive coastal waters and, in some cases, protect private drinking water wells.

A High Water Table, Stony-Soil Coastal Site with a Town Water Supply

The use of an alternative treatment system on this real-world site maintained distinctive natural and architectural features of the neighborhood while protecting public and environmental health. This one-third acre site located in a nitrogen- and pathogen-sensitive coastal watershed is almost completely surrounded by a wetland, has wet glacial till soils, many stones and large boulders, and groundwater at the surface for several months during the wet season. The home on the site and the surrounding neighborhood is serviced by a town water supply.

The existing system for this site, which was pumped four times a year, consisted of an approximately 500-gallon cesspool and auxiliary drainfield line. Shallow ponded water was present over the existing cesspool area during wet times and would flow through a neighboring lot and then into the nearby coastal wetland.

A typical size filter for a three-bedroom home is 8 feet by 20 feet. The typical conventional septic system fix would completely alter the yard and most of the yard area would be required (Figure 4-1). Boulders would need to be excavated and trees removed, 4 feet of gravel fill would be brought in to raise the drainfield above the water table, and a pump would be installed to pump septic tank effluent up to the raised drainfield. Without a level area 25 feet surrounding the drainfield, retaining walls would need to be constructed to contain the fill material. Because of all this excavation and fill material, the cost of this system would far exceed the cost of the alternative system. This type of work often drastically alters stormwater movement in the immediate neighborhood and aggravates already wet site conditions.

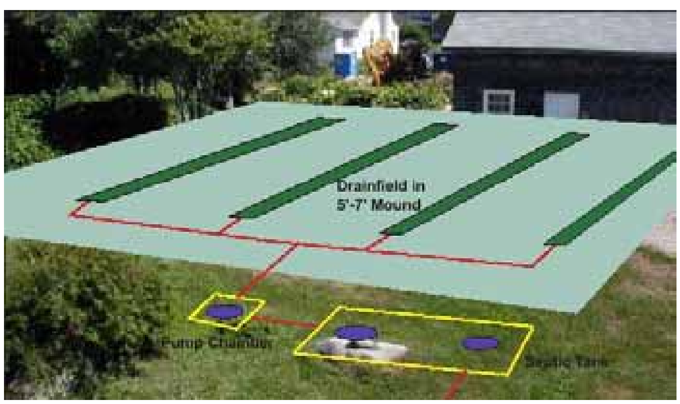

Figure 4-1
Typical Conventional Septic System

To overcome these problems, a recirculating media filter was selected as the treatment unit, with a bottomless sand filter drainfield to provide additional treatment. This system provides a minimum of 50 percent nitrogen removal to help protect nearby coastal waters. As shown in Figure 4-2, wastewater from the house flows into a septic tank with two pumps controlled by separate timers (A). One pump recirculates effluent to a media filter (B), and the other disperses this blended effluent to the raised bottomless sand filter, that is located on the highest point in the yard (C).

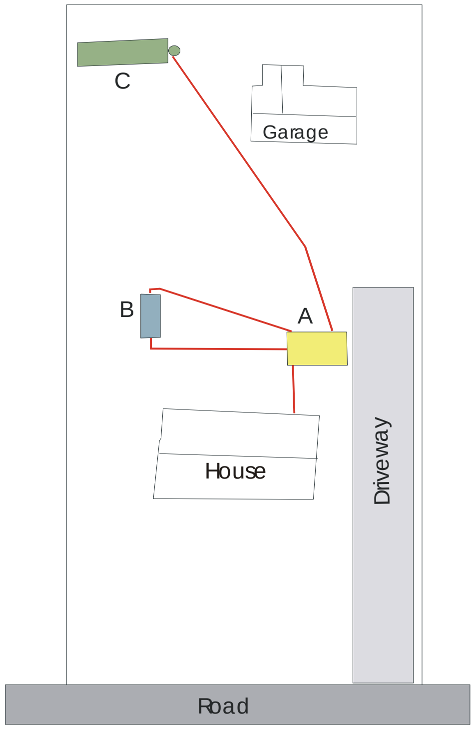

Figure 4-2
Layout of the High Water Table, Stony-Soil Coastal Site Treatment System

The media filter was selected for its small footprint and nitrogen reducing performance. The bottomless sand filter (Figure 4-3) was the only drainfield option available for this high water table site that provided bacterial reduction and avoided large amounts of fill material. This system significantly minimized site disturbance and surface topography changes that would have altered stormwater movement; at the same time it achieved a high degree of nitrogen reduction and moderate levels of bacterial reduction.

Figure 4-3
Bottomless Sand Filter Before the Final Cover of Peastone

The alternative system fits into the landscape, amid boulders and trees while providing a much higher level of treatment than a conventional system (Figure 4-4).

Figure 4-4
The Alternative Treatment System's Layout Fits into the Landscape

Small Flat Coastal Plain Lot with Nearby Private Wells

In this real-world example of a working class summer resort neighborhood, the creative design goal was to maintain the architectural and natural elements of the neighborhood by avoiding large obtrusive raised fill-type wastewater treatment system that would detract from the sense of community and compound stormwater problems. Homes in this low-lying sandy soil coastal plain area are largely seasonally occupied but often experience intense summer use. This entire community relies on wells, many of which are shallow-dug wells that rely on thin freshwater lenses floating above the heavier saltwater. This home, like most of the older homes in the neighborhood, is 1950s- to 1970s-vintage on a small lot (5,000 square foot is common), where well and septic system setbacks are rarely met. Wells on both the case study site and a neighboring lot were approximately 50 feet from a failed cesspool. Obviously nitrogen and pathogen removal are essential to protect groundwater supplies as well as the nearby poorly flushed coastal pond.

To save limited space, a modular recirculating media filter was placed under a cantilevered room of the house, leaving the remaining 15-foot by 50-foot usable space in the back yard for the septic tank and shallow narrow drainfield.

Figure 4-5 shows the final system layout for this flat coastal-plain site with nearby shallow wells. The system included a septic tank (A), media filter (B), and drainfield (C).

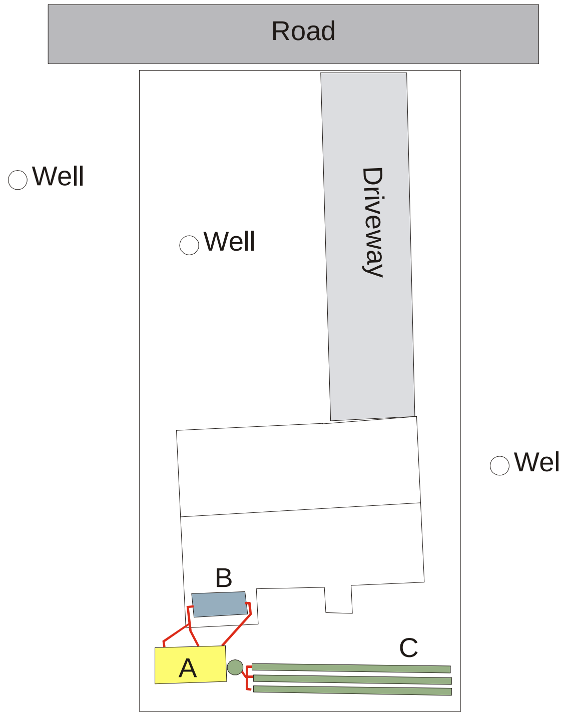

Figure 4-5
Final Treatment System Layout

Wastewater from the home enters the septic tank, where it then recirculates to the media filter in the crawl space, then is dosed to the shallow narrow drainfield where additional treatment occurs (Figure 4-6). The coastal pond can be seen in the background of Figure 4-6, approximately 300 feet away. The recirculating media filter fits in the crawl space under the cantilevered room of the house (Figure 4-7). The owners of the white building seen beyond the outdoor stairs in Figures 4-6 and 4-7 later installed a similar system.

Figure 4-6
Locations of the Final System Components

Figure 4-7
Recirculating Media Filter Under a Cantilevered Room

A Sustainable and Healthy Home Landscape

Maintaining a sustainable home landscape by removing nitrogen was a prime objective on this real-world one-third-acre lot located in a flat coastal plain with sandy soils and eight-foot-deep water table. Homes in this area are typically 1950s vintage, with about half occupied year-round. Typical of the area, the existing system consisted of a cesspool that had hydraulically failed and was surfacing. A conventional system could have easily been accommodated, but with little nitrogen treatment.

One of the homeowner's main concerns was maintaining a vigorously growing turf on his landscaped lawn. To satisfy the owner's request, the system selected for this site was a septic tank followed by a pump tank that dosed a drip-irrigated field. The drip irrigation tubing was installed six inches below ground surface to maximize nutrient and moisture use by grass. Although the yard was large enough to accommodate most any technology, the drip irrigation fit well on the site because there was sufficient level space to accommodate the required amount of drip tubing. Figure 4-8 shows the location of the system components.

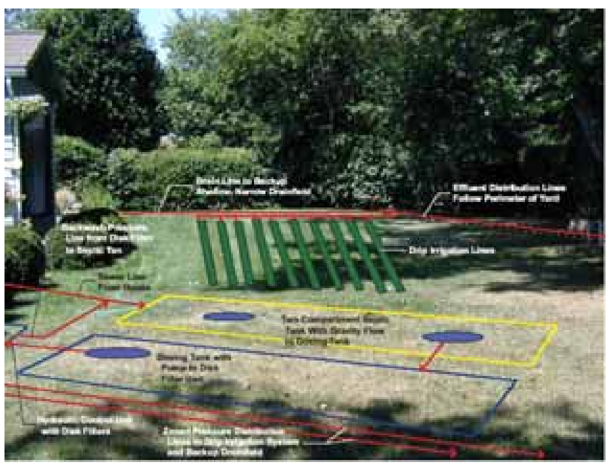

Figure 4-8
Drip-Irrigation System Layout for Turf and Landscape Maintenance

Figure 4-9 shows a diagram of the layout for the drip-irrigation system. In this system, wastewater from the home enters the septic tank (A) where solids settle. Effluent flows to the dosing tank (B) and is pumped through disc filters that remove fine organic particles that might clog the drip irrigation lines (C). A sand-lined shallow narrow drainfield (D) was also installed as a backup to the drip field but has not been used.

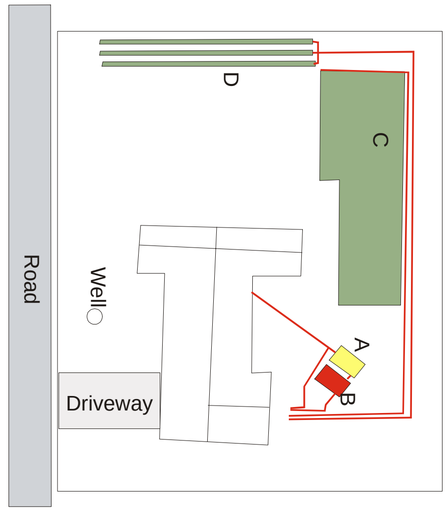

Figure 4-9
Layout of a Drip-Irrigation System

Site with a Nearby Private Well and Unique Wetlands

Maximizing pathogen and phosphorus removal were the treatment concerns on this real-world one-half-acre sandy soil lot relying on well water and having a small, yet environmentally important, vernal pool nearby. Several homes in this portion of the community have these natural vernal pools that are a unique habitat for threatened species of amphibians. The existing bed-type drainfield for this site had failed and was threatening the vernal pool. The somewhat rolling local topography with a high water table at about three feet, lent itself to using a buried single-pass sand filter with a shallow narrow drainfield. This system was used to provide maximum bacterial removal on the three-foot water table site, protect the drinking water well, and maintain the greatest setback from the vernal pool approximately 60 feet from the drainfield.

A generic single-pass sand filter was selected for this site because it is a reliable pathogen removal technology used for more than 100 years to treat water and wastewater. The single-pass sand filter is more effective in removing bacteria than a recirculating filter, which excels in nitrogen reduction. In addition, single-pass sand filters are larger than recirculating media filters and space was available at this site. The shallow narrow drainfield can be expected to provide additional nitrogen and pathogen removal to protect groundwater, and phosphorus treatment to protect the vernal pool from nutrient enrichment.

Figure 4-10 shows the system layout. Wastewater from the home enters the septic tank (A) and this effluent is then dosed to the single pass sand filter (B). Final treated effluent is then dispersed to a shallow narrow drainfield (C).

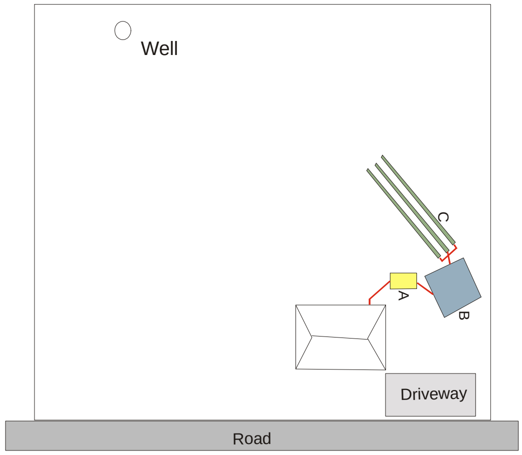

Figure 4-10
Layout for the Single-Pass Sand Filter System

This system required little site alteration, which prevented disruption of the wetland buffer and enabled existing landscaping to remain, including a small tree and several shrubs (Figure 4-11). The conventional septic system option would have required clearing, regrading, and filling to adjust for slopes and to raise the drainfield at least two feet to achieve the required separation to groundwater.

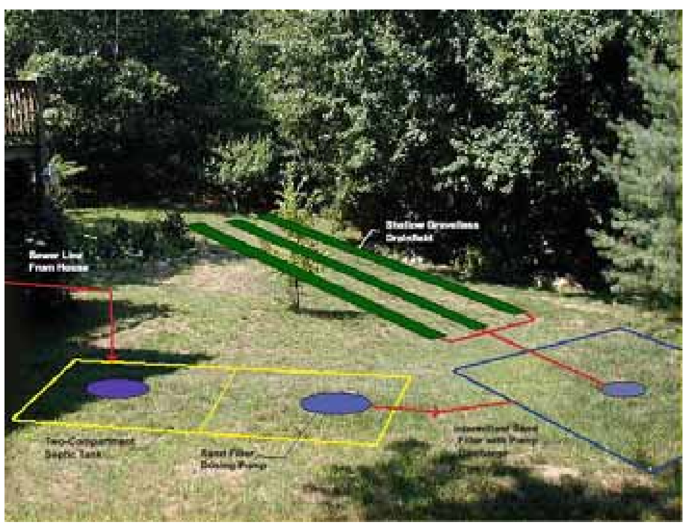

Figure 4-11
Location of System Components

Sandy Shorefront Lot with Limited Space

This real-world example site is located directly on the shore of a nitrogen-sensitive coastal pond that has been closed to shellfishing due to high bacteria levels. Nutrient enrichment at the shoreline of this property has caused an overabundant growth of nuisance algae (Figure 4-12).

Figure 4-12
An Overabundant Growth of Nuisance Algae Caused by Nutrient Enrichment

The creative community design goal in this case study was to maintain a sense of community character and charm while protecting the coastal pond and nearby well from nitrogen and bacteria. With a total land area of 5,000 square feet, the site has extremely limited usable space to fit house footprint, septic system, well, and parking area. The failed system consisted of two 55-gallon steel drums, an approximately 300-gallon steel septic tank, and a 600-gallon cesspool all in series. Located between the house and the pond shore, a dug well drawing from a shallow freshwater lense provided water to the 1950s vintage home.

The system installed on this site consists of a septic tank, a recirculating media filter, and a shallow narrow drainfield. Figure 4-13 shows the system layout. Wastewater from the house enters the septic tank (A) where effluent is then pumped to the recirculating media filter (B). The treated effluent is dosed to a two-zone shallow narrow drainfield (C1 and C2).

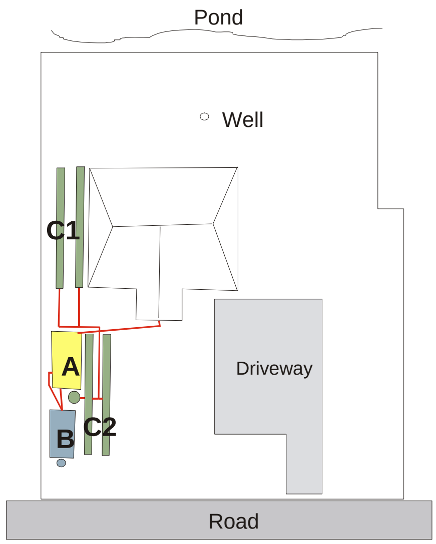

Figure 4-13
Layout for a Recirculating Media Filter System for a Lot With Limited Space

Figure 4-14 and Figure 4-15 show various views of the recirculating media filter system for this tight lot. One-half of the shallow narrow drainfield is located under the clothes line in between the home and the fence at the lot line (Figure 4-15).

Figure 4-14
Recirculating Media Filter System on a Small Lot

Figure 4-15
The System's Drainfield is Located Between the Home and the Fence

Until a few years ago, the conventional option for such small lots with deep sandy soils would have been a septic tank followed by deep concrete leaching chambers. This type of system has an extremely small footprint (4-foot by 12-foot drainfield) but provides little treatment. Shallow concrete leaching chambers could have been installed in the driveway, but again little treatment would have resulted.

Sloping Landscaped Site in a Sensitive Coastal Watershed

This real-world sloping one-half-acre lot has rocky glacial-till soils, well-established landscaping, and many obstacles that render the site with little usable space in which to fit a conventional septic system repair. Although the site has a fairly deep water table and municipal water service, the adjacent coastal pond roughly one block away is sensitive to nitrogen and bacterial inputs. Using alternative technology on this site eliminated extensive filling and regrading of the existing lot and maintained the natural elements of the landscape.

Whatever technology that was chosen for this site needed to fit into an area under an existing raised deck on the house to save space and fit the existing landscaping (Figure 4-16).

Figure 4-16
The Existing Raised Deck

The technology selected was a septic tank with a pump dosing a single-pass modular media filter. Figure 4-17 shows the system layout. Wastewater from the house enters the septic tank (A) where effluent is dosed to the single-pass media filters (B) located under the deck. Treated wastewater flows through an ultraviolet light disinfection unit (C) and then is dosed to the shallow narrow drainfield (D) adjacent to an existing fern garden (Figure 4-18).

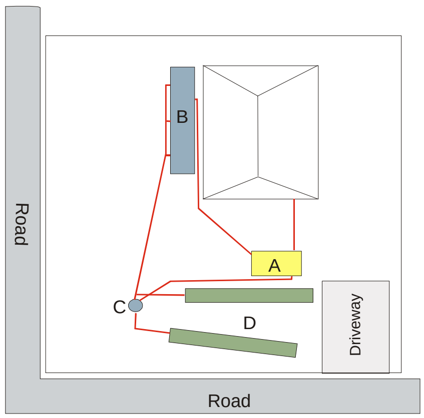

Figure 4-17
System Layout for a Sloping Site Where Bacteria Removal is Important

Figure 4-18
Locations of System Components on the Site

The media filters come in pre-packaged modular units that provide flexibility in siting, simplify installation, and enable limited site disturbance to the lot during construction (Figure 4-19). The UV light disinfection unit provides an additional level of bacterial removal to help reduce the pollution risk from this system. Due to the slope on this lot, a conventional system would have required extensive clearing with large amounts of machine time and gravel fill to enable level areas for drainfield lines, all with little nitrogen removal.

Figure 4-19
Modular Single-Pass Media Filters

A System for Tiny Waterfront Lots

Tiny waterfront building sites are lots that really should never have been built upon. They are grandfathered postage-stamp-sized lots with homes that had little impact on water quality back when first built. But now, with years of infill development and the shift to year-round use, the former summer cottage neighborhood has hastened the loss of recreational and commercial use of a waterbody for fishing and shellfishing.

This example is one such lot (Figure 4-20), located on the shore of a poorly flushed coastal pond that is permanently closed to shellfishing due to bacterial levels and is also showing signs of nitrogen enrichment. This example illustrates the use of alternative technology to maintain the quaint charm of a neighborhood and enable the landowner to renovate and revitalize his home. This roughly 4,000-square-foot-lot has unusually limited space, and a conventional system would neither fit on the site nor would it protect the beleaguered pond. Even most advanced treatment systems would not fit in the available space on this lot.

Figure 4-20
The Existing House Was Originally a Seasonal Home with a Building Footprint of Less Than 600 Square Feet

With remodeling, the footprint was slightly enlarged (Figure 4-21). The number of bedrooms remained the same, keeping potential occupancy at the same level and preventing an increase in nutrient loading.

Figure 4-21
Remodled House with a Slightly Enlarged Footprint

To meet the space and treatment demands of this site, a system incorporating fixed activated sludge technology was installed. This is a space-saver system because the treatment unit itself actually rests within the septic tank (Figure 4-22), eliminating the need for separate space to fit the treatment unit.

Figure 4-22
The Treatment Unit

Figure 4-23 shows the system layout. Wastewater from the house enters the septic tank (A) and flows through the fixed activated sludge system (B). Treated wastewater flows through an ultraviolet light disinfection unit (C) and then is dosed to the shallow narrow drainfield (D). Figure 4-21 also shows the location of system components.

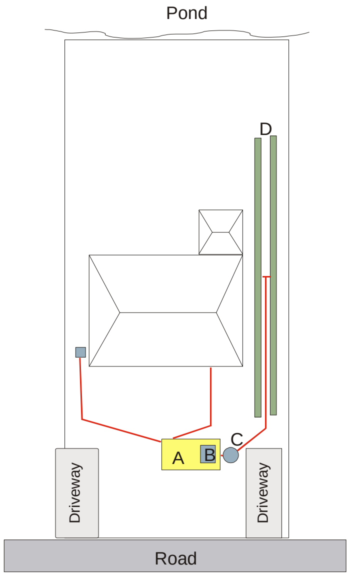

Figure 4-23
The Treatment System Layout

A recirculating media filter would have also been appropriate for this site, but would have used more space. This technology minimizes inputs of nitrogen and bacteria from this particular lot, protects the receiving waterbody, and has the smallest footprint possible.

Aesthetic Hints for Alternative Systems

This section attempts to provide an understanding of some basic system placement, setback, landscaping, and aesthetic issues that often make or break a system in the eyes of the property owner and neighbors. Although it is the designer's responsibility to make sure the system meets all these parameters, it is advantageous for planners to have basic knowledge about how a system should look, how it can fit the home landscape, or how it can blend into a subdivision without looking obtrusive. The following examples illustrate situations where more thought on the aesthetic impacts of a system and its influence on use of the home landscape may have produced a finished product that the system designer, installer, owner, and even neighbors might appreciate.

Simple Changes to Enhance Treatment System Choices

On this small flat coastal plain lot located in the watershed of a nitrogen-sensitive coastal pond, a recirculating media filter was installed to achieve a state-imposed discharge standard of at least 50 percent total nitrogen reduction. Although this technology was a good choice for this area from a treatment and space allocation perspective, the designer insisted on using a conventional (gravity-fed) drainfield. The media filter serves the house on the left in Figure 4-24 (only a corner is barely visible) the fence behind the tank and filter marks the adjoining property boundary with the house in the background.

Figure 4-24
Single-Family Home With a Raised Recirculating Media Filter and Conventional Gravity-Flow Drainfield

The recirculating media filter, which is raised well above the original ground surface and landscaped with native shrubs, uses up more space than actually needed. The raised area effectively limits the owner's use of that portion of the property and creates an aesthetic issue (in this case with several neighbors).

Incorporating the following simple changes would have enabled the homeowner greater use of the yard space. First, tank risers should be trimmed flush with the ground surface so a lawn mower can move directly over them. A second pump could have been used to dose a shallow narrow drainfield rather than using a conventional gravity-fed drainfield. This approach would have required one more pump, but the advantages would be:

- The media filter would be flush with the ground surface and would blend into the existing landscape more easily.
- A shallow narrow drainfield could have been installed easily with minimal disturbance of the yard.
- The shallow narrow drainfield would also provide additional wastewater treatment.

Recent studies show additional nitrogen removal rates in shallow drainfields average 50 percent annually (Stolt et al., 2003).

Paying Attention to the Details

An important consideration when selecting a treatment system is how the system will blend in with surrounding properties. Figure 4-25 shows a site with a demonstration system (foreground) with a shallow narrow drainfield—apparent by the greener grass.

Figure 4-25
A Conscientious Installer Paid Careful Attention to Details and Lined Up the Drainfield Lines on These Two Separate Lots to Produce a More Orderly and Aesthetically Pleasing Look

When the neighbor to the rear decided to replace his system with a similar advanced treatment system, the installer took care to line up the drainfields for a neater look. This is a minor point, but a nice touch from an installer who puts extra thought and effort into system aesthetics.

Options for Placement of System Components

Two adjoining lots in a coastal pond neighborhood upgraded failed septic systems using advanced decentralized treatment systems. Recirculating media filters followed by bottomless sand filter drainfields were used on each lot to achieve nitrogen and pathogen removal, fit on a small lot, and accommodate high water table conditions. The orange line shown in Figure 4-26 marks the property boundary, the treatment unit is outlined in yellow, and the bottomless sand filter is on the right of the pine tree.

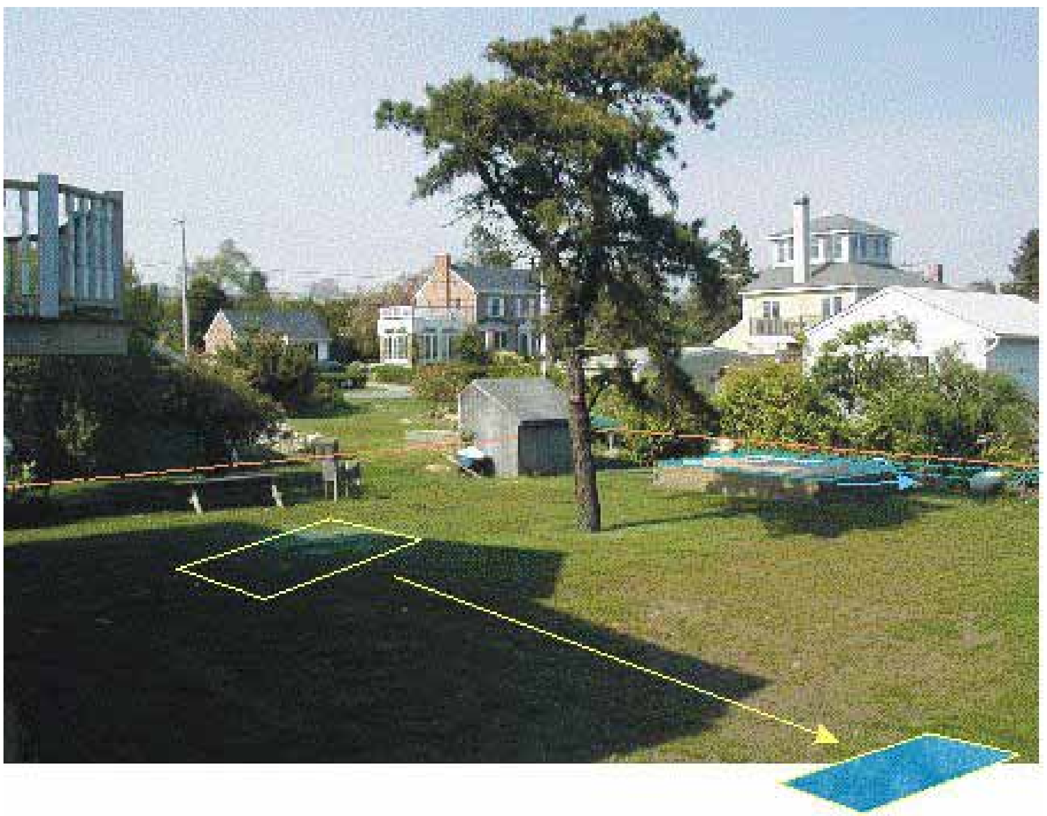

Figure 4-26
An Example of Component Placement Options

Unfortunately for the homeowner, the system components became the focal point of the landscape when placed in highly visible, open areas. An alternative placement scenario could have been to site the treatment unit along the property boundary, as shown in the foreground. The bottomless sand filter could have been designed as a long narrow rectangle and sited along the hedge line to the right of the current location, as shown with the dashed blue line. In addition to fitting the site better and opening up more usable space, a long rectangular bottomless sand filter configuration actually functions more effectively, and is easier to install and maintain.

In the adjoining lot (Figure 4-27), similar redesign would have enabled greater use of the property and avoided the need for costly landscaping to camouflage treatment units. The property boundary, as shown by the orange line, extends beyond the photo to the left, with space at the corner of the property, left of the telephone pole, for the treatment unit. The bottomless sand filter, located in front of the shed at the rear of the property, currently blocks the shed door, preventing it from opening fully. The bottomless sand filter could have been designed in a long rectangular shape and sited along the hedge following the property boundary on the left.

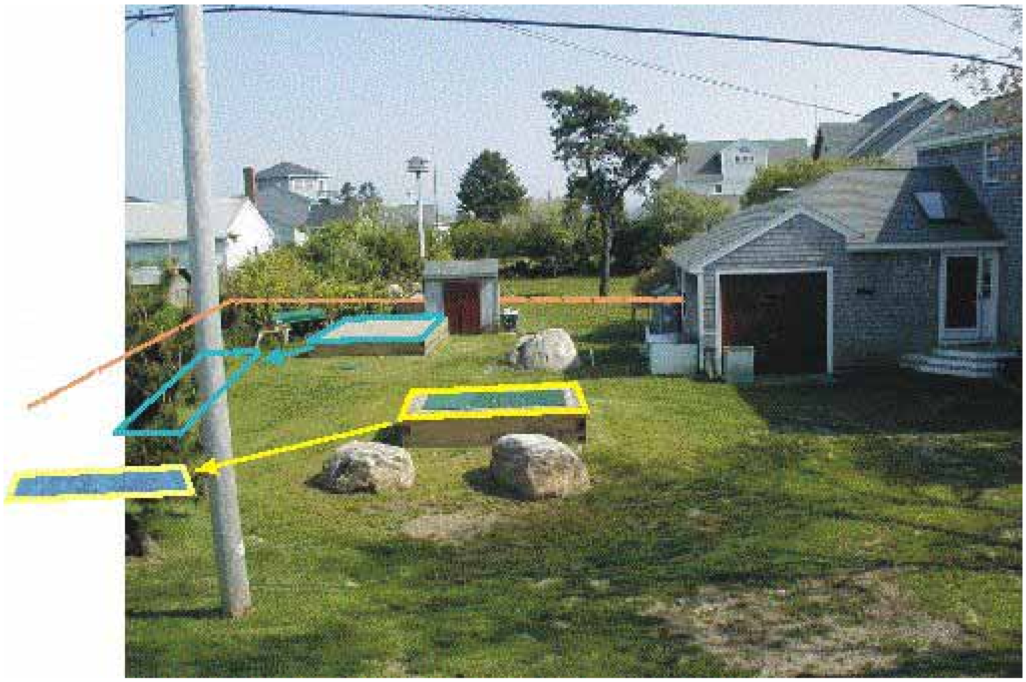

Figure 4-27
An Additional Example of Component Placement Options

These examples offer basic helpful tips to help systems blend into the home landscape so system owners and neighbors appreciate the flexibility of the technology and do not view it as an eyesore.

Fitting Alternative Systems into the Landscape

The following checklist provides guidance for fitting alternative systems into the landscape:

- Work with the existing topography, buildings, and vegetation to blend components into the landscape.
- Use grade changes to avoid an additional pump. For example, recirculating systems typically pump effluent from the septic tank to the top of the treatment unit. The treated wastewater exits from the bottom the treatment unit and returns either to the septic tank or a different recirculation tank. When using a recirculating system, locate the bottom of the treatment unit upgradient of the inlet of the recirculating tank, thereby allowing gravity flow back to the tank.

- Treatment units above ground need to fit into the landscape unobtrusively.
- Place components along existing edges such vegetation borders, shrub rows, driveways, or stone walls. Whenever possible avoid putting units in the middle of lawns or other open spaces.
- Conceal vent pipes from general view by siting them behind vegetation, stone walls, or buildings.
- Use natural materials, such as wooden timbers, to encase the sides of treatment units.
- Small modular treatment units can be tucked into crawl spaces and under decks provided access is maintained.
- Where possible, locate treatment units and drainfields away from high-use areas. This consideration becomes more important for larger systems and commercial properties. For example, treatment units should be kept away from restaurant entrances and outdoor patios.
- Electrical panel boxes can be noisy when switches controlling pumps go on and off. Locate these on the outside of utility walls or in high-use areas such as garages, entryways, or kitchens where refrigerators, air conditioners, or other utilities already create some noise.
- Keep in mind the convenience and safety of maintenance providers. Locate the panel box for easy access. Consider locating the panel box outside fenced pet areas for the inspector's convenience and safety.
- Insert activated charcoal pads at the top of drainfield inspection ports if odors are a problem.
- When locating shallow narrow drainfields in playing fields, cover inspection ports with turf for safety, but tag them beforehand with metal markers to easily identify them with a metal detector when maintenance is due.

Selecting Between Individual and Cluster Systems

The decision to use an individual system or a cluster system for two or more homes is highly site specific. Shared systems may cost more or less than several individual systems. Nevertheless, the following factors provide guidance in this decision.

- Consider if a reduction in design flow be allowed with a shared system. With individual systems, enough capacity must be provided for the worst case, maximum flow scenario. With several homes on one system, the risk that all units will experience maximum flow at the same given time is slim, so design flows for each may be lowered because peak flows from some units will be moderated by the group. Reducing peak flows increases cost-effectiveness, but regulators determine if credit is allowed.
- If the lot is too small for a system, try talking with a neighbor who may also need a system fix. The homeowner donating his extra lot as a treatment zone lot for a shared system may qualify for a tax break when the lot is deemed as unbuildable.
- There is no assurance that cluster systems will save costs due to the need to multiply treatment units and the cost of wastewater collection.

- When more than five or six houses are connected, there is potential for greater savings due to reduced design flow, a single treatment unit, and potentially fewer pumps.
- Determine if public property is available for a common treatment and drainfield area. Saving on land acquisition costs can make a shared project much more cost effective.
- Where private wells are located within 100 feet of a soil infiltration system, consider upgrading to advanced treatment to protect drinking water quality.
- Where shallow wells are located within 100 feet of a wastewater treatment system, consider installing a drilled well.
- Collection systems for alternative cluster systems serving anywhere from two homes to a whole village all require piping to carry wastewater from homes to the shared treatment units and drainfields. Typically small diameter (two- to three-inch diameter) pipes are used.
- Compare the cost of a septic tank effluent gravity collection system versus individual system repair.
- Determine if local regulations allow connection of small diameter effluent sewers to a nearby gravity sewer rather than installing a conventional (and generally more costly) traditional pump station.
- Rely on conventional treatment systems using gravity flow in areas of large lots with good soils and where advanced wastewater treatment is not essential to protect public health or environmental quality. With good soil and site conditions, conventional onsite systems generally provide reliable treatment with the least cost and lowest maintenance.
- Use of active systems should be justified with measurable improvements in health and the environment (Tyler, 2000). Active systems that provide only minimal improvements, such as reduced BOD and TSS, and reduced drainfield size, should be carefully evaluated.
- Consider electrical costs, which can add up over the life of a system and offset any minor savings in initial installation cost, especially in island locations where electricity costs are generally much higher than normal.
- When selecting advanced treatment systems of comparable complexity, reliability, and cost, it makes sense to choose the simplest technology.

5 RESOURCES FOR APPLYING CREATIVE DESIGN

This chapter provides information about community wastewater management, strategies for implementing better design, and resources for smart growth.

Community Wastewater Management

Community wastewater management involves:

- Local authority for wastewater management
- Supporting state regulations and assistance
- Wastewater management plans and ordinances
- Developing a successful wastewater management program

Local Authority for Wastewater Management

Prior to the adoption of local wastewater management programs, towns must first be granted the authority to do so through state enabling legislation. Ideally, statutes should give communities broad powers to adopt septic system inspection and maintenance programs designed to protect public health and environmental quality. Municipal authority should include:

- The right to establish wastewater management districts and zoning regulations.
- The right to enter onto private property for the purpose of inspecting a septic system.
- The ability to order the maintenance of a system in accordance with an appropriate schedule.
- The ability to levy fines and assess annual fees.

Supporting State Regulations and Assistance

To be successful, communities need strong support and assistance from a state septic system regulatory program. State agencies in charge of permitting the design, siting, and construction of septic systems can greatly assist local communities by adopting the following types of programs:

- State Licensing and Certification for Septic System Designers, Site Evaluators, Installers and Inspector—A number of states now provide training opportunities in partnership with private sector designers, maintenance care providers, contractor's associations, and universities.

- State Review and Approval of New Technologies—State agencies should consider establishing a "Technical Review Committee for Alternative Technologies" to help evaluate and approve new proprietary technologies. Once approved, new technologies can then be permitted without lengthy variance procedures.
- Standardized Inspection Procedures—State agencies should provide a guidance document to towns and the private sector that lists state-recommended standards for evaluating and maintaining septic systems. The handbook should include instructions for locating system components, conducting different types of inspections, and procedures for setting maintenance schedules.
- Community Grants for Wastewater Management Planning—States can earmark a portion of their state non-point source funds (Section 319) for wastewater management planning. In Rhode Island for example, communities are eligible for up to $25,000 for development of wastewater management programs. As of 2003, approximately 75 percent of Rhode Island communities that rely on onsite wastewater systems had received funds and were developing local wastewater management plans and/or ordinances.
- Homeowner Loans for Septic System Repair using State Revolving Funds. States can work with EPA to design a "State Revolving Loan Fund" to provide homeowners with low-interest loans for septic system repairs and upgrading. Eligibility for the program can be linked to municipal adoption of wastewater management plans. The community may also want to add its own features such as means testing, technical assistance, or supplemental grants and loans.

Wastewater Management Plans and Ordinances

As part of its 2003 *Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems,* EPA outlined five management models to assist communities in selecting appropriate program elements and activities. The models are provided as conceptual approaches and vary in level of control depending on the sensitivity of the resources being protected and the complexity of the wastewater treatment systems being constructed. The management models are designed to be flexible so that communities can customize their own programs by selecting elements from any of the five models.

The Five Management Models (USEPA, 2003) are:

- Model 1—*Homeowner Awareness* for communities or areas within communities of low environmental sensitivity and where treatment technologies are limited to conventional systems. To ensure that timely maintenance is performed, the regulatory authority mails maintenance reminders to owners at appropriate intervals.
- Model 2—*Maintenance Contracts* for communities or areas within communities where more complex technologies are employed to enhance the treatment capacity of conventional systems. Because of treatment complexity, contracts with qualified technicians are needed to ensure proper and timely maintenance.

- Model 3—*Operating Permits* for communities or areas within communities where sustained performance of treatment systems is critical to protecting public health and water quality. This typically includes limited-term, renewable operating permits for system owners. Performance-based designs may be incorporated into programs with management controls at this level.
- Model 4—*Responsible Management Entity Operation and Maintenance* for communities or areas within communities where frequent and highly reliable operation and maintenance of decentralized systems is required to ensure water resources protection. Under this model, the operating permit is issued to a management entity to provide the needed assurances that the appropriate maintenance is performed.
- Model 5—*Responsible Management Ownership* for treatment systems that are owned, operated, and maintained by a management entity. This management model is analogous to central sewerage treatment and provides the greatest assurance of system performance in the most sensitive of environments.

Developing a Successful Wastewater Management Program

Like any successful comprehensive community planning initiative, the key objective in developing the program is to ensure that it reflects community needs, is well integrated with other planning efforts, has a strong public participation and education component, and takes full advantage of existing resources and funding opportunities. A number of basic steps for developing a successful management program are as follows (USEPA, 2003):

- Identify and engage stakeholders and interested parties.
- Organize those involved through formal or informal processes.
- Develop and implement a public education and outreach program.
- Assess decentralized wastewater facilities and impacts and determine current trends.
- Project future scenarios as indicated by the trend analysis.
- Create a community vision incorporating preferred outcomes.
- Conduct a capacity assessment to determine realistic management options.
- Explore options under existing and/or revised regulatory structures.
- Select the most appropriate options, identify success indicators, and develop a work plan.
- Implement the work plan; adapt as suggested by monitoring of selected indicators.

Strategies for Implementing Better Design

Strategies for implementing better design fall into two categories:

- Land development techniques
- Site design considerations

Land Development Techniques

Land development techniques include:

- Cluster development
- Conservation easements
- Conservation subdivisions
- Development plan review
- Farm, forest, and open space tax reductions
- Overlay districts
- Phasing development
- Planned unit development
- Purchase of development rights
- Residential compounds
- Transfer of development rights
- Urban growth boundary

Cluster Development

This type of subdivision design, also known as open space development, was originally intended as a design option to assist communities in preserving rural character. A cluster development differs from a conventional subdivision in that house lots are smaller and more closely spaced on the property being subdivided. The remaining land is then set aside and managed as communal open space, usually through a homeowner's association. To enable cluster development, local regulations must permit lot size reductions and some flexibility in setback requirements. A major criticism of clustered developments is that they are often designed as scaled-down versions of conventional subdivisions, with too much attention paid to maximizing individual lawn area, and not enough attention paid to preserving the natural features of the site.

Conservation Easements

A conservation easement is a voluntary legal agreement between a landowner and a land trust or government agency that permanently protects land by limiting present and future uses. Easements are one of the most flexible conservation tools. The landowner retains ownership and use of the property (within the terms of the easement), while the land trust takes responsibility for protecting the land's conservation values. The easement agreement is designed to make certain that the protection of the land is compatible with the financial and personal needs of the landowner. Donated conservation easements that meet federal tax code requirements can provide significant tax advantages to landowners.

Conservation Subdivisions

This innovative approach to subdivision design grew out of a widespread dissatisfaction with traditional clustered subdivision designs. Conservation development is a creative land use technique that enables a community to guide growth to the most appropriate areas within the community. The conservation design process prioritizes the avoidance of environmental impacts and reductions in the fragmentation of natural land cover on the parcel to be developed as well as on a larger community scale. The goal of conservation development is to accommodate growth while preserving at least 50 percent of the development site as meaningful open space. Conservation development does not require reductions in the number of lots being developed; instead the lots are carefully sited to protect all natural and cultural features on the parcel. The conservation design process also encourages towns and developers to be mindful of the larger context of the site by helping to preserve existing wildlife corridors, riparian areas, and other open spaces.

Development Plan Review

This type of ordinance sets performance standards for larger-scale development including:

- Access and traffic impacts
- Lighting, parking
- Landscaping
- Appearances and architectural design
- Stormwater runoff
- Erosion control
- Wastewater
- Water quality
- Noise
- Utilities
- Other features of the site

Performance standards should reflect the goals of the community. When conducting development plan review, it is crucial that communities have technical experts to help with the review process.

Farm, Forest, and Open Space Tax Reductions

States interested in promoting preservation of open lands can adopt programs that assess property values based on current land use and not on the highest and best use value. The purpose of these programs is not to reduce property taxes per se, but to provide landowners with some incentive for conserving productive agricultural and forested land.

Overlay Districts

This type of zoning ordinance is tailored to protect a specific natural or cultural resource. The resource could be an aquifer, a watershed, a shoreline, an historic area, or a mountain ridge. Regulations for the protection of the resource are then "overlaid" on existing land use regulations such as subdivision requirements, site plan review, or zoning districts. The overlay district regulations supplement any underlying regulations. This approach enables towns to maintain or update current regulatory codes while at the same time extend specific protections to particularly sensitive areas. A good example is a floodplain protection district, where construction activities must meet additional standards in order to be approved. This is done to protect lives and property and to ensure the natural functioning of the floodplain.

Phasing Development

One possible way for communities to phase development is through the adoption of a rate limitation ordinance to establish an annual or quarterly cap on the number of building permits issued. The number of allowable permits must be based on the capacity of community resources, such as utilities and classrooms; it cannot be based on some historical average. Most importantly, rate limitation ordinances are by definition interim ordinances. The purpose of this type of ordinance is to gain time to study growth-related problems, to prepare legal and planning responses, and to implement local regulations to address the problems. The legality of a development cap is highly dependent on the town's findings of fact in establishing legitimate governmental interest and the reasonableness of the development limitations. A town can also adopt a subdivision phasing ordinance requiring that large residential subdivisions be phased in over an extended period of time to soften the impacts on utility providers, schools, and other municipal services.

Planned Unit Development

This type of development is intended to promote a clustering of land uses such as residential and commercial development in which lot sizes, setbacks, and dwelling types can be varied in order to achieve design objectives and to make provisions for open spaces, common areas, utilities, and public improvements.

Purchase of Development Rights (PDR)

PDR is a voluntary program, where a land trust or some other agency usually linked to local government, makes an offer to a landowner to buy the development rights on a parcel. The landowner is free to turn down the offer or to try to negotiate a higher price. Once an agreement is made, a permanent deed restriction is placed on the property restricting the type of activities that may take place on the land in perpetuity. In this way, a legally binding guarantee is achieved to ensure that the parcel will remain agricultural or as open (green) space forever. This is because the agency involved retires the development rights upon purchase. The deed restriction is similar to a conservation easement.

Residential Compounds

This type of residential development is intended for subdivision of large parcels of land into five or fewer house lots. The objective of this type of residential development is to provide flexibility in subdivision design and to promote maximum preservation of natural features on the site. Housing lots are typically clustered together with shared driveways and a single egress to a public road. Protected open space is often communally owned and managed by the homeowners.

Transfer of Development Rights

This is a method for protecting land by transferring the rights to develop from a conservation area to a more appropriate site. What is actually occurring is a consensus to place conservation easements on property in conservation areas while allowing for an increase in development densities or “bonuses” in other areas that are being developed. The costs of purchasing the easements are recovered from the developers who receive the building bonus.

Urban Growth Boundary (UGB)

This is a planning boundary designating where development should take place. The area between the current urban or suburban area and the UGB is considered land that can accommodate future growth. The UGB can also be conceptualized as an urban service boundary for future extension of public utilities, while land outside the growth boundary is slated to remain predominantly rural. The town of Shelburne, Vermont recently passed a Sewer Capacity Allocation Ordinance that establishes a sewer area boundary. The ordinance reduces development pressure on land outside of the boundary and creates a capacity estimate set aside so that there will be sufficient capacity for anticipated projects in the service area over the 20 year life span of the sewerage treatment plants.

Site Design Considerations

Site design considerations include:

- Minimize cul-de-sacs
- Reduce roadway widths
- Relax setback and frontage distances
- Rooftop runoff requirements
- Shared or alternative driveways

Minimize Cul-de-Sacs

Many communities require the end of cul-de-sacs to be 50 to 60 feet in radius, creating large circles of impervious cover. There are several different options for reducing the total amount of impervious cover created by traditional cul-de-sacs. One option is to reduce the radius of the turnaround bulb. Several communities have implemented this successfully and the smaller radii can range from 33 to 45 feet. Since most vehicles only use the outside of a cul-de-sac when turning, a second option is to create a pervious island in the middle of the cul-de-sac creating a donut like effect.

Reduce Roadway Widths

Excessively wide residential streets can often be attributed to blanket applications of high-volume/high-speed highway design criteria applied to local subdivision streets. Communities have a significant opportunity to reduce impervious cover by revising their street standards so that street widths are minimized. Residential streets widths should be designed according to traffic volumes while providing adequate parking and access for residents and service, maintenance, and emergency vehicles. Several national engineering organizations have recommended residential streets as narrow as 22 feet in width (AASHTO, 1994; ASCE, 1990).

Relax Setback and Frontage Distances

Decreasing the required distance from a dwelling to its property line (setback), or the length of a property adjacent to a road (frontage), enables developers to create attractive, compact lots that are marketable and livable. Concerns that fire could spread easily from one home to another and the potential for housing to obstruct sight lines for drivers are common reasons cited against relaxed setbacks. Use of fire-retardant building materials and placement of visual obstructions no less than 1.5 feet from the road will alleviate these concerns.

Rooftop Runoff Requirements

Direct rooftop runoff to pervious areas such as yards, open channels, or vegetated areas and avoid routing it to the roadway and the stormwater conveyance system. Another alternative to managing rooftop runoff is to drain the runoff directly into rain barrels, which can store the water for later use in gardens, yards, or for house plants.

Shared or Alternative Driveways

When two or more adjacent properties use the same driveway for ingress and/or egress, it helps to reduce lot size and impervious surface area on a property. Driveway widths are generally required to be 10 feet for one car and 20 feet for two cars. Decreasing these width requirements or using a permeable paving material can also significantly reduce driveway imperviousness.

Resources for Smart Growth

The following list provides resources available for obtaining further information about smart growth.

- The **U.S. Environmental Protection Agency** maintains a smart growth website that is an excellent clearinghouse of valuable information on smart growth. The site contains links, publications, fact sheets, funding sources, and information on EPA's Smart Growth Initiatives. http://www.epa.gov/livability/
- **Smart Growth America** is a coalition of nearly 100 advocacy organizations that have a stake in how metropolitan expansion affects our environment, quality of life, and economic

sustainability. The diverse coalition partners include national, state, and local groups working on behalf of the environment, historic preservation, social equity, land conservation, neighborhood redevelopment, farmland protection, labor, and town planning. http://www.smartgrowthamerica.com/

- **Smart Growth Network** was formed in response to increasing community concerns about the need for new ways to grow that boost the economy, protect the environment, and enhance community vitality. The network's partners include environmental groups, historic preservation organizations, professional organizations, developers, real estate interests; and local and state government entities. http://www.smartgrowth.org/sgn/default.asp
- **Low Impact Development Center** was established to develop and provide information to individuals and organizations dedicated to protecting the environment and water resources through proper site design techniques that replicate pre-existing hydrologic site conditions. http://www.lowimpactdevelopment.org/
- **National Association of Local Government Environmental Professionals (NALGEP)** assists local government officials responsible for dealing with environmental concerns. Most local government entities are required to undertake environmental activities. NALGEP was established in recognition that local government environmental professionals are often confronted with tight budgets, complicated requirements and problems which, although are first-time problems for a particular local entity, may have been encountered and dealt with by other localities. http://www.nalgep.org/
- **Non-Point Education for Municipal Officials (NEMO)** is an educational program for local land use officials that addresses the relationship of land use to natural resource protection. NEMO publishes numerous fact sheets and other educational materials related to smart growth. Some are listed as follows. All materials can be ordered or downloaded from their website: http://nemo.uconn.edu/index.htm
  - *Open Space Developments: A Better Way to Protect Water Quality, Retain Wildlife, and Preserve Rural Character*. 1998. This fact sheet, developed in collaboration with nationally known expert Randall Arendt of The Natural Lands Trust, explains the many benefits of open space developments, including the protection of water resources.
  - *Carving Up the Landscape: Habitat Fragmentation and What to Do About It*. 1999. This fact sheet explains habitat fragmentation, suggests why people should care about it, and proposes a three-part strategy to reduce its impacts.
  - *Natural Resource-Based Planning for Watersheds: A Practical Starter Kit. 2001*. Intended as a broad guide to help local officials and others get started on watershed planning, this booklet is illustrated with natural resource mapping examples from the Eightmile River Watershed Project.
  - *Open Space Planning Packet*. 1998. This substantial packet of materials answers questions about identifying, characterizing, prioritizing, acquiring, and funding open space. The packet is comprised of about 20 individual fact sheets, a set of model open space regulations regarding subdivision, and a manual on how to conduct a natural resource inventory.

- **The Center for Watershed Protection** provides local governments, activists, and watershed organizations around the country with the technical tools for protecting some of the nation's most precious natural resources: our streams, lakes and rivers. Like NEMO, the Center has several publications on planning and smart growth. Some are listed as follows. All can be downloaded or ordered from their website: http://www.cwp.org/index.html
  - *Redevelopment Roundtable Consensus Document* is a publication that documents the center's Redevelopment Roundtable Project and outlines the resulting model development principles, which are designed to promote more environment-friendly redevelopment and infill projects.
  - *Code and Ordinance Worksheet* (COW) is a simple worksheet used to see how the local development rules in a community stack up against the model development principles outlined in *Better Site Design*.
  - *Better Site Design: A Handbook for Changing Development Rules in Your Community c*overs everything from basic engineering principles to actual vs. perceived barriers to implementing better site designs. The handbook outlines 22 guidelines for better developments and provides detailed rationale for each principle. *Better Site Design* also examines current practices in local communities, details the economic and environmental benefits of better site designs, and presents case studies from across the country.
- **Grow Smart Rhode Island** seeks to bring together diverse interests to protect and improve Rhode Island's quality of life, economic vitality, environmental health, and the unique physical character created by the state's historic cities, towns, and villages and by its farms, forests, and open spaces. http://www.growsmartri.com/
- ***Community Rules: A New England Guide to Smart Growth Strategies*** was written by the Conservation Law Foundation and the Vermont Forum on Sprawl as a guidebook for volunteer board members, planners, concerned citizens, and others who want to achieve smart growth in their communities through better planning, zoning, and permitting. *Community Rules* is accessible and authoritative, and is full of examples of communities in New England and elsewhere that have laid the groundwork for smart growth through sensible planning, zoning, and other strategies. http://www.clf.org/pubs/community_rules.htm
- The **Natural Lands Trust** works proactively to protect significant open lands in the Philadelphia region. Although it is focused regionally, its website contains planning and smart growth information that can be applicable nationwide. http://www.natlands.org/index.html

Wastewater

- **Consortium of Institutes for Decentralized Wastewater Treatment**, often referred to as "The Onsite Consortium", is a group of educational institutions cooperating on decentralized wastewater training and research efforts. The consortium includes people from educational institutions, citizens groups, regulatory agencies, and private industry. All of the established onsite wastewater training centers and programs in North America are consortium-member institutions and would be excellent local or regional sources of educational information and classes. http://www.onsiteconsortium.org/

- **EPA Office of Wastewater Management** offers many resources for small communities with links to publications including the new *Onsite Wastewater Treatment Systems Manual* and EPA voluntary standards for onsite wastewater management. http://www.epa.gov/owm/
- **National Decentralized Water Resources Capacity Development Project** (NDWRCDP) is a cooperative effort funded by the EPA that supports research and development to improve understanding and strengthen the foundations of training and practice in the field of onsite/decentralized wastewater treatment. http://www.ndwrcdp.org/
- **National Onsite Wastewater Recycling Association** provides leadership and promotes the onsite wastewater treatment and recycling industry through education, training, communication, and quality tools to support excellence in performance. http://www.nowra.org/
- The **National Small Flows Clearinghouse** helps America's small communities and homeowners solve their wastewater problems to protect public health and the environment. The NSFC assists in providing information on planning, operating, financing, and managing new or existing sewage systems, both for individual households and communities of less than 10,000 people. http://www.nesc.wvu.edu/nsfc/
- **URI Onsite Wastewater Training Center** is a demonstration and field training center for conventional and alternative septic system technologies in the Northeast—one of eight regional centers nationally. The training center is operated in partnership with more than 40 private sector contractors, Rhode Island Department of Environmental Management (RIDEM), the EPA, and others. The center has 22 full-scale systems constructed above ground for hands-on learning and more than 50 demonstration and research systems installed in seven communities. See the Consortium of Institutes for Decentralized Wastewater Treatment listed previuosly for the locations of regional training centers. For more information and fact sheets go to: http://www.uri.edu/ce/wq/owtc/html/owtc.html.

Cost of Community Services

- A **Cost of Community Services** study examines the cost to a town of community services such as police, schools, water, sewer, and roads for different types of land uses. Studies in numerous towns throughout New England and the nation show that residential development tends to cost towns more in services than it pays in taxes and fees, and that undeveloped land and farmland tend to generate more income to a town than they cost in services. For more information on Cost of Community Services studies, go to: http://www.farmland.org/research/index.htm

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7 LIST OF ACRONYMS AND ABBREVIATIONS

A&I	Alternative and Innovative
ATU	Aerobic Treatment Unit
BOD	Biochemical Oxygen Demand
D box	Distribution Box
EPA	United States Environmental Protection Agency
GPD	Gallons Per Day
mg/l	Milligrams per Liter
NALGEP	National Association of Local Government Environmental Professionals
NDWRCDP	National Decentralized Water Resources Capacity Development Project
NEMO	Non-point Education for Municipal Officials
NSFC	National Small Flows Clearinghouse
PDR	Purchase of Development Rights
ppm	Parts per Million
PVC	Polyvinyl Chloride
RBC	Rotating Biological Contactor
RIDEM	Rhode Island Department of Environmental Management
RME	Responsible Management Entity
SBR	Sequencing Batch Reactor
STEG	Septic Tank Effluent Gravity

STEP	Septic Tank Effluent Pump
TSS	Total Suspended Solids
UGB`	Urban Growth Boundary
URI	University of Rhode Island
UV	Ultraviolet Light Disinfection

8 GLOSSARY

This section contains definitions of terms used throughout this document.

Activated sludge process—A biological wastewater treatment process in which biologically active sludge is agitated and aerated with incoming wastewater. The activated sludge is subsequently separated from the treated wastewater (mixed liquor) by sedimentation, and most of it is returned to the process. The rest is wasted as needed.

Aerobic—Having molecular oxygen as a part of the environment, or growing or occurring only in the presence of molecular oxygen (as in aerobic organisms).

Aerobic treatment unit (ATU)—A mechanical onsite treatment unit that provides secondary wastewater treatment by mixing air (oxygen) and aerobic and facultative microbes with the wastewater. ATUs typically use a suspended growth treatment process (similar to activated sludge extended aeration) or a fixed-film treatment process (similar to trickling filter).

Alternative onsite wastewater treatment system—An onsite treatment system that includes components different from those used in a conventional septic tank and drainfield system. An alternative system is used to achieve acceptable treatment and dispersal/discharge of wastewater where conventional systems may not be capable of meeting established performance requirements to protect public health and water resources. (for example, at sites where high groundwater, low-permeability soils, shallow soils, or other conditions limit the infiltration and dispersal of wastewater or where additional treatment is needed to protect ground water or surface water quality). Components that might be used in alternative systems include sand filters, aerobic treatment units, disinfection devices, and alternative drainfields such as mounds, gravelless trenches, and pressure and drip distribution.

Anaerobic—Characterized by the absence of molecular oxygen, or growing in the absence of molecular oxygen (as in anaerobic bacteria).

Biochemical oxygen demand (BOD)—A commonly used gross measurement of the concentration of biodegradable organic impurities in wastewater. The amount of oxygen, expressed in milligrams per liter (mg/L), required by bacteria while stabilizing, digesting, or treating organic matter under aerobic conditions is determined by the availability of material in the wastewater to be used as biological food and the amount of oxygen used by the microorganisms during oxidation.

Black water—Liquid and solid human body waste and the carriage waters generated through toilet usage.

Clarifiers—Settling tanks that typically remove settleable solids by gravity.

Cluster system—A wastewater collection and treatment system under some form of common ownership and management that provides treatment and dispersal/discharge of wastewater from two or more homes or buildings but less than an entire community.

Constructed wetland—An aquatic treatment system consisting of one or more lined or unlined basins, some or all of which may be filled with a treatment medium and wastewater undergoing some combination of physical, chemical, and/or biological treatment and evaporation and evapotranspiration by means of macrophytes planted in the treatment medium.

Conventional onsite system—A wastewater treatment system consisting of a septic tank and subsurface wastewater infiltration system.

Decentralized system—Onsite and/or cluster wastewater systems used to treat and disperse or discharge small volumes of wastewater, generally from dwellings and businesses that are located relatively close together. Decentralized systems in a particular management area or jurisdiction are managed by a common management entity.

Denitrification—The biochemical reduction of nitrate or nitrite to gaseous molecular nitrogen or an oxide of nitrogen.

Disinfection—The process of destroying pathogenic and other microorganisms in wastewater, typically through application of chlorine compounds, ultraviolet light, iodine, ozone, and other treatments.

Drainfield—A shallow covered excavation made in unsaturated soil into which pretreated wastewater is discharged through distribution piping for application onto soil infiltration surfaces through porous media or manufactured (gravelless) components placed in the excavations. The soil accepts, treats, and disperses wastewater as it percolates through the soil, ultimately discharging to groundwater.

Effluent—Sewage, water, or other liquid, partially or completely treated or in its natural state, flowing out of a septic tank, subsurface wastewater infiltration system, aerobic treatment unit, or other treatment system or system component.

Effluent filter (effluent screen)—A removable, cleanable device inserted into the outlet piping of the septic tank designed to trap excessive solids due to tank upsets that would otherwise be transported to the subsurface wastewater infiltration system or other downstream treatment components.

Environmental sensitivity—The relative susceptibility to adverse impacts of a water resource or other environments that may receive wastewater discharges.

Fixed-film wastewater treatment system—A biological wastewater treatment process that employs a medium such as rock, plastic, wood, or other natural or synthetic solid material that supports biomass on its surface. Fixed-film systems include those in which the medium is held in place and is stationary relative to fluid flow (tricking filter), those in which the medium is in motion relative to the wastewater (for example, rotating biological disk), and dual process systems that include both fixed and suspended biomass together or in a series.

Graywater—Wastewater drained from sinks, tubs, showers, dishwashers, clothes washers, and other non-toilet sources.

Management entity—An entity similar to a responsible management entity, but managing a limited set of management activities (for example, a homeowners' association or contracted provider of management services).

Mansionization—The act of tearing down an existing house and replacing it with one that is bigger, especially one that is much larger than the surrounding houses.

Nitrification—The biochemical oxidation of ammonium to nitrate.

Onsite wastewater treatment system (OWTS)—A system relying on natural processes and/or mechanical components that is used to collect, treat, and disperse/discharge wastewater from single dwellings or buildings.

Operating permit—A renewable and revocable permit to operate and maintain an onsite or cluster treatment system in compliance with specific operational or performance requirements.

Package plant—Term commonly used to describe an aerobic treatment unit serving multiple dwellings or an educational, health care, or other large facility.

Pathogenic—Causing disease; commonly applied to microorganisms that cause infectious diseases.

Perched water table—The permanent or temporary water table of a discontinuous saturated zone in a soil.

Percolation—The flow or trickling of a liquid downward through a contact or filtering medium.

Performance-based management program—A program designed to preserve and protect human health and environmental resources by focusing on the achievement of specific, measurable performance requirements based on site assessments.

Performance requirement—Any requirement established by the regulatory authority to ensure future compliance with the public health and environmental goals of the community. Performance requirements can be expressed as numeric limits (for example, pollutant concentrations, mass loads, wet weather flows, structural strength) or narrative descriptions of desired performance, such as no visible leaks or no odors.

Permeability—The ability of a porous medium such as soil to transmit fluids or gases.

Regulatory authority (RA)—The level of government that establishes and enforces codes related to the permitting, design, placement, installation, operation, maintenance, monitoring, and performance of onsite wastewater treatment systems.

Responsible management entity (RME)—An entity responsible for managing a comprehensive set of activities delegated by the regulatory authority; a legal entity that has the managerial, financial, and technical capacity to ensure the long-term, cost-effective operation of onsite and/or cluster water treatment systems in accordance with applicable regulations and performance requirements (for example, a wastewater utility or wastewater management district).

Rotating biological contactor (RBC)—A means of wastewater treatment in which large closely-spaced plastic discs are rotated about a horizontal shaft. The discs alternately move through the wastewater and the air, to develop a biological growth on their surface.

Sand filter—A packed-bed filter of sand or other granular materials used to provide advanced secondary treatment of settled wastewater or septic tank effluent. Sand/media filters consist of a lined (for example, impervious PVC liner) excavation or structure filled with uniform washed sand that is placed over an under drain system. The wastewater is dosed onto the surface of the sand through a distribution network and allowed to percolate through the sand to the under drain system, which collects the filter effluent for further processing or discharge.

Septage—The liquid, solid, and semisolid material that results from wastewater pretreatment in a septic tank, which must be pumped, hauled, treated, and disposed of properly (in accordance with 40 CFR Part 503).

Septic tank—A buried, preferably watertight tank designed and constructed to receive and partially treat raw wastewater. The tank separates and retains settleable and floatable solids suspended in the raw wastewater. Settleable solids settle to the bottom to form a sludge layer. Grease and other light materials float to the top to form a scum layer. The removed solids are stored in the tank, where they undergo liquefaction in which organic solids are partially broken down into dissolved fatty acids and gases. Gases generated during liquefaction of the solids are normally vented through the building's plumbing stack vent.

Sequencing batch reactor—A sequential suspended-growth (activated sludge) process in which all major steps occur in the same tank in sequential order. Sequencing batch reactors include intermittent-flow batch reactors and continuous-flow systems.

Silt—A textural class of soils consisting of particles between 0.05 and 0.002 millimeters in diameter.

Soil texture—The relative proportions of the various soil separates (for example, silt, clay, or sand) in a soil.

Topsoil—The layer of soil moved in agricultural cultivation.

Treatment system—Any technology or combination of technologies (treatment trains or unit processes) that discharge treated wastewater to surface waters, groundwater, or the atmosphere.

Vegetated submerged bed—A constructed wetland wastewater treatment unit characterized by anaerobic horizontal subsurface flow through a fixed-film medium that has a growth of macrophytes on the surface.

Water quality criteria—A set of enforceable requirements under the Clean Water Act that establish measurable limits for specific pollutants based on the designated use(s) of the receiving water body. Water quality criteria can be expressed as numeric limits (for example, pollutant concentrations or mass loads) or narrative descriptions of desired conditions (for example, no visible scum, sludge, sheens, or odors).

Water table—The level in saturated soil at which the hydraulic pressure is zero.

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