

# **Model Decentralized Wastewater Practitioner Curriculum**

## **Technology Overview**

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# TECHNOLOGY OVERVIEW

## INTRODUCTION

Two primary methodologies are available to treat and dispose of wastewater from residences, business, factories and other wastewater generating sources. Centralized wastewater systems collect wastewater from each source and transmit it to a centralized treatment and dispersal facility. Decentralized wastewater systems incorporate treatment and dispersal technologies that serve each individual source of wastewater or small groups of sources. Decentralized systems use on-site wastewater treatment systems (OWTS). Centralized and decentralized systems both have their advantages and disadvantages, and communities need to be aware of them as they conduct their wastewater management and land use planning processes. However, the purpose of this training module is not to discuss the two options and help communities decide which the best option for them is. Instead, this training module focuses on technologies used in decentralized systems.

This is an introductory course containing information all professionals (site evaluators, designers, installers/contractors, pumpers, monitoring & maintenance professionals and regulatory personnel) in the onsite wastewater industry should know about the various technologies and their components used in OWTS. This course assumes that an individual has some familiarity with onsite wastewater systems. It is not designed to be an introduction to onsite wastewater treatment and disposal; thus, it is not intended for someone who is new to the industry. Time will not be spent describing the detailed basic principles of treatment and disposal common to all systems. If some of the terminology used to describe the systems and components and how they function is not understood, an entry-level class in onsite wastewater systems should be attended.

Within the United States and Canada, a variety of different systems and components are used. Discharge into the soil is used in all states and provinces. Discharge to surface water or to the surface of the land of effluent treated by onsite wastewater treatment components is permitted in fewer jurisdictions. States with appropriate climatic conditions also permit systems that use as their final disposal means a “discharge” to the atmosphere in the form of evaporation and transpiration. While mentioning the surface discharge options, this course will focus primarily on systems that have their final dispersal into the soil.

There is not only considerable variability throughout the United States and Canada of the types and of systems and components that are permitted, but also how a particular technology is applied. What may be the primary application of a particular technology in one jurisdiction may not be permitted in an adjacent jurisdiction. This overview attempts to highlight some of these differences and mention as many different applications of the technologies as can be found.

Furthermore, there is considerable difference in the terminology that is used. One purpose of this overview is to start developing consistent terminology that can be used by all onsite wastewater practitioners. A companion glossary of terms has been developed with this and other practitioner modules. Having a copy of the glossary of terms may be helpful if terms used in this course are not understood.

The Environmental Protection Agency has released a 2002 copy of the Onsite Wastewater Treatment Systems Manual. This course uses some of the descriptions, terminology, diagrams, and categorization used therein. However, it also uses those from other sources in order to be consistent with other practitioner and university training & education modules.

As noted in the 2002 United States Environmental Protection Agency's manual, there are several conditions that have, and still are, creating challenges that constantly must be overcome. These challenges include:

1. "Only about one-third of the land area in the United States has soils that are suited for conventional subsurface soil absorption fields.
2. "System densities in some areas exceed the capacity of even suitable soils to assimilate wastewater flows and retain and transform their contaminants.
3. "Many systems are located too close to ground water or surface water and others, particularly in rural areas with newly installed public water lines, are not designed to handle increasing wastewater flows.
4. "Conventional onsite system installations might not be adequate for minimizing nitrate contamination of ground water, removing phosphorus compounds, and attenuating pathogenic organism (e.g. bacteria, viruses)."

The concerns and risks raised by these challenges can be overcome by OWTS. This training module assumes that OWTS can properly treat and disperse wastewater into the various receiving environments while minimizing risk to public health and the quality of ground and surface water. **However, this assumption is dependent on having a comprehensive management program in place that will assure that proper decisions are made and that OWTS are properly sited, designed, installed, operated, monitored and maintained.**

### **Primarily for single family residential development**

The bulk of this course provides a general overview of the various technologies used as on-site wastewater/sewage systems for single-family residential development. Many of the technologies are also usable for cluster development or larger wastewater systems. General descriptions of and information about different on-site sewage systems and their primary components, including important features and expected treatment efficiencies are provided. Detailed information on each technology is not provided. It is anticipated this course will serve as an introduction to detailed design, installation and monitoring/maintenance courses for each of the technologies.

The technologies are grouped in several different categories according to function. Some of these technologies are especially suitable for cluster or larger systems. More cursory information will be provided on those technologies, since information is available on them from a variety of other sources. Also, technologies used for cluster and larger systems tend to be covered more thoroughly by university engineering curricula and training programs for certified wastewater works operators. A section on this course will be provided on each of the following types of system components:

1. Collection and transmission components – primarily for cluster systems and larger.
2. Pretreatment components
3. Application/Distribution components
4. Final treatment and dispersal components

The following information will be provided for many of the various components:

1. Descriptions of technology - What is it?
2. The technology's components - What does it consist of?
3. How the technology functions - How does it work?
4. Why & where the technology is used - Why & where is it used?
5. Design, installation and monitoring/maintenance considerations
6. Other pertinent information.

Lastly, while considerable information is presented on the technologies, the selection of the components that make up a system to serve a specific situation depends on other factors also. Thus, the next section summarizes the information needed to help select the best technologies for a given scenario.

## USE STRATEGIES

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### System Selection Process

Design and regulatory professionals have the responsibility to match a specific set of components that make up an OWTS to a set of specific site and soil characteristics. In order to select the proper set of components for a given site, information is needed. This section briefly 1) summarizes the information needed to make proper decisions and 2) presents optional considerations in the system selection process.

#### Soil and site information

OWTS are intended to provide levels of treatment that assure the final dispersal/discharge of the treated effluent will not have an undesirable impact on the receiving medium, whether it is water or soil. When soil is the final receiving environment for pretreated wastewater, passage of effluent through minimum depths of suitable soil are necessary to assure adequate final treatment. Systems consisting only of a septic tank and a gravity flow drainfield require the greatest depth of suitable soil. As soil depth available for water treatment becomes less (or coarser), other more sophisticated systems, assuring higher levels of treatment prior to discharge to the dispersal system become necessary. Discharge on to the surface of the soil or even into surface water after significant pretreatment is permitted in some locales. **Figure 1** depicts the general progression of soil depth and system types used for increasingly reduced soil depth.

Because of OWTS dependence on soil for both final treatment and dispersal into the receiving environment, the conditions of the soil and other site characteristics must be adequately

evaluated prior to making the choice of system components. Additionally, other facts must be gathered prior to making a final selection of components and commencing the layout and drawing of the system for submittal to the local regulatory jurisdiction. The needed information to assist this process includes at least the following:

1. Detailed description of the soils – depth, texture, structure, color, compaction, cementation, bulk density and/or other characteristics.
2. The hydrology of the site – ground water and surface water movement onto and off of the site.
3. Slope, topography and landscape position of the site.
4. Location of drainage ditches, foundations, sources of drinking water, surface water, steep banks/cuts, utility and other easements, driveways, buildings, and other features from which horizontal setbacks exist.
5. The sensitivity of a site – shallow unconfined aquifer, nearby shellfish growing or recreational areas
6. Client needs and aspirations, as well as financial limitations.
7. Local health requirements.
8. Local planning and building requirements and the presence of any critical areas, for example flood zones, wetlands, unstable slopes.
9. Potential restrictive features on adjacent or nearby properties.
10. The availability of a management system that can assure proper siting, design, installation, operation, monitoring, and maintenance.

#### Wastewater source

Additionally, the design and regulatory professionals must assure the pretreatment and dispersal components are sized and designed to handle the quantity and quality of the wastewater to be flowing to the system. Wastewater from residential sources usually is quite different than wastewater from non-residential or commercial sources. Wastewater from commercial sources can be highly variable, both in terms of quantity and quality.

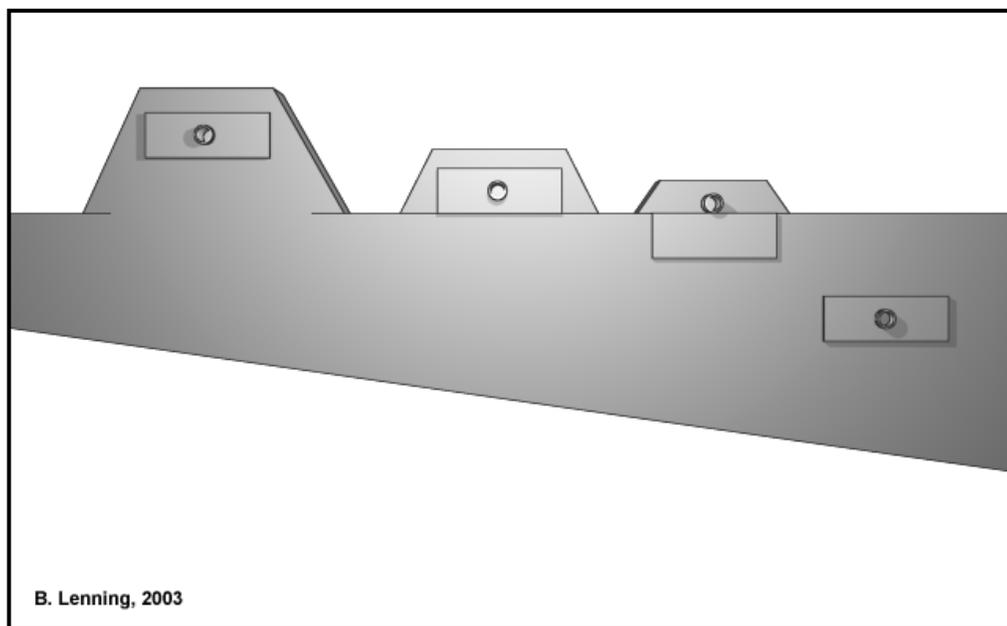
Historically, especially for residential sources, most of the emphasis has been on the quantity side. For residential sources, the number of bedrooms in a residence usually determines the daily design flow (gallons/day). Some locations look at other variables such as the size of the living area within a residence. A range of 120 to 150 gallons/bedroom/day makes up the typical daily design flow. For non-residential facilities, the primary methods used to determine daily design flows are a variety of tables in various references, some kind of plumbing fixture use assessment, or an evaluation of similar facilities.

The daily design flow, together with the results of the soil characterization, provides the information needed to determine the size of system components and the needed available area on a parcel. Hydraulic loading rates (or long-term acceptance rates) are used by design professionals to size components. These rates are soil specific and are measured in

gallons/ft<sup>2</sup>/day. As the soils become less permeable, the hydraulic loading rates decrease, resulting in larger systems. Recently, especially on sloping sites, more emphasis has been placed on determining the linear loading rate. This rate quantifies how much wastewater can flow through each linear foot of slope width. Linear loading rates are measured in gallons/day/linear foot.

More recently, there is increasing awareness that quality, especially quality parameters such as biochemical oxygen demand (BOD), total suspended solids (TSS), and fats, oils and greases (FOG) should also be considered when sizing and designing a system. Especially for non-residential flows, design professionals are starting to explore the use of organic loading rates for sizing an infiltrative surface. Such a rate is measured in pounds/ft<sup>2</sup>/day.

**Figure 1. Progression of Systems as Soil Depth Decreases**



### Selection Strategies

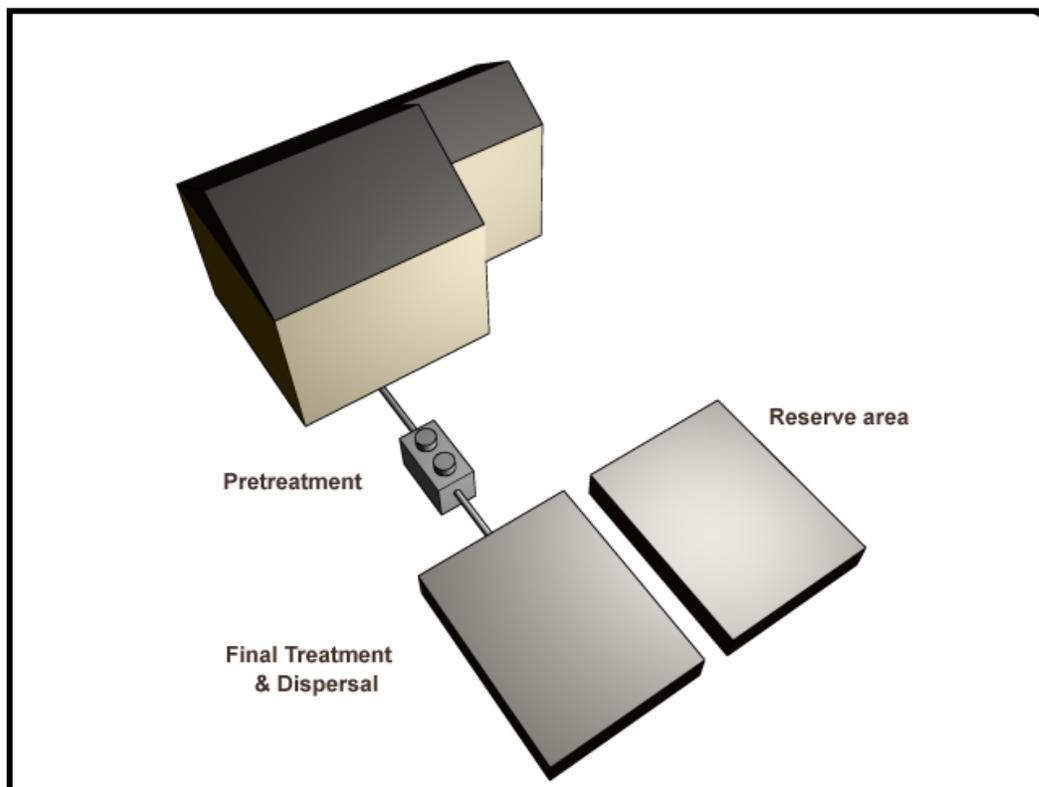
Some of the quality constituents can have an adverse impact on either system components or on the receiving environment (water or soil). These include BOD, TSS, nitrogen, phosphorous, FOG and pathogens. As a prelude to the discussion on the technologies and to provide a clearer understanding of the system selection process, **Table 1** provides general information on which processes and specific methods are/can be used to treat the various quality constituents. This

information will help one understand why the different technologies are used when the specific technologies are discussed in this training module. Table 1 is an adaptation of a table in the 2002 USEPA On-site Wastewater Systems Treatment Manual. There are other infrequently used technologies that are mentioned to in the USEPA manual. The reader should refer to the USEPA manual for further information.

### Typical System

There are many variations in pretreatment and dispersal components and how they are applied throughout North America. An OWTS typically consists of one or more pretreatment components and a dispersal component. The simplest and least expensive system consists of a septic tank (pretreatment component) and a drainfield (dispersal component). **Figure 2** depicts such a system. However, even the typical system varies substantially from jurisdiction to jurisdiction and from code to code.

**Figure 2. Typical System**



As will be noted during the discussion on the wide variety of pretreatment components (also evident in **Table 1**) pretreatment components treat wastewater so other downstream pretreatment components or a dispersal component can more readily handle the effluent. For example, a primary purpose of a septic tank is to remove solids from the wastewater stream so that the drainfield, the most expensive component in a typical system, is protected and can more readily provide final treatment of the effluent and dispersal into the subsoil environment. Likewise, purposes of an ATU or media filter may be 1) to clean the effluent sufficiently so disinfection can be effective or 2) to provide alternative final treatment and dispersal opportunities.

**Table 1. Commonly used treatment processes & optional treatment methods**

<b>Treatment Objective</b>	<b>Treatment Process</b>	<b>Treatment Method/Technologies</b>
<b>Suspended solids</b>	Sedimentation	Septic tank Constructed wetland
	Filtration	Effluent filters Media filters Soil infiltration
<b>Organic material (CBOD)</b>	Aerobic processes	Aerobic treatment units Aerobic media filters Lagoons (also facultative)
<b>Pathogens</b>	Filtration, Predation, & Inactivation	Soil infiltration Media filters
	Disinfection	Chlorination, Ultraviolet
<b>Nitrogen</b>	Biological Nitrification (N) Denitrification (D)	Single pass aerobic processes (N) Aerobic treatment units (N, some partial D) Recirculating processes (N,D) Anaerobic upflow filter (D)
	Ion Exchange (not discussed in this class)	Cation exchange (ammonium removal) Anion exchange (nitrate removal)
<b>Phosphorous</b>	Adsorption in soil	Infiltration by soil and other media
<b>Grease</b>	Flotation	Grease trap Septic tank
	Absorption	Mechanical skimmer (not discussed)
	Aerobic biological treatment	Some aerobic treatment units

Adapted from USEPA, 2002

For the simplest, as well as the most complex system, the following are needed to maximize the probability that the system will continue to treat and disperse of the wastewater for many years:

1. As mentioned, the site evaluator, soil scientist, designer, and/or regulatory professionals must properly assess or characterize the soil and site conditions, find out the desires of the property owner, and determine what components will make up the system that can be constructed to serve a specific residence or other facility. This will include looking for site encumbrances and assessing typical horizontal setbacks for different technologies.
2. The installation professional must then construct the system in accordance with all requirements and the approved design.
3. The installation, design and regulatory professionals are responsible for installation of a system that is easy to operate, monitor and maintain.
4. The system owner/user must use or operate the system in a proper fashion, consistent with design quantity and quality. This includes generating appropriate quantities and qualities of wastewater, not discharging non-biodegradable materials into their system, and protecting the areas where the system and reserve area are located.
5. The monitoring and maintenance professional(s) must regularly inspect the system to assure the system is functioning within acceptable parameters, the system components are maintained when necessary, and problems are readily evaluated and corrected when they occur.

### Segregation of wastewater flows

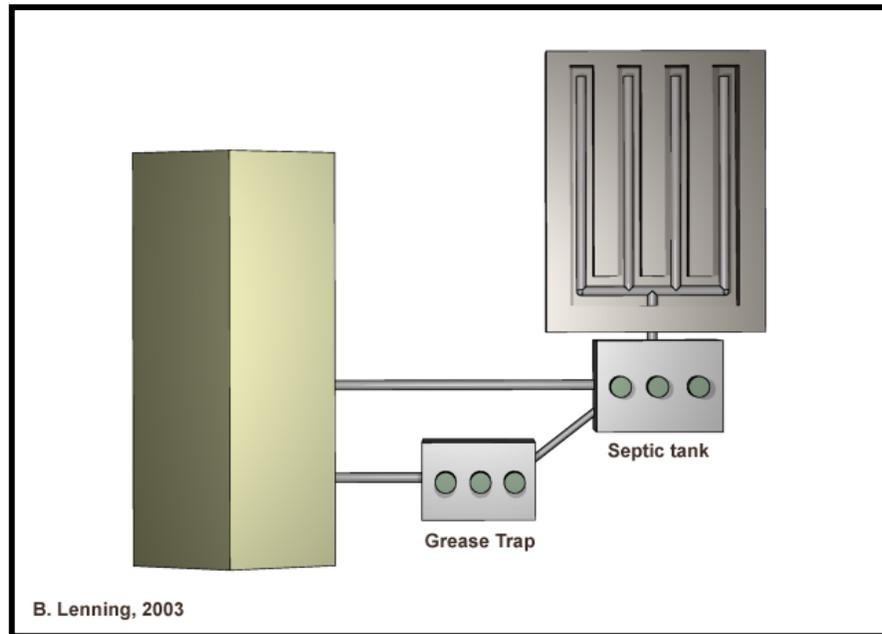
Wastewater that is treated by OWTS is generated by a number of activities in a residence or other facility. Wastewater consists of blackwater (in most locations this is just wastewater from toilets) and greywater (wastewater from all other plumbing fixtures). Most of the time, systems treat the combined wastewater, wastewater from all sources in a structure. Occasionally, the decision is made to split the system so one or more components treat one source of wastewater while another one or more components treat other sources. This will require separate plumbing networks in the residence or other structure. The primary reasons for splitting flows include:

1. Wanting to have separate systems treat blackwater and greywater:
  - a. To minimize nitrogen being discharged to ground or surface water in nitrogen sensitive areas by using non-discharging blackwater toilets, such as composting or incinerating toilets. These toilets retain most of the nitrogen in residential wastewater flows, since most of the nitrogen is in the blackwater.
  - b. To reuse wastewater where wastewater reuse is a priority, by treating and reusing greywater for landscape irrigation, toilet flush water or other uses.
2. Keeping wastes containing high concentrations of fats, oils and greases from fouling components handling wastewater from other sources until the fat, oil and grease concentrations have been significantly reduced.

Sometimes, even though the flows are initially split, they are combined somewhere downstream. A simple example of the two flows being combined is when a grease trap or interceptor is used

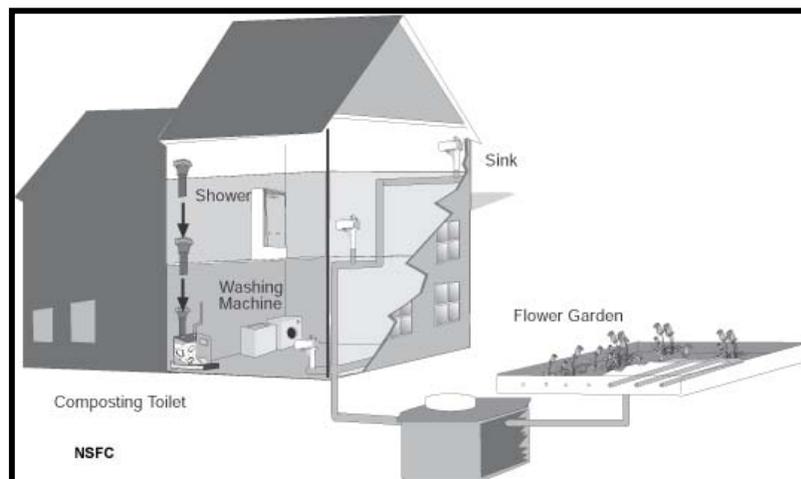
to handle wastewater from the kitchen only, with the resulting effluent being combined with the rest of the wastewater in a downstream septic tank. See **figure 3**.

**Figure 3. Typical split flow system combined for dispersal**



Other times this separation continues throughout the entire system, so there are two complete wastewater systems. See **figure 4**. Examples of this are when non-discharging toilets are used to handle the blackwater and another pretreatment and dispersal system is designed and constructed to handle the greywater.

**Figure 4. Example showing separate blackwater and greywater systems**



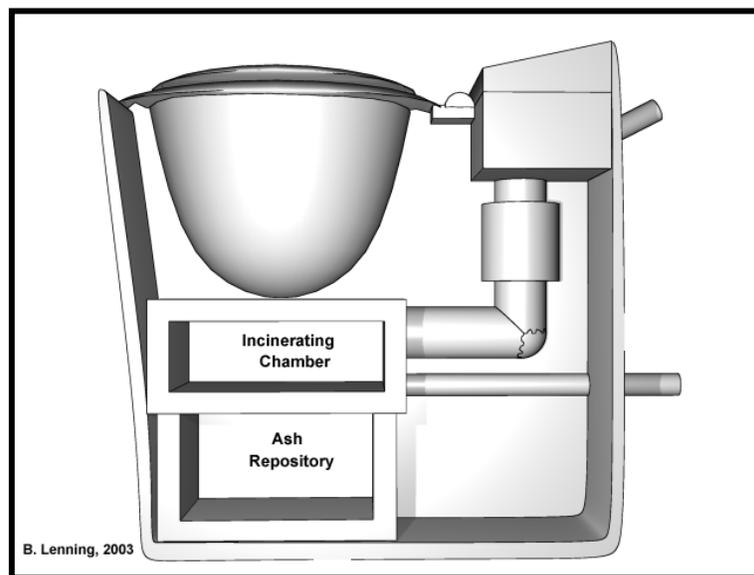
Following is information on two different classes of non-discharging toilets and on greywater systems. In some jurisdictions, plumbing codes may prohibit non-discharging toilets for some uses.

I. Incinerating toilet

a. **Description** – See **Figure 5**.

1. A “toilet” that reduces human excreta and urine to ash and vapor by incineration. This toilet only handles blackwater and is not designed for any water-carried sewage.
2. The process is fueled by natural gas or electricity.

**Figure 5. Schematic of typical incinerating toilet**



B. **Other pertinent information**

1. Careful consideration must be given to select the appropriate model and size for a specific application.
2. As this process only handles blackwater, a system providing treatment and dispersal for the greywater is necessary.
3. This blackwater handling process is located inside a residence, requiring extra considerations for the OWTS professional, especially those responsible for monitoring and maintenance.
4. Requires the use of a bowl liner and/or other methods specified by the manufacturer to keep the toilet bowl clean.
5. There are gases that must be properly ventilated.
6. Residual ash must be taken from the toilet and disposed of.
7. Operation of the toilet (i.e. use of a liner and activating the burning cycle) is

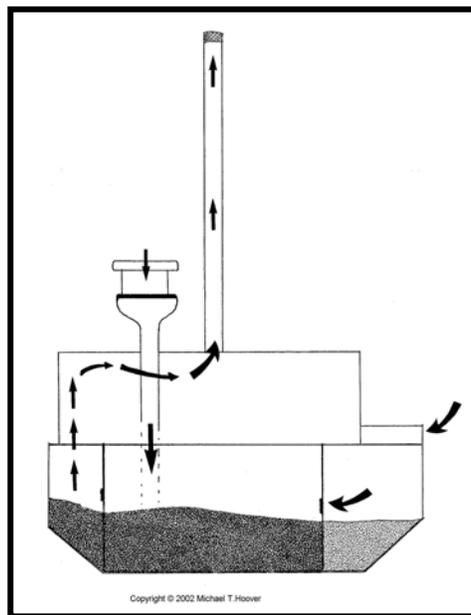
unfamiliar to the general public and, therefore, may not be appropriate for public access restrooms.

## II. Composting toilet

### A. **Description** – See **Figure 6**.

1. A toilet that receives human excreta and urine, and some carbonaceous kitchen wastes and transmits it to a composting chamber.
2. Depending on the size of the composting chamber, the material undergoes drying and varying degrees of decomposition.

**Figure 6. Schematic of typical composting toilet**



### B. **Other pertinent information**

1. Toilets may be large or small capacity units. Careful consideration must be given to select the appropriate model and size for a specific application. If larger units are to be used, they are usually installed as part of a building's construction. Retrofitting an existing structure with a larger unit can be difficult.
2. As this process only handles blackwater, a system providing treatment and dispersal for the greywater is necessary.
3. This blackwater handling process is located inside a residence, requiring extra considerations for the OWTS professional, especially those responsible for monitoring and maintenance.
4. Some of the units are relatively small and are self-contained. Others have big

- chambers under the toilet, requiring space in a basement or crawl space.
5. These units have been used extensively in many public and commercial recreational facilities. They have also been used in communities to minimize wasteful use of valuable potable water.
  6. May contain mechanical agitators, thermostats, humidistats, heaters and fans to assure the proper moisture content and temperature are maintained.
  7. Must be properly vented.
  8. Direct homeowner involvement in the operation, monitoring and maintenance of the toilet is required. This involvement includes monitoring moisture content, control of flies, periodic mixing of the composting material, and periodic removal and proper disposal of the composted material.

### III. Greywater systems

#### A. **Description**

1. May be a typical OWTS to handle just the greywater.
2. Greywater may go through one or more treatment processes so that the greywater can be used for one or more non-potable uses: irrigation, toilet flushing, and greenhouses. This allows the greywater to be reused as a resource.
3. Greywater may be collected in a holding tank, where permitted, and periodically pumped and hauled away to a site that can treat and dispose of it properly.

#### B. **Other pertinent information**

1. Data indicate that greywater contains significant concentrations of organic and inorganic material (whatever is poured down a sink or drain). Greywater also can contain fecal coliform concentrations as high as found in blackwater. Thus, greywater must be carefully and properly handled.
2. If a typical OWTS is used, it may be reduced in size since just the greywater is being treated. Alternatively, some jurisdictions may require a typical full size system.
3. When reductions in size have been permitted for an OWTS to handle greywater, there have been historical concerns that a non-discharging blackwater toilet will be replaced with a flush toilet.
4. When greywater is being treated for a later non-potable use (toilet flush water, landscape irrigation), there must be assurances that the treatment is being reliably provided. On-going monitoring and maintenance is critical. Effects of not meeting treatment standards include: 1) clogging of pipes, valves, and orifices by nutrients, algae, and solids, and 2) exposure of humans to pathogens in inadequately treated reuse water.

## Distribution Media Options In Pretreatment and Final Treatment/Dispersal Components

A number of soil based, or other media, pretreatment components, as well as final treatment and dispersal components, use material 1) to help distribute treated effluent to infiltrative surfaces or 2) to assist in underdraining media filters. This topic is discussed here because it is potentially a part of so many other components. It is also part of the selection process that the design and regulatory professionals must complete. This subsection will briefly examine the options available to perform these functions. All of them are generally available for drainfields and many of the pretreatment components to be discussed.

### I. Gravel or crushed rock

#### A. **Description**

1. Porous media used to accomplish the following purposes:
  - (1) Supporting the distribution pipe.
  - (2) Providing a media through which wastewater can flow from the pipe to the infiltrative surface.
  - (3) Providing temporary storage of peak wastewater flows until the wastewater can infiltrate into the soil.
  - (4) Dissipating energy the wastewater may have that could potentially erode the infiltrative surface.
  - (5) Supporting the sidewall and cover material over the excavation.
  - (6) NOTE: Gravel has not been documented to be a treatment media in this use. Therefore, providing wastewater treatment is not a purpose of gravel.
2. Typical sizes are from  $\frac{3}{4}$  to 2  $\frac{1}{2}$  inches.
3. Typically 6 or more inches are placed below the distribution pipe and 2 inches above.
4. Must be durable and resistant to slaking and dissolving.
5. May be used as cover material over the excavation, especially in some media filters.

#### B. **Other pertinent information**

1. This is the option that has been historically used.
2. Gravel or rock must be clean. It must be washed to remove fines, dust, silt and/or clay. In many areas finding suitably clean gravel or rock is problematic. Fines, dust and soil particles remaining in the washed gravel can accelerate soil clogging. Therefore, inspection of the gravel at a construction site is critical.
3. The gravel or rock should be properly graded and sorted. Gravel relatively uniform in size (there is typically a range of diameters permitted) is desirable to minimize soil clogging and root penetration and maximize temporary storage capacity.
4. When placing the gravel or rock in a trench or bed, it is typically dropped from a few feet above the trench or bed bottom. This can cause the gravel to become partially imbedded in the soil material and can compact the soil, especially soils with a finer texture. The moisture content of the soils will affect the impact dropping gravel may

- have on the infiltrative surface – too wet and there may be smearing and compaction, too dry and there may be displacement of fines/dust.
5. Machinery required to place the gravel should not contact the infiltrative surface to minimize compaction of the soils at the infiltrative surface, especially in finer textured, shallower soils.

## II. Gravelless technologies

A. **Description:** Technologies consisting of preformed structures or gravel substitute materials used to provide a void space for passage and storage of effluent and an interface with the exposed infiltrative surface.

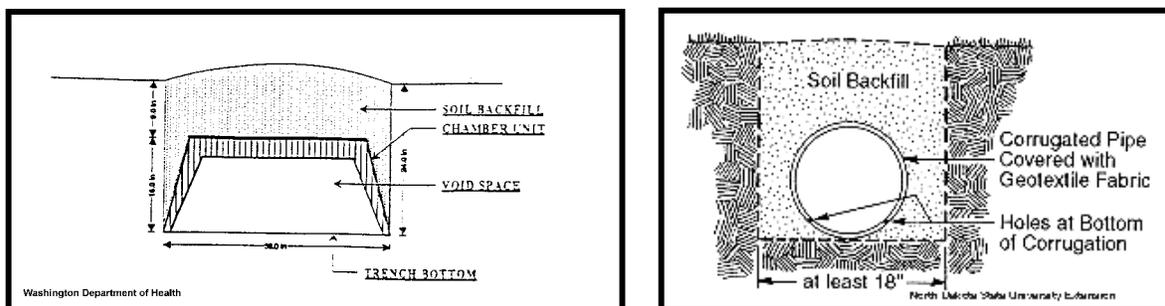
### B. **What is their function?**

1. The various gravelless options perform the same functions as gravel.
2. Some gravelless technologies may provide additional temporary storage capacity and/or minimize the introduction of fines, dust, etc. that frequently accompanies gravel.
3. To enhance the infiltrative capacity of the soil at the trench bottom by minimizing fines, embedding of gravel, and compaction.

### C. **What are important considerations?**

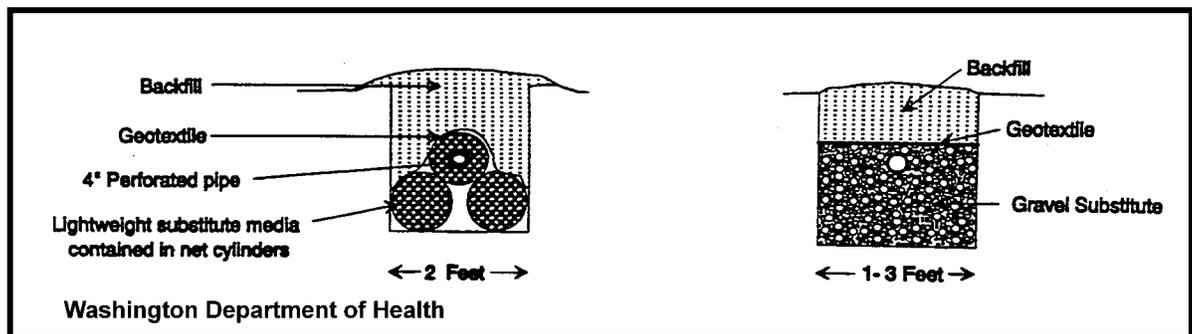
1. They are used to avoid the potential limitations posed by using gravel (concerns about clean gravel, compaction when placing gravel).
2. They are also used where gravel, especially clean gravel, is not readily available or is costly.
3. If the system is located in a site that creates difficulty in getting heavy machinery to deliver the gravel (for example steep slope or isolated areas, such as an island), the use of one of these gravelless technologies may be indicated.
4. There are a variety of different gravelless technologies, each with its typical site, soil, application, and design requirements.
  - a. Aggregate-free technologies. See **figure 7** for examples.
    - (1) Open-bottom chambers.

**Figure 7. Different types of aggregate-free technologies**



- (2) Gravelless pipe – a large diameter pipe wrapped in a synthetic geotextile
  - (3) Plastic forms or multiple 4-inch pipe bound together
- b. Non-gravel porous media (also called gravel substitute or replacement). See **figure 8** for examples.
- (1) Synthetic expanded polystyrene foam.
  - (2) Ground up rubber tires or concrete

**Figure 8. Different types of non-gravel porous media technologies**



5. Because of the light weight of most gravelless products, many of them can be placed by hand, limiting potential damage to the system site associated with machinery. Avoid or minimize walking on the infiltrative surface when placing the media to minimize damaging the infiltrative surface.
6. Some jurisdictions permit reductions in required infiltrative surface when such technologies are used.
7. They typically can be used wherever gravel is used as part of the distribution network or underdrain of pretreatment and final treatment/dispersal components.
8. Once installed, some gravelless technologies or models of a specific technology are sensitive to traffic of heavy equipment or vehicles over the trenches.

### Available components

The rest of this document provides information on the various components available from which the design and regulatory professionals can choose to make up the system for a given site. As noted in **table 2**, the components used in on-site wastewater industry are categorized according to function. The categories include:

- **Collection and transmission components** – a component in cluster or bigger systems to collect the wastewater from the homes and other sources and transmit it to the treatment and dispersal processes.

- **Pretreatment components** – a component designed to remove contaminants from the wastewater before it either flows to another pretreatment component or is dispersed into the receiving environment.
- **Application/Distribution components** – a component that collects the effluent from a pretreatment process, transmits the effluent to the next downstream component, and applies/distributes it to the infiltrative surface of the downstream pretreatment or final treatment/dispersal component.
- **Final treatment/dispersal component** – a component that assimilates the treated effluent in to the final receiving environment, usually providing additional treatment in the process.

**Table 2** summarizes the options discussed in this module. At the beginning of each primary section is a table that gives more detail on the options discussed in that section. There are other options used in different locations in North America that generally fall into one of the categories given in this module. There are still other options that are not yet sufficiently proven to include in this document. As more data and experience are gathered on them, they will be included in future iterations of this module. Some of the options discussed in this module are given different terms or used in different ways in places.

**Table 2. List of available components**

Category of Component	General Component Options	Page
Collection & transmission components	<ul style="list-style-type: none"> <li>❖ Solids handling sewers</li> <li>❖ Effluent sewers</li> <li>❖ Holding tank</li> </ul>	18
Pretreatment components	<ul style="list-style-type: none"> <li>❖ Septic tank</li> <li>❖ Grease interceptor</li> <li>❖ Aerobic treatment unit (ATU)</li> <li>❖ Media filters</li> <li>❖ Constructed wetlands</li> <li>❖ Disinfection</li> <li>❖ Other</li> </ul>	25
Application/Distribution components	<ul style="list-style-type: none"> <li>❖ Gravity-flow distribution</li> <li>❖ Dosed-flow distribution</li> </ul>	56
Final treatment/dispersal components	<ul style="list-style-type: none"> <li>❖ Subsurface dispersal</li> <li>❖ Atmospheric dispersal</li> <li>❖ Surface dispersal</li> </ul>	79

## COLLECTION & TRANSMISSION COMPONENTS

Component	Page #
❖ Solids handling sewers	18
• Traditional gravity sewer	18
• Pressure sewer with grinder pumps	19
• Vacuum sewer	20
❖ Effluent sewers	21
• Septic tank effluent gravity sewer (STEG)	21
• Septic tank effluent pump sewer (STEP)	22
❖ Holding tank	23

**Component purpose:** For cluster or small community systems, wastewater must be collected and transmitted to the pretreatment and dispersal components. Thus, the purpose of these components is to collect the wastewater from the building or other facility where the wastewater is generated and to transmit it to the cluster or small community OWTS.

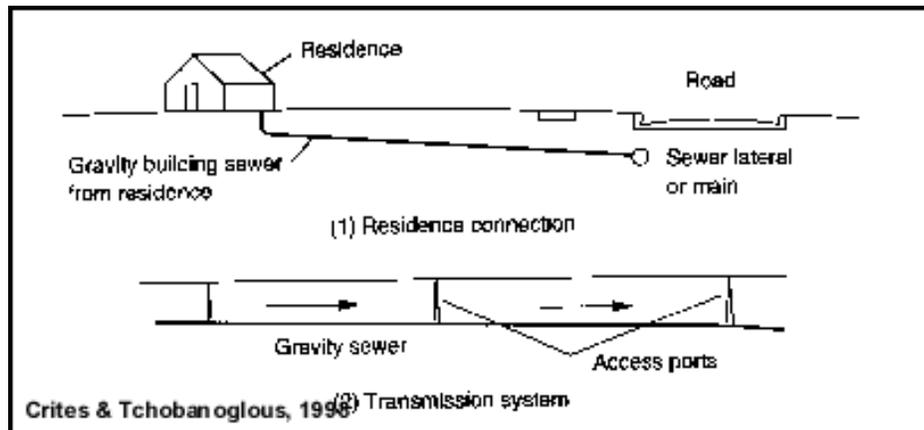
There are several options available, some that handle the total wastewater flow, and others that handle primarily the liquid fraction of the wastewater. Frequently, the options are used in combination to better serve a community.

There are a wide variety of resources available that discuss these collection and transmission components in detail. USEPA has a publication, Manual: Alternative Wastewater Collection Systems, EPA 625/1-91/024, produced in 1991. For this course, just general information will be presented on the options available.

### Different Options:

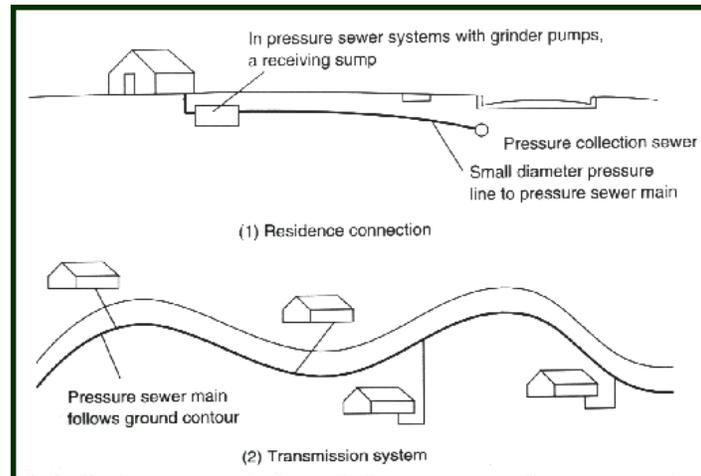
- I. Solids handling sewers – collect and transmit all the wastewater, both blackwater and greywater.
  - A. Traditional gravity sewer – See **figure 8**.
    1. Transmits the entire wastewater stream, both liquid and solids. Some older systems may be combined gravity sewers, conveying both sewage and stormwater.
    2. Minimum diameter is 6 to 8 inches. Diameters of big trunk and interceptors are routinely several feet or more in diameter.

**Figure 8. Schematic of traditional gravity sewer**



3. Must maintain a minimum slope so all the wastewater contents flow. Because of this, construction can get quite deep and expensive. Where gravity flow is not possible, for example when a house or group of houses is at an elevation lower than the gravity sewer line, lift or pump stations are constructed.
  4. Periodic access ports (manholes) provide access to the collection and transmission lines.
  5. Usually there are problems with inflow and infiltration. During wet weather times there are concerns for infiltration. During dry weather times, there may be concerns for exfiltration.
  6. Must be designed to maintain minimum velocities so solids don't get hung up.
  7. Typically requires denser development to justify the high cost for the sewer.
  8. Because the entire wastewater stream flows through the pipe, contents such as fats, oils and greases, and solids can cause problems by clogging the pipe.
- B. Pressure sewer with grinder pumps – See **figure 9**.
1. Each house or small group of houses has a small pump basin containing a grinder pump.
  2. The grinder pump grinds up or macerates the sewage before pumping it into the collection and transmission sewer.
  3. Because the liquid and solids are turned into slurry by the grinder pump, they can be transmitted through small diameter pipe under pressure.
  4. Grinder pumps tend to cost more initially and require more maintenance than effluent pumps used in some effluent sewers, which are discussed later in this section.
  5. The pump basin is typically quite small, usually around 30 gallons capacity for a single home grinder pump station.

**Figure 9. Schematic of typical pressure sewer using grinder pumps**



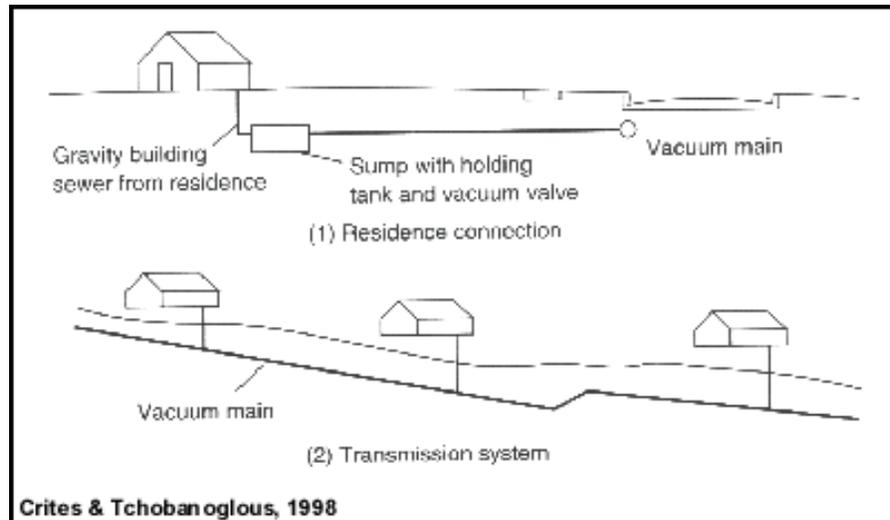
**Crites & Tchobanoglous, 1998**

6. Because they transmit the entire wastewater flow, the oil and grease content in the wastewater can create problems by plugging the pipes.
7. Because the grinder pumps comminute the sewage into small size particles, the particles can be difficult to remove if traditionally sized septic tanks are the first step in the pretreatment process.
8. The grinder pumps pressurize the collection and transmission mainline.
9. Because a ground up slurry is being transmitted, the collection and transmission line is smaller diameter (minimum of 2 inches) than a conventional gravity sewer and can follow the topography, either being insulated or installed just below the frost level in cold climate areas.
10. Infiltration and exfiltration should not be problems as the sewer is designed and installed to be watertight.
11. The grinder pumps may be time-dosed to reduce the size of the force main.
12. Solids handling pumps, capable of passing 3-inch solids, have been used in lieu of grinder pumps, to pump the entire waste stream through small diameter sewers. There may be an increased risk due to solids plugging the lines.

C. Vacuum sewer – See **figure 10**.

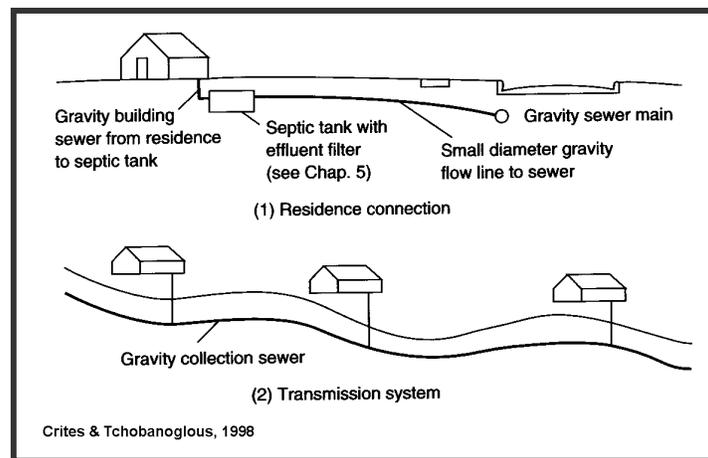
1. Sewage from one or more residences or other structures flows by gravity into a small sump.
2. The sump is connected to a main vacuum line, but is isolated from the vacuum line by a pneumatic pressure controlled vacuum valve. A negative pressure (typically 15 to 20 inches of mercury) is maintained in the main vacuum line by a central vacuum station.

**Figure 10. Schematic of typical vacuum sewer**



3. After a predetermined volume of wastewater has entered the sump, the valve opens. The pressure differential between the sump and the main vacuum line results in the wastewater being pulled into the main vacuum line and down to the central vacuum station. Before closing, a quantity of air enters the sump, so the sump does not remain under a vacuum.
  4. As the wastewater moves down the main vacuum line, the solids are broken up, resulting in slurry reaching the receiving tank at the central vacuum station. This is enhanced on level or upgrade slopes where the vacuum line has a saw tooth configuration, containing periodic upturns, as noted in **figure 10**. From there, the wastewater is pumped to the treatment process.
  5. Vacuum sewers can flow downhill or uphill. The maximum lift expected is between 15 and 20 feet.
  6. As with other alternative collection and transmission components, vacuum sewers are designed and constructed to be watertight. Thus, exfiltration should not be a problem.
  7. Historically, this type of collection system has not functioned well continuously. These problems appear to have been resolved in the last decade or so.
- II. Effluent sewers – collect and transmit only septic tank effluent. Because they don't carry solids, they typically have smaller diameters than solids handling sewers.
- A. Septic tank effluent gravity (STEG) – See **figure 11**.
1. Each residence or structure or group of structures has a septic tank, which must be watertight. Each septic tank should have an effluent filter/screen and an access riser.

**Figure 11. Schematic of typical STEG sewer**

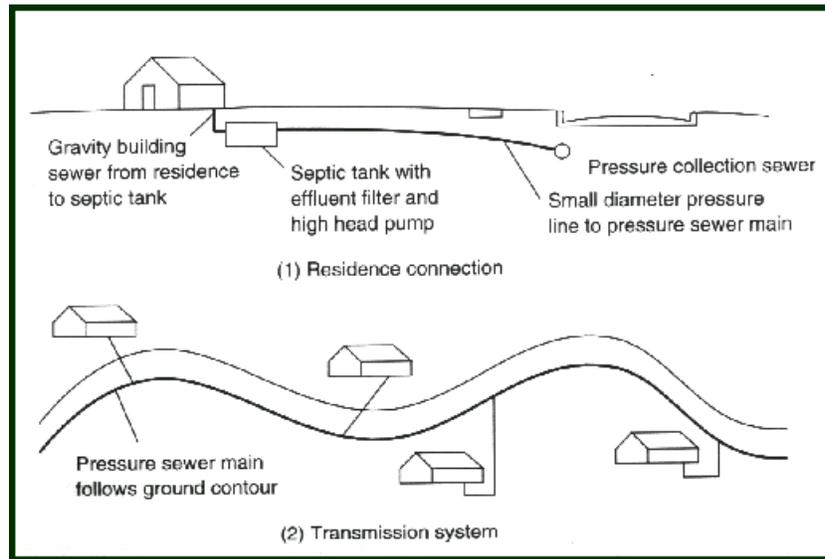


2. Effluent flows from the septic tank via a 1 to 2 inch plastic pipe into a small diameter (typically 2 to 8 inches) gravity flow collection and transmission mainline.
3. Because only septic tank effluent is being carried, the mainline can be placed at somewhat variable grades. This helps minimize the depth of construction.
4. Infiltration and exfiltration should not be problems as the sewer is designed and installed to be watertight.
5. On-going monitoring & maintenance program must include periodic pumping of the septic tanks.

**B. Septic tank effluent pump (STEP) – See **figure 12**.**

1. Each house or small group of houses has a septic tank, which must be watertight.
2. Each septic tank typically has an effluent pump (frequently it is a high head pump) to discharge septic tank effluent into a pressurized discharge line (typically 1 to 1 ½ inches diameter) which discharges into the pressure sewer.
3. It is desirable to use an effluent filter/screen in the septic tank to remove more solids prior to pumping into the pressure sewer.
4. The effluent pumps pressurize the collection and transmission mainline.
5. Because it transmits only septic tank effluent, the collection and transmission line is smaller diameter (minimum of 2 inches) and can follow the topography, either being insulated or installed just below the frost level in cold climate areas.
6. Infiltration and exfiltration should not be problems as the sewer is designed and installed to be watertight.
7. The pumps may be time-dosed to reduce the size of the force main.
8. On-going monitoring & maintenance program must include periodic pumping of the septic tanks.

**Figure 12. Schematic of typical STEP sewer**



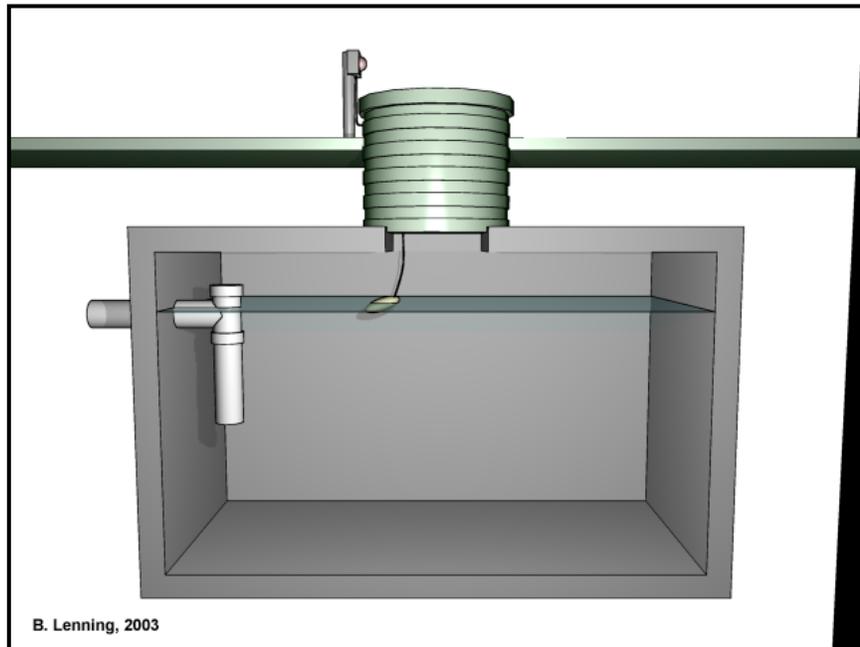
Crites & Tchobanoglous, 1998

III. Holding tank - See **figure 13**.

- A. A tank that receives wastewater from a residence or other structure and temporarily stores it until it is pumped out and transmitted to some receiving station.
- B. The wastewater must be removed regularly. The frequency of pumping is dependent on the size of the tank and the wastewater quantities generated. The pumped sewage must be treated and dispersed of by some means. This can include an OWTS or a sewage treatment plant. The holding tank is the collection component and the pump truck serves as the “transmission” component.
- C. While similar to septic tanks, they have no outlet.
- D. They must be watertight.
- E. Should contain audio and visual alarms so it is apparent when pumping is needed.
- F. Can collect the entire wastewater flow, just the blackwater, or just the greywater, depending on the sensitivities and other conditions of a site.
- G. Best used when the soil and site conditions do not permit the installation of other OWTS and sewer is not available. However, pumping gets expensive so many jurisdictions will not permit them for full-time, residential situations.
- H. The more full-time the generation of wastewater is and/or the greater the distance to the OWTS or sewage treatment plant (or other septage/biosolids handling process), the less desirable the use of a holding tank becomes.
- I. A holding tank should only be permitted where a proper monitoring and maintenance program exists. This includes having a regulatory agency that is adequately staffed to

- provide the needed oversight and inspections.
- J. Holding tanks have been used in phased developments where the community OWTS or public sewer and treatment plant is already permitted and under construction, but the number of homes currently occupied is too few to justify startup of the treatment works.

**Figure 13. Typical holding tank**



## PRETREATMENT COMPONENTS

Component	Page #
❖ Septic tank	26
❖ Grease interceptor	34
❖ Aerobic treatment unit (ATU)	36
❖ Media filters	41
❖ Constructed wetlands	47
❖ Disinfection	49
❖ Other – Lagoons, Anaerobic upflow filter	52

**Component Purpose:** The primary purpose of a pretreatment component is to remove contaminants from the wastewater before it either 1) flows to another pretreatment component, or 2) is dispersed into the receiving environment.

Traditionally, treatment was designated as primary, secondary, or tertiary, representing the expected effluent quality. Primary treatment generally refers to a separation process for removal of settleable or floatable solids, as typically occurs in a septic tank. Secondary treatment generally refers to removal of organic material and an associated reduction in biochemical oxygen demand and total suspended solids. Good examples of technologies that typically provide secondary treatment are many of the aerobic treatment units and media filters. Historically, tertiary treatment has generally referred to the removal of nutrients. Currently, the term is used to refer to the removal of parameters other than those removed in primary or secondary treatment processes or disinfection. A variety of technologies are combined to obtain the desired effluent quality.

The treatment processes generally use microbes for contaminant removal. The type of microbe that will be prevalent in any treatment process is related to the presence or absence of free oxygen. Thus, one of the ways we categorize microbes is by the availability of free oxygen.

- (i) **Anaerobic** microbes can't survive with free oxygen in the system. Treatment by these organisms is relatively slow and inefficient. The final products include smelly gases and acids and are not stable, requiring further treatment before discharge

to a receiving environment.

- (ii) **Aerobic** microorganisms require free oxygen in the system. Aerobic treatment or decomposition is more efficient and faster, leading to final treatment products that are less objectionable than with anaerobic treatment. Aerobic microbes are good at reducing the organic matter (BOD) in wastewater.
- (iii) An extra category of microorganisms, described as **facultative**, exists where the system fluctuates between the presence and absence of free oxygen.

Finally, it is important to understand that anaerobic and aerobic processes are compatible. The primary working microbes in many components are facultative and have the ability to work in either aerobic or anaerobic environments. Typical complete treatment processes integrate both aerobic and anaerobic phases into the system. Both suspended and attached growth aerobic processes are highly effective and efficient at treating anaerobic primary treated effluents. Also, one of the methods of reducing total nitrogen in a wastewater stream is to direct effluent that has been aerobically treated through an anoxic or anaerobic environment so conversion to atmospheric nitrogen gas occurs. Thus, it is not unusual to see more than one pretreatment component in a system, both aerobic and anaerobic, depending on what contaminants must be removed prior to discharge to the final treatment and dispersal component.

## Component Options:

### I. Septic tank

#### A. What is it?

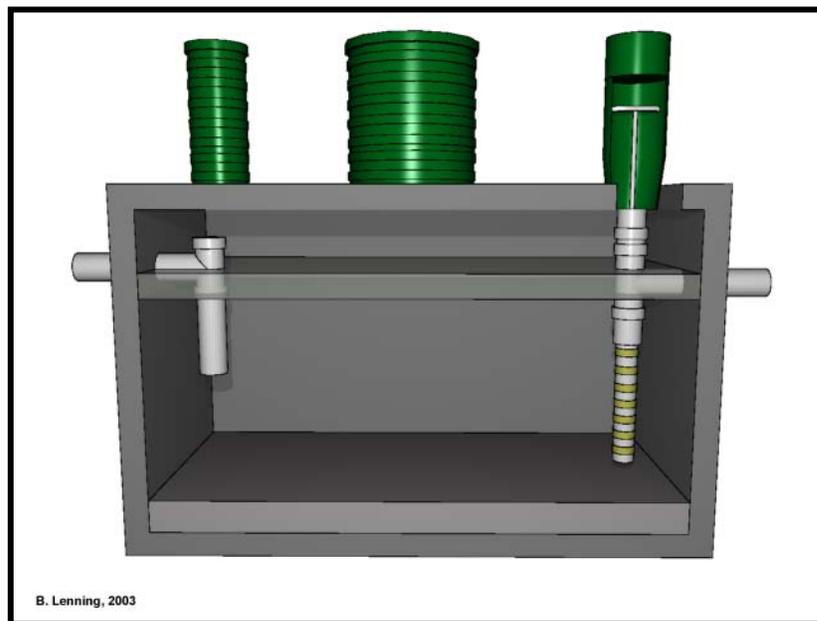
1. A pretreatment component consisting of a typically buried tank designed and constructed to receive and partially treat raw wastewater from the source where it originated.
2. The pretreatment reduces the quantity of solids contained in the effluent, thereby protecting downstream components from plugging.

#### B. What does it consist of?

1. A one or two compartment tank made of concrete, fiberglass or plastic (polyethylene, ABS). See **Figure 14** and **Figure 15**. Some locations use a metal tank, but most locations prohibit the use of metal tanks because of their corrosion. In a two-compartment tank, the first compartment has typically  $\frac{1}{2}$  to  $\frac{2}{3}$  of the entire tank volume.

2. Tanks serving single-family residences are typically at least 1000 to 1500 gallons. These tanks are typically prefabricated and delivered to a site. Tanks serving larger facilities are usually: 1) constructed in place, 2) manufactured and delivered in two pieces (top and bottom halves), or constructed of a lighter material such as fiberglass and delivered in one piece to the site.
3. The tank may be rectangular, oval or cylindrical in shape.
4. The tank typically has an inlet baffle or tee that is several inches higher than the outlet to assure a flow gradient through the tank. The purpose of the inlet is to 1) direct the flow downward so as not to disturb the scum and 2) dissipate the energy of the flow to prevent turbulence and the resulting disturbance of solids, as well as minimizing short-circuiting. Some states do not require an inlet baffle or tee because of concerns that it may plug.
5. The tank has an outlet baffle or tee extending into the liquid depth to draw the effluent from the clearest portion of the tank and to retain the scum in the tank.
6. Most experts tend to agree that a two-compartment septic tank will remove greater quantities of solids than a single compartment tank.

**Figure 14. Typical one-compartment septic tank**

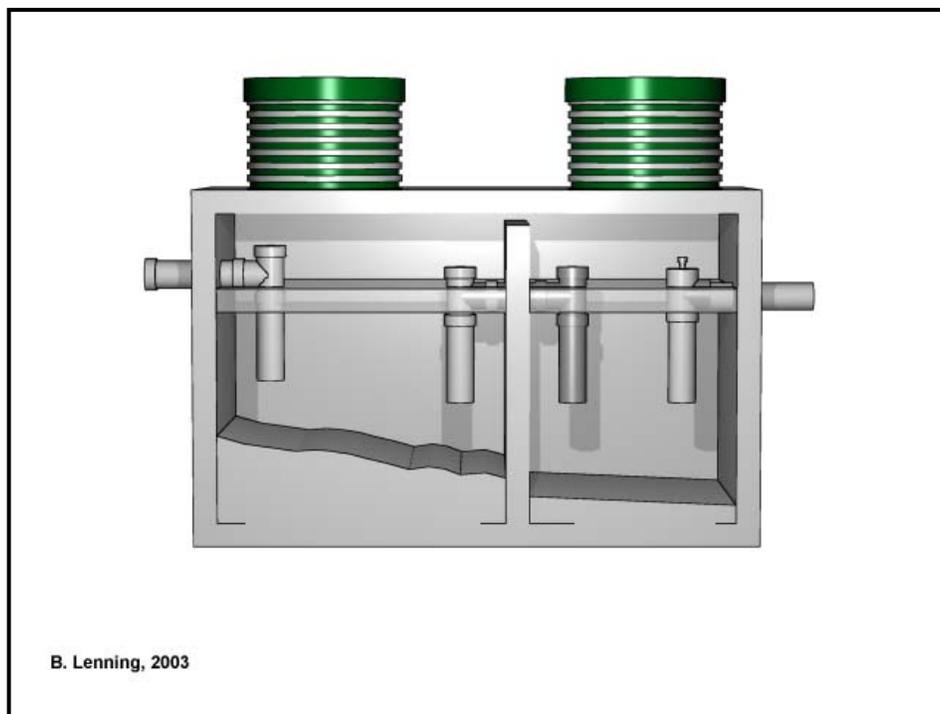


**C. How does it work?**

1. Raw wastewater flows into the tank and in most cases is diverted downward.
2. The tank separates and retains settleable and floatable solids suspended in the raw wastewater in as quiescent environment as possible.

3. The settleable solids fall to the bottom and form a **sludge** layer. Some of the sludge will float to the top as gases produced in the sludge (product of anaerobic digestion) carry solids with the bubbles.
4. The lighter materials, including grease, float to the top and form a **scum** layer.
5. Solids are retained in the tank for at least 48 hours where facultative and anaerobic organisms break down some of the wastes to dissolved fatty acids and gases.
6. Gases generated during this treatment process are usually vented back through the building's plumbing stack vent.
7. The environment within a septic tank is extremely hazardous due to a lack of oxygen and potentially toxic and explosive gases, such as hydrogen sulfide and methane.
8. Total solids are reduced and a relatively clear effluent is discharged to the next downstream component.

**Figure 15. Typical two-compartment septic tank**



9. The tank's design also allows it to attenuate influent surges so the effluent discharges over a longer period of time, minimizing the potential for solids carryover.

**D. Why and where is it used?**

1. A septic tank is the most commonly used pretreatment unit for OWTS.
2. Can be used alone or in combination with almost any other treatment and or dispersal/discharge component, i.e., it can be used as part of almost any OWTS.

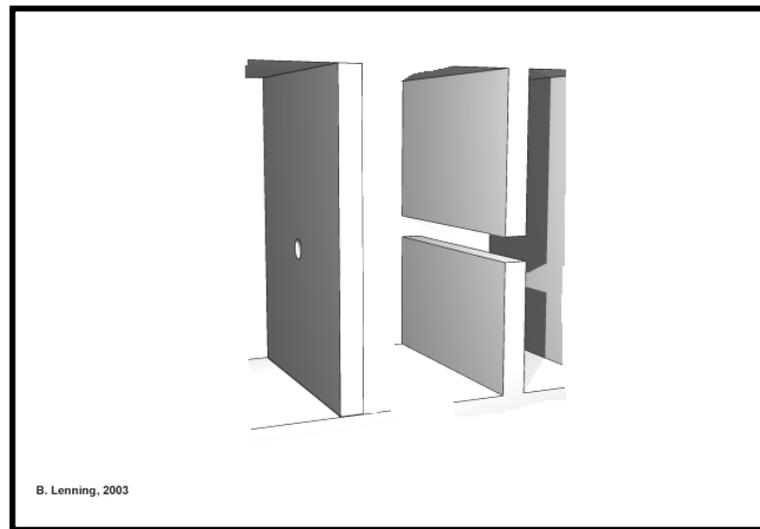
3. In many cases septic tanks are the first and only pretreatment step used prior to the final treatment/dispersal component.
4. Provides primary treatment at a reasonable cost.
5. Doesn't require an energy source.
6. It doesn't take up much space.
7. It is simple and inexpensive, compared to most other pretreatment options.
8. A properly operating septic tank is expected to produce effluent with the following characteristics:
  - a. 30-50% reduction in BOD.
  - b. 60-80% reduction of settleable and suspended solids.
  - c. Some removal of pathogens, though millions of microorganisms still typically exist in 100 milliliters of effluent.
  - d. 10-30% reduction in total nitrogen, with conversion of some organic nitrogen to ammonia.

**E. Design considerations**

1. While some jurisdictions allow single compartment septic tanks, others require a two-compartment septic tank, with the first or primary compartment typically consisting of 1/2 to 2/3 of the total liquid volume.
2. American Society for Testing and Materials (ASTM) C1227 98 (Standard Specification for Precast Concrete Septic Tanks), International Association of Plumbing and Mechanical Officials (IAPMO) PS 1-93 (Material and Property Standard for Prefabricated Septic Tanks), and Canadian Standards Association (CAN/CSA) B66-M90 (Prefabricated Septic Tanks and Sewage Holding Tanks) are standards that have been developed for septic tanks. The National Pre-Cast Concrete Association (NPCA) offers a "best practices manual" and video.
3. The tanks must be durable and watertight. Leakage out of the tank (exfiltration) may cause contamination of groundwater. Infiltration of groundwater into the tank may inhibit the functioning of the tank and hydraulically overload the downstream components. The ASTM, IAPMO, and CAN/CSA standards, as well as the NPCA manual, contain instructions for conducting tests for watertightness.
  - a. Cast in place, flexible inlet and outlets can help maintain watertightness. ASTM C 923-98 (Standard Specification for Resilient Connectors between Reinforced Concrete Manhole Structures, Pipes, and Laterals) is a standard for such devices.
  - b. Any seams or joints should also be watertight. ASTM C 990-96 (Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections using Preformed Flexible Joint Sealants) is a standard that exists for materials to be used for such purposes.
4. Inlet and outlet baffles are necessary to help the tank achieve its function. These baffles should be made of non-corrodible material. Concrete baffles tend to dissolve above the liquid level line due to the corrosive atmosphere in the tank. As mentioned,

- several states don't require inlet baffles or tees because of concerns about plugging.
5. The volume should be sufficient to maintain at least a 48 hour hydraulic retention time. To accomplish this, many jurisdictions have increased the minimum volume of the tank to serve a three-bedroom residence to 1,000 gallons.
  6. For multiple compartment tanks, there are a variety of methodologies used for flow to occur between the compartments. See **Figure 15** and **Figure 16** for examples.
  7. Increasingly tanks are being installed with risers to final grade to allow easy access for monitoring and maintenance activities. These should be watertight and properly constructed to prevent unauthorized or accidental entry.
  8. Many jurisdictions require gas deflection mechanisms below the opening in the outlet baffle/tee to deflect solids away from the outlet.

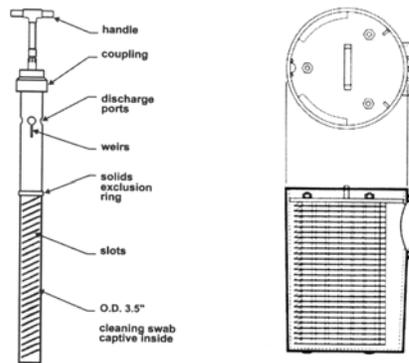
**Figure 16. Optional methods used for intercompartmental flow**



9. Increasingly, a device called an **effluent screen (filter)** is being placed in the outlet tee or being used in lieu of the outlet baffle or tee; or being placed in a stand-alone unit following the tank. See **Figure 17** for an example.
  - a. The purpose of the effluent screen is to help keep more solids in the tank. It serves as the “circuit breaker” for the tank.
  - b. Effluent screens are made of mesh, slotted screens, stacked plates made of plastic, or other material such as brush or fibrous material.
  - c. Effluent screens are designed to not permit solids greater than 1/8 inch in diameter to pass, though some are designed to remove even smaller particles.
  - d. Some of these devices also have design features that also help the tank mitigate flow surges.

- e. Hydraulic and/or biological overloading, as well as failure to service the tank and filter when needed, will cause the screen to plug. Floats and alarms can be added to detect when the liquid level is rising due to the screen being plugged. The use of a float and alarm is highly recommended.

**Figure 17. Two examples of many available outlet filters/screens**



**USEPA Manual, 2002**

- f. The effluent screen needs to be carefully cleaned periodically. Cleaning a screen located in the second compartment of a two-compartment tank should be needed at a lesser frequency than for a screen located in a single compartment tank.  
When cleaning:
  - (1) Care should be taken to minimize the amount of solids that can flow out the outlet when the screen is withdrawn. Some filters or screens have features that help minimize this. If the scum layer is above the top of the filter, the liquid level must be pumped down before the screen is withdrawn. This will keep scum from exiting the tank.
  - (2) Solids should be carefully washed from the screen back into the tank, preferably into the access opening on the inlet side of the tank.
- g. While some proponents claim that microorganisms establish residency on some of the filters providing biological filtration and additional BOD reduction, their primary function has been the retention of solids.
- h. Effluent screen design should accentuate the amount of filter surface area to maximize solids removal and minimize cleaning frequency.
- i. In lieu of an effluent screen, some locations still use gas deflection mechanisms to deflect rising gasses produced in the sludge layer from carrying solids up the outlet tee or baffle.

**F. Installation considerations**

1. Must be installed level.
2. Proper orientation of the tank inlet and outlet as well as proper alignment of the top and bottom tank sections if two-piece tanks are being used must be assured.
3. Must be located where it can be easily accessed for pumping
4. Must be located away from drainage swales or depressions where surface water can collect.
5. Should rest on a level, granular base capable of bearing the weight of the tank, its contents, and the soils on top of the tank.
6. Inlets and outlets should be sealed to prevent exfiltration of wastewater and/or infiltration of surface or ground water. These pipe penetrations should be made of flexible resilient butyl rubber boots that are cast into the tank and allow a watertight seal around the pipe. As mentioned, ASTM C 923-98 provides a standard for such devices.
7. The pipes entering and exiting the tank should not only be watertight and structurally sound, but also be firmly supported by the soil preceding and following the tank to prevent shifting and movement of the pipe and breaking the inlet and outlet seals.
8. Manhole covers should be properly sealed to prevent infiltration of ground or surface waters through the manholes, yet be removable to allow access for inspection and maintenance.
9. If risers are used, both the lid and the riser-tank connection should be durable, and watertight. The lid should also be locked or secured in such a way to make access difficult for anyone other than someone responsible for checking the tank.
10. A field watertightness test is increasingly being required by local and state jurisdictions. As mentioned, ASTM, IAPMO, and CAN/CSA standards contain instructions for possible testing.
11. Field testing methods for determining concrete strength, such as a Schmidt rebound hammer and a Windsor probe test, may be employed to assure structural integrity of the tank.

**G. Monitoring & maintenance considerations**

1. Routine inspections should be made to:
  - a. Observe sludge and scum accumulations, especially at the outlet end of the tanks.
  - b. Check for structural soundness and watertightness.
  - c. Insure that baffles, tees, and/or filters are in proper position and properly secured to the tank.
  - d. Insure that inlets, outlets, access risers and the lids are in good condition and properly sealed or protected.
  - e. Assess whether the tank is functioning properly - odor, effluent characteristics (temperature, pH, D.O., clarity), and proper stratification of scum, sludge and clear zone.
  - f. Assess past and present water levels.

2. Devices can be made or commercially available products can be used to make these measurements. Also, sensors are commercially available to help monitor sludge, grease, and scum levels in the tank on an on-going basis.
3. At some point the tank should be pumped. The recommendations for when pumping should occur differ considerably and include:
  - a. When the distance between the bottom of the outlet to the bottom of the scum or top of the sludge is a set distance.
  - b. When sludge and scum accumulations exceed 30 percent of the tank's liquid volume.
  - c. When the volume of the "clarified" zone between the scum and sludge is less than one day's design flow.
  - d. At some set, defined period of time, for example every three years. If OWTS are properly used and sized properly, this option will produce excess septage/biosolids that must be handled and increase on-going monitoring and maintenance costs unnecessarily.
4. If a tank has been pumped, a more in-depth inspection of the tank's structural integrity can be performed. Also, any backflow from the next downstream component indicates problems.
5. When performing these inspections or pumping the tank, never enter the tank. If the tank must be entered after pumping to repair a baffle or crack, appropriate protective confined-space measures must be taken.
6. Appropriate protective gear should be worn when performing inspection or maintenance activities on a septic tank or any of its subcomponents, including outlet filters/screens because of potential exposures to pathogens and/or any hazardous chemicals that may be in the sewage.
7. Both chambers of a 2-compartment tank should be pumped out whenever a tank is serviced. It is not necessary to leave any material in the tank to help "seed" the tank so it starts functioning more quickly after pumping.

#### H. Other pertinent information

1. The septage pumped from a tank must be properly handled.
2. Access is needed to assure proper inspections can be done. The diameter of the access openings needs to be adequate so monitoring, and maintenance activities can properly occur.
3. System owners may experience an increase in odors from the roof vents after having the tank pumped out. This usually subsides after the scum layer in the tank has been re-established. Odor control devices, which use activated carbon to remove odors, can be retrofitted on vent stacks to help prevent this.
4. No independent studies have shown that septic tank additives provide any benefit to the septic system. Their use is neither recommended nor necessary. Rather, practicing water conservation, avoiding materials that may be harmful to the system,

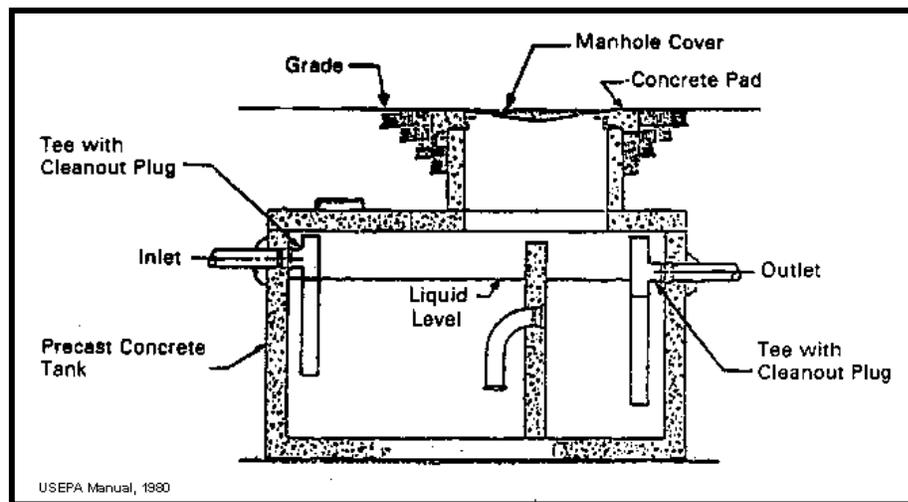
and implementing an on-going monitoring and maintenance program should be stressed.

## II. Grease interceptor

### A. **Description**

1. A component used to remove grease and oils from the wastewater stream prior to further pretreatment so the downstream components don't become plugged with grease and oils. They are designed to handle flows only from fixtures where fats, oils and/or greases are generated.
2. Consists either of;
  - a. A tank (sometimes just a septic tank, but hopefully with some modifications to help retain greases and oils), which is called a grease interceptor (also called a grease trap). See **figure 18**. This purpose of this tank is to provide time for the wastewater to cool and for fats, oils and greases to float to the top.

**Figure 18. Typical grease interceptor/trap**

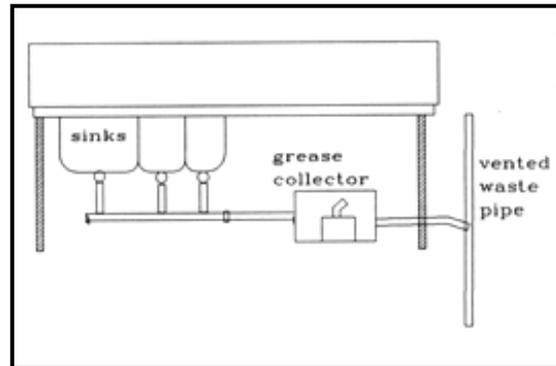


- b. Some type of commercial grease/oil separator. See **figure 19** for an example of a commercially available grease/oil separator.

### B. **Other pertinent information**

1. Grease trap
  - a. Typically consists of flotation chambers with no mechanical parts where fats, oil and grease floats to the water's surface in the tank and are retained. The remaining liquid is then discharged to the next downstream component.

**Figure 19. Typical commercial grease/oil separator**



Courtesy of Big Dipper Thermaco, Inc.

- b. They are rarely used for individual homes, but for treating wastewater from sources expected to contain greases and oils, usually commercial kitchens. Such sources include restaurants, schools, institutions, cafeterias, convenience stores, and gas stations with food service facilities.
- c. Wastewater flows going to grease interceptors should not contain blackwater and other flows that typically do not include significant oils and greases.
- d. Wastewater temperature, solids concentrations, inlet conditions, retention time, nature of the grease and oils, and maintenance practices can affect the performance.
- e. Grease traps were designed initially for animal fats (lard) that are semisolid at normal room temperatures. Today, many liquid vegetable oils are used, which are liquid at normal room temperature. Grease interceptors have more difficulty removing these. Wastes that include degreasers and emulsifiers also affect the coagulation of greases and oils.
- f. The closer the grease interceptor is to the source, the warmer the temperature of the wastewater entering the tank may be. This may inhibit the floatation of fats, oils and greases and the ability of the interceptor to retain them. Likewise, any surges or turbulence in the interceptor may result in fats, oils and greases being discharged from the interceptor.
- g. As can be seen in **figure 18**, the inlets and outlets of a grease interceptor extend deeper than with a normal septic tank. This is to allow more storage volume for the greases and oils.
- h. Volumes for grease interceptors usually vary from 1 to 3 times the average daily flow of the facility, with a minimum recommended volume of 1500 gallons.
- i. IAPMO PS-95, Material and Property Standard for Grease Interceptors and Clarifiers, is an existing standard for grease interceptors.

2. Grease/oil separators
  - a. Typically these consist of small chambers that are plumbed into plumbing fixtures where grease and oils are found (kitchen sinks, dishwashers, etc.).
  - b. Historically, there has been a problem with these mechanisms functioning properly. Much of this may be due to lack of retention time because of their small volumes in combination with the high temperatures found in the waste stream and periodic flow surges.
3. Grease interceptors require periodic maintenance. Sensors are commercially available to help monitor sludge, grease, and scum levels in the tank. Discharge from these components may remain in its own stream or may be combined with flows from the rest of the facility, as indicated in **figure 3**.
4. Effluent screens made primarily to help interceptors retain fats, oils and greases are commercially available. These are high maintenance devices that need frequent servicing to prevent blockage of wastewater flows.

### III. Aerobic treatment unit (ATU)

#### A. **What is it?**

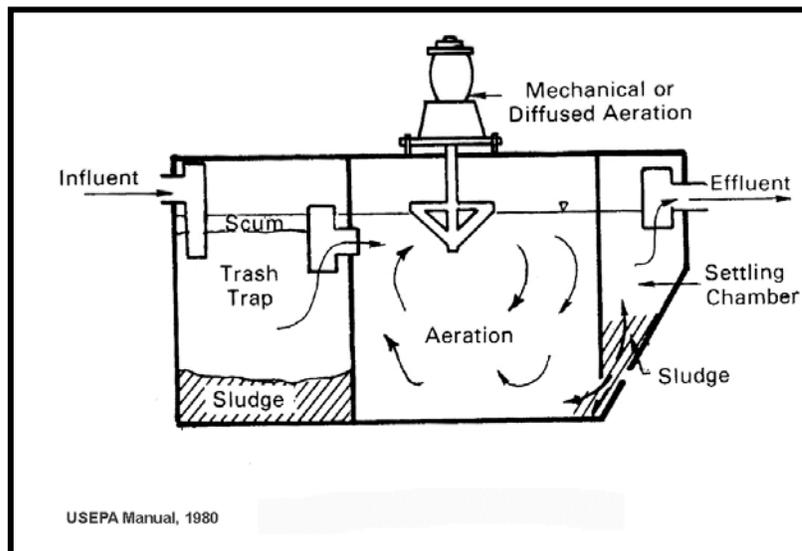
1. Mechanisms typically used in lieu of a septic tank or in series with a septic or trash tank, though some employ an aeration device inserted into a regular septic tank.
2. Provides treatment of wastewater using aerobic decomposition processes which occur in a saturated state. Other pretreatment processes using aerobic decomposition which occur in an unsaturated state are included with “media filters.”
3. Produces significant reductions of BOD, TSS and microorganisms, though the microorganism levels may still indicate a significant risk of containing pathogens.

#### B. **What does it consist of?**

1. A concrete, fiberglass or polyethylene tank, with or without a preceding trash trap (small septic tank).
2. Most have the following subcomponents: (See **figure 20**)
  - a. A trash trap to remove gross solids. Some units, which do not have a trash trap as an integral part of the unit, may require one to be placed in front of it.
  - b. An aeration chamber - provides dissolved oxygen and wastewater constituents (food) to the aerobic organisms. This mixture of dissolved oxygen, wastewater constituents and microorganisms is called mixed liquor. Aeration and mixing occurs by one of the following mechanisms:
    - (1) Mechanical aeration – a propeller-like device or the impeller of a pump aspirate air from the atmosphere and inject it into the mixed liquor by their spinning action.
    - (2) Diffuser – a porous ceramic device or a plastic manifold containing small orifices through which air is injected under pressure from a blower or

- compressor. The size of the air bubbles will vary, depending on the type of mechanism used. Typically, the smaller the bubbles, the greater the amount of oxygen that can dissolve in the liquid.
- (3) Airlift pump – A small diameter pipe through which air is injected by a blower or compressor. The small pipe, surrounded by a larger diameter pipe, is inserted a distance below the top surface of the mixed liquor. When the air is discharged out of the bottom of the small pipe, it rapidly rises, bringing with it mixed liquor from lower in the aeration chamber. Usually a splash plate exists above the mixed liquor surface that causes the rising air and mixed liquor to hit it and help mix and aerate the mixed liquor.
  - (4) Rotating biological contactor – the fixed media is on a drum partially suspended in the mixed liquor. The drum slowly rotates, with air being available to the microorganisms on the media when they are above the liquid surface. This option will be discussed later.
- c. A clarification chamber - allows settling and/or filtration of biological cells and other solids to provide a clarified effluent. The clarification chamber may be a separate chamber immediately following the aeration chamber, as noted in **figure 20**, or it may be located within the aeration chamber or totally outside the ATU unit. Filters or effluent screens may substitute for or be used in combination with a clarification chamber in some units.

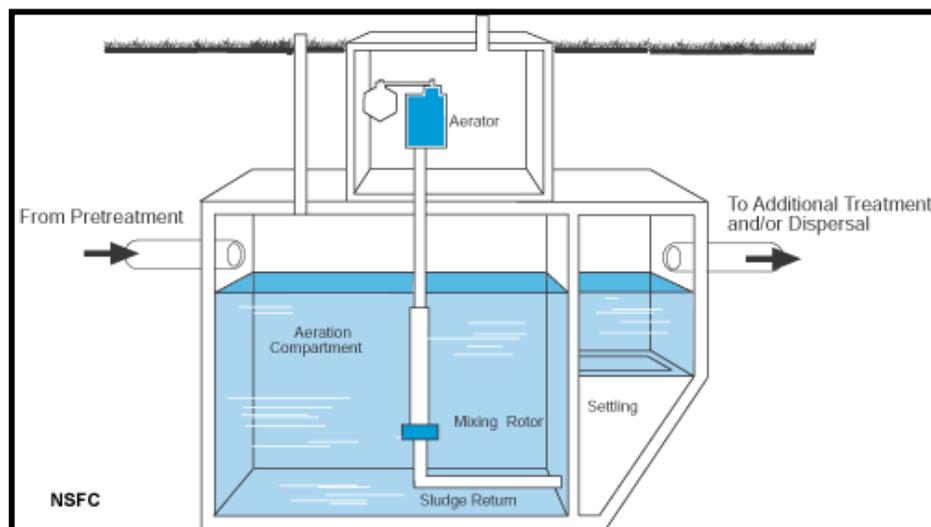
**Figure 20. Cross-section of generic ATU**



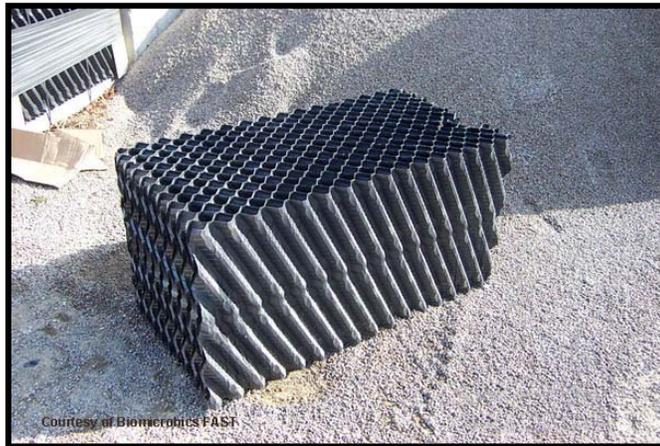
**C. How does it work?**

1. In its aeration chamber an ATU contains a variety of potential mechanisms bringing dissolved oxygen, microorganisms and wastewater into contact with each other.
  - a. Suspended growth units - See **figure 21**.
    - (1) Contain some means of injecting air into the liquid in the chamber. The smaller the air bubbles, the easier it is for oxygen to be dissolved by the liquid.
    - (2) Wastewater constituents, dissolved oxygen, and microorganisms are in suspension within the chamber.
    - (3) Designed to have uniform mixing throughout chamber.
  - b. Fixed (Attached) growth units - See **figure 22** for an example of attached growth media.
    - (1) This type of aerobic treatment unit has very similar principles of operation to media filters. The primary distinguishing feature is that an aerobic treatment unit uses some mechanical means to aerate the effluent. Fixed growth media using unsaturated flow through the media will be discussed in the section on media filters.
    - (2) The aeration chamber contains a fixed media to which the microorganisms fix or attach themselves.
    - (3) The fixed growth media is usually submerged below the liquid level.
    - (4) They contain some means of injecting air into the liquid in the chamber.
    - (5) The liquid containing the dissolved oxygen and wastewater constituent pass by the microorganisms on their fixed media.

**Figure 21. Cross-section of suspended growth unit**

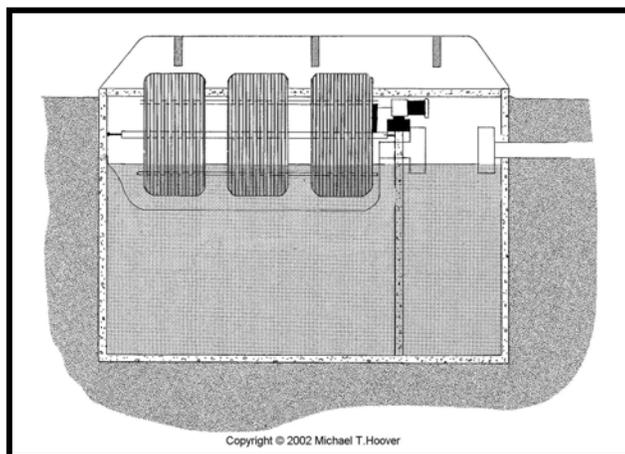


**Figure 22. Example of fixed growth media**



- (6) A subset of this option is the rotating biological contactors (RBC) – See **figure 23**.
- (a) The fixed media consists of many disks with a drive shaft going through their center.
  - (b) The drive shaft rotates the disks alternatively exposing portions of the disks to the atmosphere and to the wastewater.
  - (c) Some units inject air to the liquid portions so that it stays aerobic.

**Figure 23. Typical RBC**



- 2. Flow schemes
  - a. Continuous flow through (the actual flow is intermittent due to wastewater generation patterns within the structure – when wastewater flows in, some

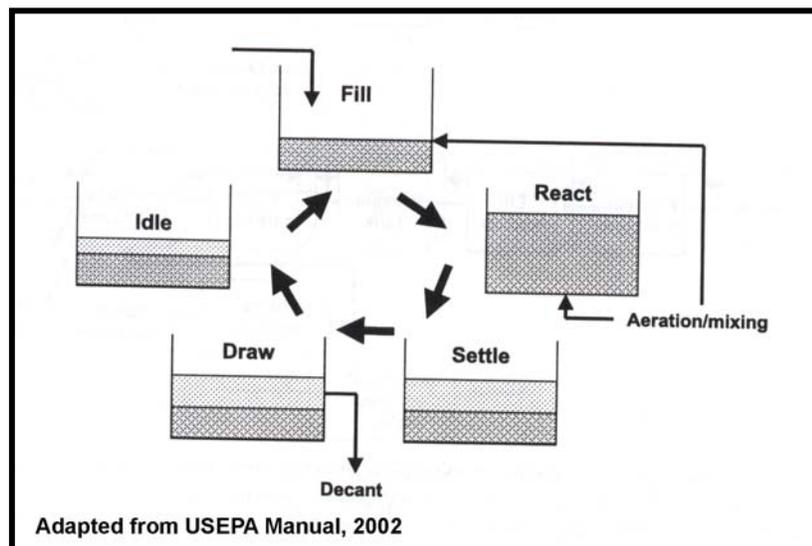
effluent flows out, like in a typical septic tank. Most ATUs for small flows use this flow mode. Figure 21 depicts an example of this.

- b. Sequencing batch reactors (SBR) – See **figure 24**. SBRs are sometimes called Periodic Processes. They historically have been suspended growth units, though variations have been developed that use attached growth.

(1) Intermittent inflow

- (a) Accepts influent only at specified intervals
- (b) A unit-volume of influent usually goes sequentially through each of the 5-steps of this process - fill, react, settle, draw, idle. The time frames for each step vary according to the specific product being used.

**Figure 24. Flow sequence for a SBR**



- (c) Closed to inflow during the treatment cycle, necessitating a parallel intermittent flow unit or a large storage chamber prior to the treatment unit from which liquid is periodically dosed to the treatment unit.

(2) Continuous inflow

- (a) Influent can flow continuously during all phases of the treatment cycle, even though the actual flow will be intermittent due to wastewater generation patterns within the structure.
- (b) To reduce short-circuiting, a partition is normally added to the tank to separate the turbulent aeration zone from the quiescent area.

**D. What are important considerations?**

- 1. Aerobic treatment units come in a variety of mechanical configurations and sizes and incorporate a variety of mechanical and non-mechanical means to enhance the aerobic biodegradation of wastewater.

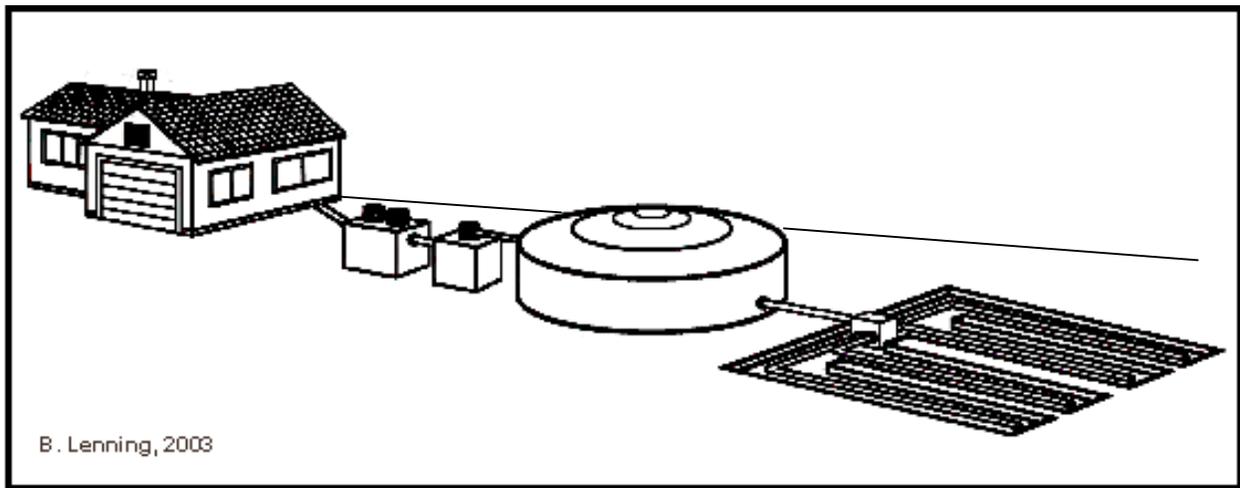
2. ATUs are processes similar to the secondary treatment processes used in public sewage treatment plants. They have been downsized for use with smaller flows. Like their cousins at the public sewage package treatment plants, ATUs are designed for specific hydraulic and biological loading rates. Unlike the larger aerobic treatment plants, most ATUs do not routinely receive consistent quantity and quality of flows. This is one of the major causes of stress for ATUs.
3. Most have been developed to treat domestic strength wastewater. Several ATUs have been developed specifically for higher-strength wastes. Some, like some SBRs, are typically found in packaged configuration for small community or cluster applications.
4. Pre-treatment in the form of a trash trap/tank or septic tank, either external or internal, is required with most ATUs.
5. Treatment performance and stability may be improved using a time-dosed submersible effluent pump located in an external trash tank to dose the ATU. This will help overcome the disadvantages posed by the variable quantity and quality of the influent into the units from residences and other structures.
6. Final treatment/dispersal components preceded by ATUs may have sizing and location requirements that differ from those following septic tanks due to the higher quality of effluent that is expected.
7. The National Sanitation Foundation (NSF) has developed Standard 40, which serves as the protocol for certifying and listing of ATU products that meet specific performance standards. Standard 40 is used to test ATU products that treat up to 1500 gallons of wastewater per day. The testing protocol provides for two different classes of performance. Class I units are expected to perform to secondary standards – CBOD<sub>5</sub> of 25 mg/L and TSS of 30 mg/L.
8. NSF Standard 40 does not include a standard for fecal coliform. While there is considerable variability in pathogen removals, an ATU can be expected to produce effluent with less than 10<sup>4</sup> fecal coliform/100 ml.
9. On-going operation, monitoring and maintenance by competent, trained personnel is especially crucial with these systems.

#### IV. Media Filter

##### A. **What is it?**

1. An aerobic, fixed-film bioreactor (sometimes called a packed bed filter or biofilter)
2. A pretreatment process usually consisting of a lined excavation or watertight structure filled or packed with some specific media to which microorganisms can attach or fix themselves, in an aerobic environment, and treat wastewater as it passes by. See **figure 25** for a general drawing of system using a media filter.

**Figure 25. Typical system using media filter**



**B. What does it consist of?**

1. A container for the medium – either a lined excavation (most commonly lined with 30 mil PVC) or a watertight structure made of concrete, polyethylene or fiberglass.
2. A distribution and dosing system to assure effluent uniformly passes by the microorganisms.
3. A filtering medium - varying depths of some type of media to which microorganisms can attach. A variety of media have been and are being used, including:
  - a. Washed, graded sand
  - b. Gravel
  - c. Bottom ash from coal-fired plants
  - d. Foam chips and cubes – primarily in proprietary products
  - e. Peat – primarily in proprietary products
  - f. Synthetic textile materials – primarily in proprietary products
  - g. Plastic shapes
  - h. Anthracite
  - i. Crushed glass
  - j. Expanded shale
4. An underdrain system
5. Other subcomponents, depending on the type of filter being used.

**C. How does it work?**

1. Effluent is dosed, preferably time-dosed, out of the distribution network and flows slowly, in an unsaturated flow, downward through the filter medium.

- a. The wastewater must remain in the filter media for sufficient time so treatment will be acceptable.
- b. Time between doses must be sufficient to allow reaeration of the media.
2. Treatment occurs in an aerobic environment via:
  - a. Microbiological processes
    - (1) Like a fixed growth ATU, bacteria attach themselves to a media. Effluent passes through the media and microorganisms provide the bulk of treatment.
    - (2) Bacterial slimes created by microbial masses can absorb soluble and colloidal material, as well as wastewater microorganisms.
  - b. Physical processes - filtering and sedimentation.
  - c. Chemical processes – adsorption of dissolved small colloidal constituents.
  - d. The filter can be designed so that the liquid flows through the media just once or multiple times. These flow options will be discussed in greater detail later in this section.

#### D. Why and where is it used?

1. Media filters can provide high levels of treatment.
2. Used for single-family residences, small communities, and commercial facilities.
3. Used when higher levels of pretreatment must be provided because the soil has insufficient depth or is too coarse to provide adequate treatment or there is a need for higher levels of protection due to an environmentally sensitive site.
4. Used when sufficient area is not available for other components.
5. Used in locations to provide adequate pretreatment levels where surface application is permitted.
6. Other specific applications, depending on type of filter being used.

#### E. Options

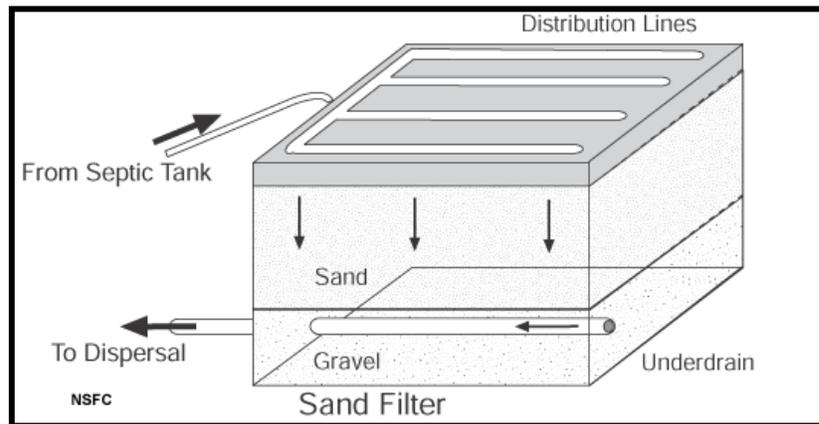
1. Single pass media filters
  - a. **Description** – Effluent passes downward slowly in an unsaturated flow through the filter medium, is collected, and then is transmitted via either a gravity-flow or dosed-flow distribution network to the infiltrative surface/medium in the next downstream component.
  - b. **What does it consist of?** See **figure 26**.
    - (1) The containment vessel – which is preceded by a septic tank and a pump or siphon chamber. Although it isn't recommended, a single pass media filter may be fed by gravity in some situations.
    - (2) A pressure or dripline distribution network.
    - (3) 24 to 36 inches of media – a wide variety of media are used, some of them in proprietary systems.
    - (4) An underdrain that drains by gravity to the next component or to a vault in which a pump will transmit the effluent under pressure to the next

downstream component.

c. **Why and where is it used?**

- (1) For single family, small cluster developments, and other relatively low-flow applications.
- (2) Where nitrogen removal is not important.
- (3) Because they typically have lower monitoring and maintenance requirements and are more passive, a single-pass media filter is periodically used in lieu of an ATU. Some single-pass media filters, however, have similar monitoring and maintenance requirements as an ATU.

**Figure 26. Typical single pass media filter**



d. **Other pertinent information**

- (1) The design should account for both hydraulic and organic loadings. The typical hydraulic loading rate is between 1 and 2 gallons/ft<sup>2</sup>/day.
- (2) In order to have sufficient retention times in the medium to provide assurances of treatment, single pass media filters typically use finer media to slow the flow down.
- (3) Dosing volume and frequency are important design elements. Historical dosing frequency had been four times daily. The current recommendations are up to 12 to 24 doses per day. Media characteristics/types and distribution network characteristics limit the number of doses per day.
- (4) The distribution method most commonly used is pressure distribution, though dripline distribution can also be used. Pressure distribution with spray nozzles has also been used, especially if the filter is an appropriate enclosure.
- (5) These filters may be buried or may be open (free access) to maximize aeration. Single pass media filters using peat, foam cubes/chips and synthetic textile material usually are free access, but they have covers to protect them from the elements.

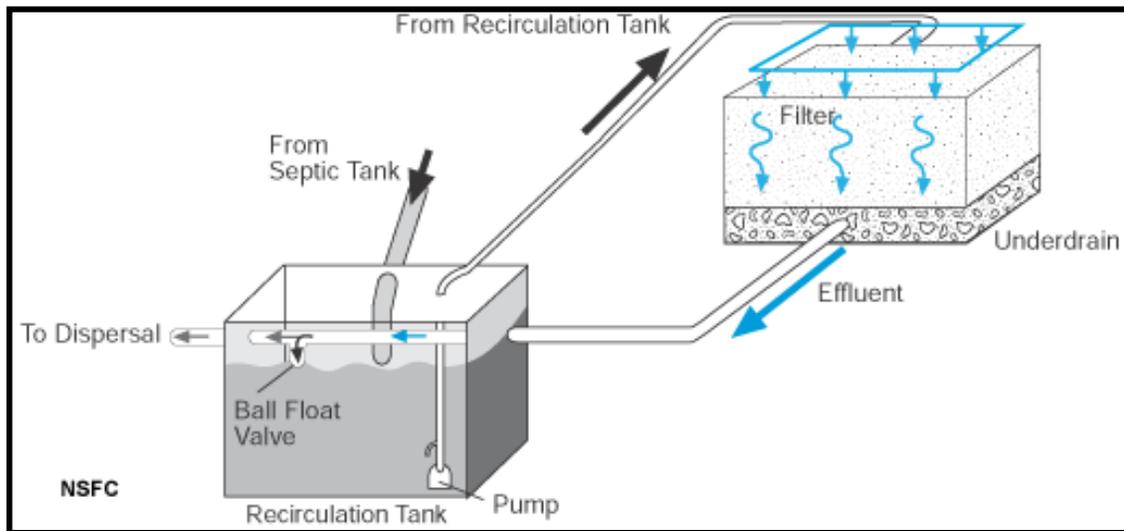
- (6) These filters may be below ground level or be totally above ground level.
- (7) The underdrain may drain by gravity to the next component or to a vault that collects filtered effluent and is transmitted to the next downstream component under pressure by a pump. The vault may be located inside the filter or outside it.
- (8) Single pass sand and peat filters may not be lined on the bottom in some locations where there is suitable soil and sufficient soil depth to transmit the treated effluent away from the filter. One version of this used in many jurisdictions is a sand-lined trench in which a typical drainfield with pressure distribution is lined on the bottom (also sides in some locales) with a certain depth of specific sand. This is done usually where the soils are coarse and can't be expected to provide much treatment.
- (9) Because of the high quality of effluent from a single pass filter, many jurisdictions permit increases in loading rates for final treatment/dispersal components receiving the filter's effluent.
- (10) One variation of a single-pass media filter that is available is a stratified sand filter. Effluent passes through various grades of sand and gravel prior to being collected and transmitted to the next component.

## 2. Recirculating (multiple-pass)

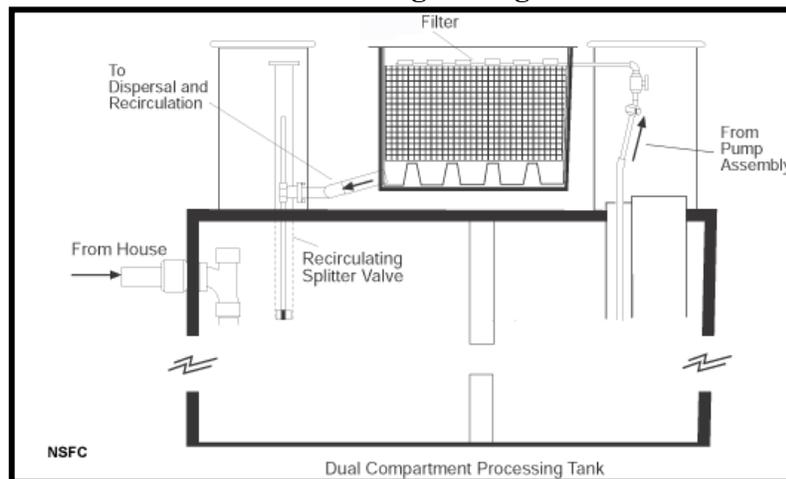
- a. **Description:** Effluent passes from a recirculating/dosing tank to the media filter and downward in an unsaturated flow state through the filter medium. There it is collected and transmitted back to the recirculating/dosing tank where at least a portion of it is again pumped to the filter. Periodically, or routinely as part of every dose, some treated effluent flows to the next downstream component.
- b. **What does it consist of?** See **figure 27**.
  - (1) A recirculating/dosing tank, though some smaller units use a single two-compartment septic tank both for providing primary treatment and as the recirculating/dosing tank (see **figure 28**).
  - (2) A distribution network
  - (3) A filter bed
  - (4) An underdrain system
  - (5) A return line fitted with a flow-splitting device that will return a portion of the filtered effluent back to the recirculating/dosing tank and the balance to the next down stream component.
- c. **Why and where is it used?**
  - (1) Recirculating media filters have been used successfully to treat wastes from sources with higher concentrations of organic material than typically found in residential wastewater.
  - (2) They are used where nitrogen reduction is important. Significant nitrogen reductions are possible because nitrified effluent returning to the

recirculating/dosing tank from the filter mixes with septic tank effluent creating the potential for denitrification. Units that recirculate effluent back through the septic tank (see **Figure 28**) to maximize nitrogen removal.

**Figure 27. Typical multiple pass media filter**



**Figure 28. Typical multiple pass media filter using a septic tank as the recirculating/mixing tank**



- (3) Because they typically have lower monitoring and maintenance requirements and are more passive, a recirculating media filter is periodically used in lieu of an ATU. Some recirculating media filters, however, have similar monitoring and maintenance requirements as an ATU.

**d. Other pertinent information**

- (1) A timer controls the pump in the recirculating/dosing tank. It isn't unusual to have 48 to 96 doses per day, depending on the type of media and design.
- (2) For mineral media, the medium is usually coarser than that used for a single pass filter.
- (3) A multiple pass filter will have a hydraulic loading rate of 3 to 5 or more gallons/ft<sup>2</sup>/day of forward flow. For some media filters, the hydraulic loading rate may be much greater as the units are quite small.
- (4) Recirculation ratios, which typically range from 2:1 to 5:1, can be changed depending on flows giving greater performance control than exists for many other pretreatment units.
- (5) Flow splitting devices can be located inside the filter, inside the recirculating/dosing tank, or in the line between them.
- (6) Most are constructed open to the atmosphere because of the need for reaeration between the frequent doses. Vented covers can be placed on the top to control odors or to help protect the filter from the elements, if needed.
- (7) Some recirculating media filters receiving wastewater with higher organic or grease/oil content may use a blower to assist the aeration process.
- (8) In some jurisdictions variations of these are called trickling filters.

F. Expected treatment provided— there can be considerable variability in the treatment provided by the different types of media filters, both due to the type of media filter and the loading rate. Generally, they can be expected to provide the following levels of treatment:

1. Single pass media filters: BOD<sub>5</sub> and TSS – < 5-10 mg/l, Fecal coliform – 2-4 logs reduction (99 – 99.99% reduction), Total nitrogen – 18-33% removal
2. Multiple pass media filters: BOD<sub>5</sub> and TSS - <10 mg/l, Fecal coliform – 2-3 logs reduction (99-99.9% reduction), Total Nitrogen – 45-75% removal

**V. Constructed wetlands**

**A. What is it and what does it consist of?**

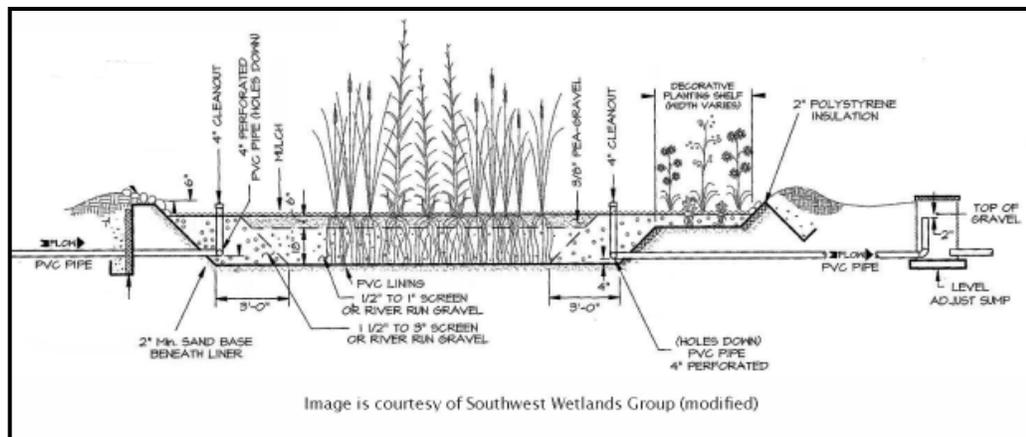
1. A pretreatment component that employs the same natural microbial, biological, chemical and physical processes found in larger natural wetland ecosystems.
2. There are two primary types of constructed or artificial wetlands: free water surface and subsurface flow. For on-site wastewater applications, the subsurface flow constructed wetland is used.
3. This is a largely anaerobic process that will contain some aerobic sites. Some designs inject air via a small air pump distribution network along the bottom of the wetland to make it more aerobic.
4. The 2002 USEPA manual categorizes this as a “high-specific-surface anaerobic reactor” rather than a constructed wetland, including it with other pretreatment components such as anaerobic upflow filters. They term this component as a vegetated submerged bed (VSB).

5. A subsurface constructed wetland consists of a lined bed or channel containing: (see **figure 29**)
  - a. A liner – compacted native or bentonite clay, concrete, PVC, hypalon or other heavy-duty plastic liner suitable for placement in a wet soil environment.
  - b. A bed or channel is typically made up of 20 - 24 inches of porous media, consisting of rock, gravel, sand or other porous media.
  - c. Plants that are able to survive in a saturated environment.
  - d. Normally, a layer of bark or similar material is placed on the top. This may result in additional debris accumulating in the wetland accelerating plugging of the system.
  - e. A distribution means at the inlet end of the bed/channel.
  - f. A collection and outlet mechanism at the other end of the bed/channel. Included is a mechanism that can adjust the flow levels. The liquid depth typically ranges between 16 – 20 inches.

**B. How does it work?**

1. Septic tank effluent flows into the inlet and is typically distributed across the width of the bed or channel.
2. Effluent flows slowly toward the outlet end of the bed/channel.
3. As the effluent flows through the media, the plants provide some oxygen to the bed/channel and microbes provide treatment. Other treatment processes, including filtration and adsorption, also occur. The longer the effluent stays in the bed/channel, the more time the microbes and plants have to treat it.

**Figure 29. Cross-section of typical constructed wetland**



4. The treated effluent flows out of the outlet to the next downstream pretreatment or final treatment/disposal component. The final component may be another constructed wetland that is unlined where soil and site conditions permit.

**C. Why and where is it used?**

1. They can produce effluent that meets a secondary standard of 30 mg/l BOD<sub>5</sub> and 30 mg/l TSS.
2. When flowering vegetation is used, they can be aesthetically pleasing. However, sufficient area must exist to install it.
3. Until recently, it was thought considerable nitrogen reduction would occur. This has proven to not be the case, except maybe for an aerated constructed wetland.

**D. Other pertinent information**

1. The USEPA has a manual that provides guidance on the design of constructed wetlands. For residential flows, important design considerations include:
  - a. The bottom slope is a maximum of 1 percent. For larger flows, the bottom slope should be based on hydraulic loading rates.
  - b. To assist in providing adequate retention time, the length-to-slope ratio typically ranges between 2-to-1 and 3-to-1.
  - c. Sufficient cross-sectional areas must exist in the bed/channel for water to move through it without surfacing.
  - d. Usually, the desired hydraulic retention time in the bed/channel (amount of time the effluent remains in the bed/channel), is a minimum of 2 – 3 days.
  - e. A number of variables affect the size of a constructed wetland. These include the quantity and quality of the influent and other previously mentioned variables.
  - f. For discharges other than into the soil, they usually require disinfection (maximum two log reduction in fecal coliform) and aeration (they are anaerobic).
2. It is not unusual for a small berm to be built around them to help keep out surface water and in which to place the edges of the liner.
3. All media should be washed clean of fines and be resistant to crushing or breaking.
4. Soft-tissue plants are desirable because they can be flowering and, thus, be more colorful.
5. The flow levels can be adjusted by a mechanism at the outlet end of the tank. Levels may be varied to prevent odors or to minimize the potential of freezing.
6. The wetland should be managed as a rock garden. This may include removing dry material as plants “die-off” during the winter. Also, removing and replanting plants periodically may be necessary to help keep the pore spaces in the media open so the liquid continues to flow laterally through the media readily.

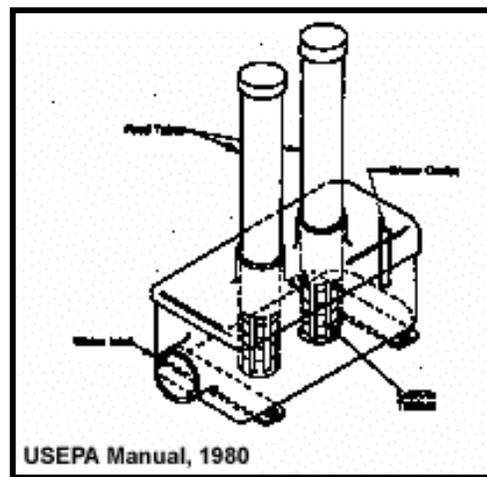
**VI. Disinfection**

**A. What is it and what does it consist of?**

1. A pretreatment process that uses an agent to destroy pathogens and microorganisms in the wastewater stream by either killing them or by preventing their replication. This is not sterilization.
2. Disinfecting agents consists of either 1) a chemical agent, such as chlorine, ozone or iodine, 2) a physical agent, such as heat, or 3) irradiation, such as ultraviolet. The two used primarily in OWTS are chlorination and ultraviolet radiation. Ozonation

- has also been tried.
- Both chlorination and ultraviolet disinfection bring the effluent into direct contact with the disinfection agent. For chlorine, this is typically done in a chamber, called a stack feeder. The stack feeder contains calcium hypochlorite tablets (see **figure 30.**) For ultraviolet, this is typically done with a flow-through pipe containing an ultraviolet tube (see **figure 31.**).

**Figure 30. Typical chlorine stack feeder**



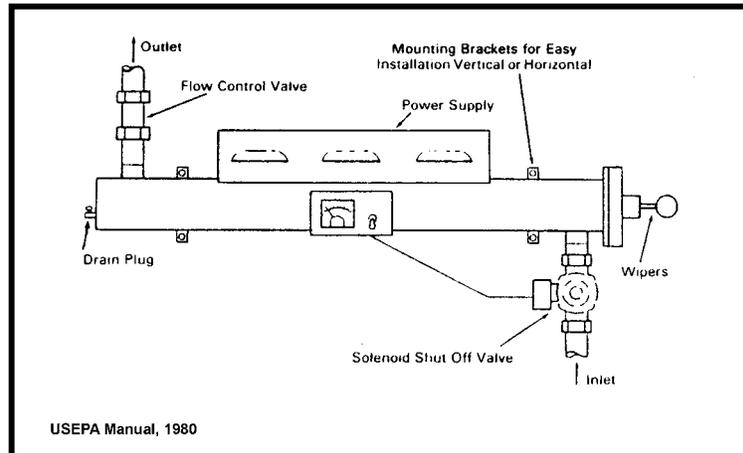
**B. How does it work?**

- Adequately treated effluent flows into the disinfection unit.
- Depending on the specific disinfection means used, microorganisms are exposed to the disinfecting agent. There are a number of variables that control how effective the disinfection process will be
  - The concentration (chemical) or intensity (irradiation) of the disinfecting agent.
  - The contact or exposure time.
  - The number and type of organism that is to be destroyed.
  - Wastewater characteristics – temperature, pH, total suspended solids, BOD<sub>5</sub>.
  - Uniformity of exposure of the disinfecting agent to the microorganisms.
- Disinfected effluent flows to the final dispersal component.

**C. Why and where is it used?**

- For OWTS, where the site conditions (primarily soils that are too coarse and/or shallow) indicate there may be a potential problem of contamination of ground or surface waters by bacteria.

**Figure 31. Schematic of typical ultraviolet unit**



2. For any surface applications, to minimize the potential of exposure of the public to pathogens.
3. Where reuse of any of the wastewater stream, for example greywater, is indicated, and a reduction in microorganisms is required.
4. Where insufficient treatment has been provided prior to the disinfection to assure the disinfection will occur.

#### D. Options typically used for small flows

##### 1. Chlorine

- a. Most widely used disinfectant
- b. For individual systems, typically calcium hypochlorite tablets are used. These tablets are typically placed in a stack feeder and the effluent flows by being exposed to the chlorine. A liquid formulation of chlorine (sodium hypochlorite) may also be used.
- c. Oxidizable material must be removed or it will exhibit a chlorine demand and minimize the effect of the chlorination
- d. The pH of the effluent will determine which species of chlorine will be the primary disinfectant. Chlorine is a more effective disinfectant when the pH is slightly acidic. Fortunately, effluent from on-site wastewater components is typically neutral to slightly acidic.
- e. If ammonia is present, chlorine will combine with the ammonia to form chloramines that are less effective disinfecting agents.
- f. If sufficient organic matter (high BOD) is present, chlorine can readily combine with it and form synthetic organic compounds that may be carcinogenic if they reach drinking water.
- g. A contact time of 30-45 minutes is desirable. Thus, a contact chamber should be

immediately downstream of the chlorination unit. Many systems that use chlorine disinfection today do not have sufficient contact time to properly disinfect.

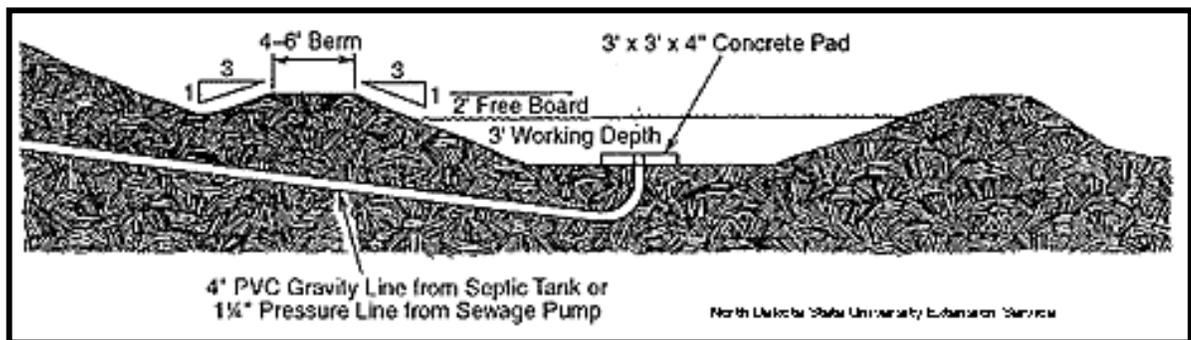
- h. Chlorine will typically leave a residual to keep on disinfecting. If this is not wanted, tablets that can dechlorinate or take the chlorine out of the effluent can be used. These usually are placed downstream of the chlorinator in another stack feeder. Dechlorination should not occur until sufficient contact time with the chlorine has occurred. A stack feeder similar to the chlorine stack feeder noted in **figure 30** will be used for the dechlorination tablets
  - i. Some pathogens are not readily affected by normal concentrations of chlorine. These include giardia and, especially, cryptosporidium organisms.
  - j. The tablets must be replenished periodically. Also, observations must be made to assure the tablets are not stuck in the stack feeder or the tablets are not eroded through the stack feeder's flow channel, allowing effluent to pass without contacting the chlorine tablets.
2. Ultraviolet radiation (UV)
- a. Ultraviolet rays are used to irradiate pathogens by disrupting the organism's DNA/RNA molecules, disabling the organism's capability to reproduce.
  - b. Wavelengths between 250 and 265 nanometers are most effective at destroying the pathogens.
  - c. Low-pressure mercury lamps are typically used to disinfect small flows with UV.
  - d. Because glass blocks UV rays, tubes are usually made of fused silica or quartz.
  - e. Some UV units use a Teflon tube around the UV bulb to keep it from fouling or getting dirty from the wastewater.
  - f. There are a number of factors that influence the effectiveness of UV disinfection. Suspended solids can provide "hiding" places for microorganism. Solids and certain chemicals can also absorb UV rays, minimizing the intensity.
  - g. The bulb must be periodically cleaned to maximize exposure of the microorganisms to the UV rays. The bulbs must also be replaced periodically (usually on an annual basis) as their intensity will wane after a while.
  - h. To guarantee proper contact time, each unit has a maximum number of gallons per minute that can pass through the UV unit. For single-family residential units, this maximum flow is typically between 5 and 10 gallons per minute.
  - i. Currently, most UV disinfection units have the bulb in a vertical orientation.
  - j. There is some evidence that suggests microorganisms may repair themselves if they are immediately exposed to sunlight following UV irradiation. The solution to this is to keep the effluent in the dark after irradiation by putting into the soil or a contact chamber.
- VII. Other – There are a variety of other treatment options that are available that could be discussed. Some of them, such as ion exchange and physical-chemical options, are more

experimental. These options are promoted primarily to reduce nitrogen and phosphorous. These will not be discussed further. Two other options consist of more proven technology but are not widely used for various reasons. These two technologies, lagoons and anaerobic up flow filters, will be briefly discussed.

A. Lagoons

1. The 2002 USEPA manual describes this as one of the different types of aquatic systems consisting of a “large basin filled with wastewater undergoing some combination of physical, chemical, and/or other biological treatment processes that render the wastewater more acceptable for discharge to the environment.” (See **figure 32.**)

**Figure 32. Plan view of a typical lagoon**



2. In many jurisdictions a lagoon is called a wastewater stabilization pond.
3. Because they tend to be relatively large in area and require a substantial buffer zone and maybe fencing around it, they are not widely used. However, in the rural areas of some states, lagoons are used fairly frequently for residential situations.
4. While there are many forms of lagoons used (aerobic, anaerobic, facultative), the facultative version is usually used for residential purposes.
5. Facultative lagoons tend to perform best when there are multiple cells, but single cell lagoons are most frequently used for residential purposes.
6. Consist usually of lined basins into which effluent from a septic tank or an aerobic process flows. After many days of retention, effluent flows out to the next downstream component. Where the soil doesn't create a concern, unlined lagoons are periodically used.
7. Lagoons obtain the oxygen necessary for microbial metabolism from the atmosphere and combine sedimentation of particulate matter with biological degradation.
8. BOD levels are consistently reduced 75 to 95 percent in facultative lagoons, but TSS levels can vary widely because lagoons are very conducive to algal growths (from

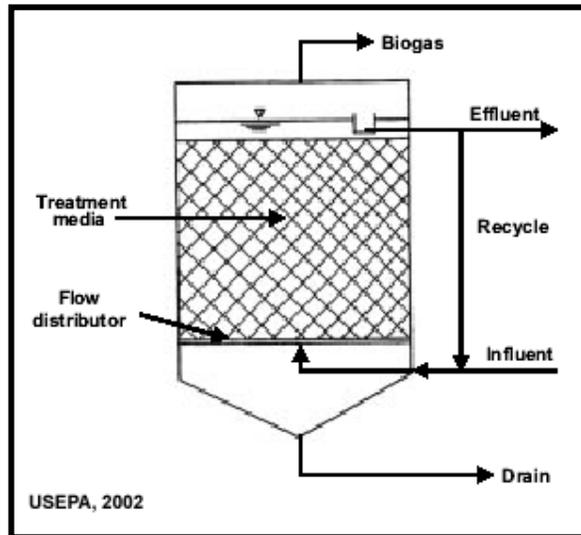
- little reduction in hot seasons to 90% in colder seasons). Total nitrogen reductions can approach 60% and total phosphorous reductions can approach 50%. Algae provide part of the treatment with their uptake of nutrients.
9. Wastewater depth is typically between three and five feet. The top surface is typically aerobic with the environment becoming more anaerobic as the bottom is approached.
  10. Facultative lagoons are typically sized using incoming BOD levels. Usually, at least a septic tank is required prior to the lagoon. If a lagoon receives septic tank effluent, it is not unusual for a lagoon to be sized to contain 20 to 150 times the daily flow, depending on the final discharge method and the lagoon's depth. Size can usually be reduced if aerated effluent flows into the lagoon.
  11. Lagoons require berms (usually topping out at least two feet above the liquid level), fencing (to keep animals out), and a buffer area of 300 feet or more; thus, large areas are required for this technology.
  12. Usually, trees within a certain distance of the lagoon are removed to maximize the exposure of the lagoon's surface to sunlight and wind.
  13. While a lagoon is relatively low-maintenance, mowing of the berm and fence maintenance is required. Also, periodic pumping of the lagoon may be necessary as solids collect over time.
  14. There are safety concerns with lagoons. It is crucial that lagoons be properly fenced and secured to prevent access by children and animals.

B. Anaerobic upflow filter

1. The 2002 USEPA manual describes this as a "high-specific-surface anaerobic reactor" and includes it in the same category as vegetated submerged beds.
2. There are a variety of different types of anaerobic upflow filters containing different media. The filter used in the United States is one using rock as the media. See **figure 33**.
3. As per the name of this option, the flow through these components is vertically upward.
4. Outside the United States and Canada, especially in hot climate areas, these are used to pretreat high BOD and TSS levels so that an aerobic process can provide higher levels of treatment.
5. Where the objective is to reduce BOD and TSS levels, these units, like constructed wetlands, are designed to have long hydraulic retention times. Further treatment is necessary if the final discharge is to be to the surface of the ground or to surface water.
6. Because of their anaerobic nature, they have been touted as mechanisms to denitrify nitrified effluent. However, the addition of a carbon source, such as methanol, is usually necessary to help drive the denitrification process. This adds to the cost and the on-going monitoring and maintenance requirements for this technology.

7. Will require periodic flushing.

**Figure 33. Typical anaerobic up flow rock filter**



## APPLICATION/DISTRIBUTION COMPONENTS

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❖ Dosed-flow distribution	66
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• Pressure manifold	71
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**Component Purpose:** Effluent must 1) flow from one pretreatment component to the next pretreatment component (for example, from a septic tank to an intermittent sand filter) or from a pretreatment component to the final treatment/dispersal component, and 2) be distributed or applied to the infiltrative surface of that pretreatment or final treatment/dispersal component. These are the two purposes of application/distribution components. It has become increasingly accepted that uniformly distributing the effluent over the entire infiltrative surface assists in achieving unsaturated flows, increasing the predictability of good levels of treatment in the soil.

**Component Options:** There are a wide variety of means of applying or distributing the effluent to an infiltrative surface. Throughout North America there are many variations of how each application & distribution option are used locally. This class will discuss two broad classifications of application/distribution: gravity flow distribution and dosed flow distribution. Several distribution network design options will be discussed for each one.

### I. GRAVITY-FLOW DISTRIBUTION

#### A. **Description**

1. Effluent flows by gravity from the outlet of one pretreatment component to the next or from the last pretreatment component in a system to the final treatment and dispersal component.
2. Using a septic tank as an example, wastewater flowing into the septic tank displaces effluent in the tank which flows from the tank to the next component, for example a drainfield..

3. If the receiving pretreatment or final treatment/dispersal component has multiple distribution lines or laterals, this component includes a mechanism for distributing the flow to each of the lines/laterals.
4. Under a gravity flow scenario, the flow is intermittent throughout the day depending on when wastewater is generated. This results in effluent discharges too low to flow uniformly throughout the infiltrative surface of the downstream pretreatment component or dispersal component.
5. This results in non-uniform distribution, with most of the flow occurring in localized areas of the infiltrative surface. Especially in coarser textured soils, effluent may not spend sufficient time in the soil to receive proper treatment until a biomat forms.
6. Unless properly managed, the biomat may continue to develop until the component can't handle the inflow any longer and the component either backs up or surfaces.

#### **B. Other pertinent information**

1. The piping network typically consists of 4-inch, perforated plastic pipe made of smooth wall polyvinyl chloride (PVC), flexible corrugated polyethylene (PE) or acrylonitrile-butadiene-styrene (ABS), having one or two rows of holes or slots at or near the bottom. While there are varying opinions about the purposes and efficiencies of the piping network, expressed purposes include:
  - a. To assist in moving effluent throughout the length of trenches and beds.
  - b. To allow an open bypass around sludged rock, soil infiltration in rock, and root blockages.
  - c. To encourage redistribution in a trench or bed.
2. The outlet of a pretreatment device must be at a higher elevation than the invert of the inlet of the next downstream component.
3. Is the simplest and least expensive distribution method.
4. Results in non-uniform distribution over the infiltrative surface.
5. The distribution network may consist of one or more lines.
6. Typically, the maximum length of any one lateral allowed by regulation is 100 feet.

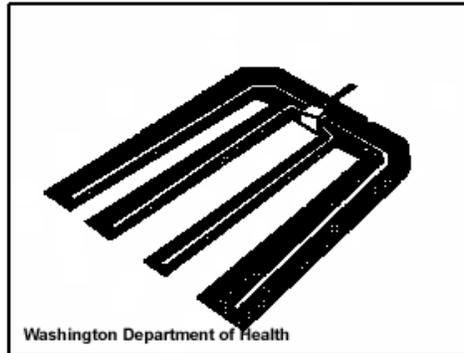
#### **C. Options**

##### **1. Parallel distribution**

###### **a. What is it and what does it consist of?**

- (1) A network of equal length laterals designed to 1) receive flow by gravity from a pretreatment component and 2) distribute flow to the infiltrative surface of a pretreatment or final treatment/dispersal component by gravity. See **Figure 34**.
- (2) Typically, a 4-inch diameter non-perforated pipe extends from the upstream pretreatment component.

**Figure 34. Typical layout for a parallel distribution network**



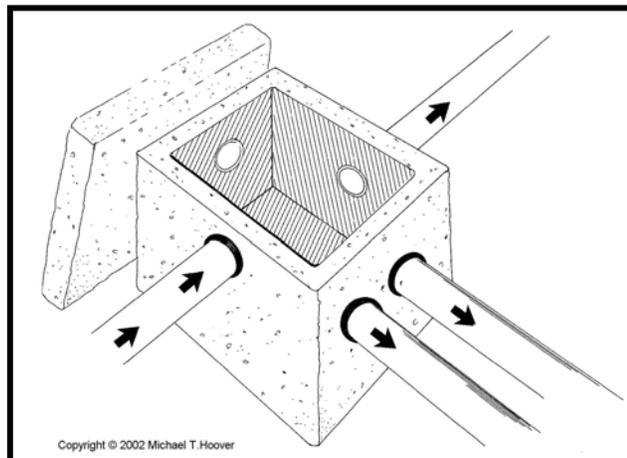
(3) A flow-splitting device to theoretically provide equal flows to each of the laterals in the distribution network.

(a) Distribution box

i. **What is it and what does it consist of?**

- A flow-splitting device designed to 1) receive wastewater flowing by gravity from a pretreatment component and 2) distribute equal flows to each distribution line or lateral in the next downstream component.
- A shallow box typically made of concrete, plastic or fiberglass.
- It has one inlet and two or more outlets, both usually 4 inches in diameter, with their inverts at the same elevation. See **Figure 35** for an example of a typical distribution box.

**Figure 35. Typical distribution box**



ii. **How does it work?**

- Effluent flows into the box through the single inlet.
- The box is designed for equal amounts of effluent to flow out of each outlet.
- Unfortunately, due to uneven settlement of the box or material getting hung up on the outlet, as well as the extremely low flow rate, equal flow to each trench or lateral usually does not occur.
- Invert leveling devices are commercially available to try and equalize the flow from each outlet. Also, distribution boxes that have leveling capabilities built into the box are commercially available.
- Even if the objective of equal flows to each lateral is achieved, flow does not occur uniformly throughout the length of the lateral.
- By design or by actual operation, flow can be directed to one lateral. When the receiving infiltrative surface cannot handle the inflow any longer, the flow can back up into the box and flow out of another outlet. In this way, a distribution box operates similarly to a drop box, which is discussed later as part of serial distribution.

iii. **Other pertinent information**

- Distribution boxes are one of the most frequently used components in OWTS.
- The invert of the inlet is higher than the inverts of the outlet.
- To prevent surges from flowing out one outlet, many distribution boxes have features, such as baffles, ells or slotted inlet plates, to break the surge.
- Designs should include the commercially available devices or boxes designed to help assure uniform flows out of each outlet.
- The box does have a lid, which historically has been buried and inaccessible. A watertight riser should extend to the ground surface to facilitate monitoring and maintenance.
- The box must be installed level to increase the potential for equal flows from each outlet. Some installers will even set it on a level concrete pad or compacted stone.
- The lids, inlets and outlets should be sufficiently watertight to prevent any surface or ground water from infiltrating into the box.
- The box should be pumped out when the septic tank is pumped and should be cleaned out periodically.
- The distribution box provides access for grabbing a sample of effluent or for making direct observations of 1) flow distribution, 2) the clarity of the effluent going to the next component, or 3)

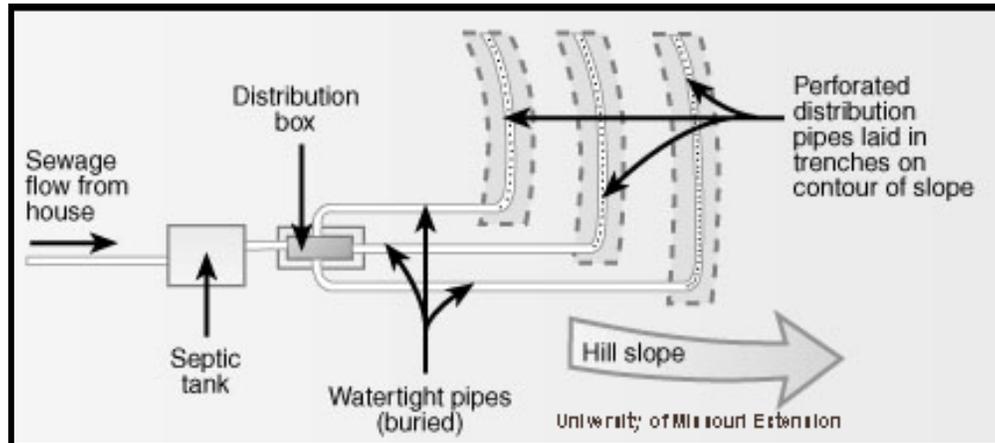
- whether the next component is backed up.
- Many studies have showed their deficiencies. Thus, distribution box systems aren't permitted or promoted in some local regulations or codes.
- (b) Other flow splitting devices, such as tees, wyes, headers, and a variety of proprietary flow splitters, flow dividers and weir boxes. Two of these are portrayed in **figure 36**.
- (4) A few feet of typically 4-inch diameter non-perforated pipe extending out of the flow-splitting device connecting to typically 4-inch perforated pipe out of which the effluent flows toward the infiltrative surface.
- (5) Flow splitting devices must be separated from the trenches or bed with solid earth dams to prevent short-circuiting of effluent around the outside of the device.
- b. **Why and where is it used?**
- (1) Parallel distribution is used in strictly gravity flow scenarios. If the receiving component is located at a higher elevation than the pretreatment component, effluent may be pumped to the distribution flow splitting device.

**Figure 36. Alternative flow splitting mechanisms for parallel distribution networks**



- (2) Parallel distribution is usually on sites with slopes less than 5 percent, though some local regulations/codes allow them on greater slopes, with each lateral at a different elevation. See **figure 37**. On relatively flat topography, the flow-splitting devices can operate as drop boxes (discussed under serial distribution) if one or more laterals no longer can handle the flows to them, allowing flow from one lateral to another. As slopes become greater, this capability becomes unavailable as effluent will surface rather than backing up to the flow-splitting device. Thus, serial distribution is frequently required on steeper slopes when using gravity distribution.

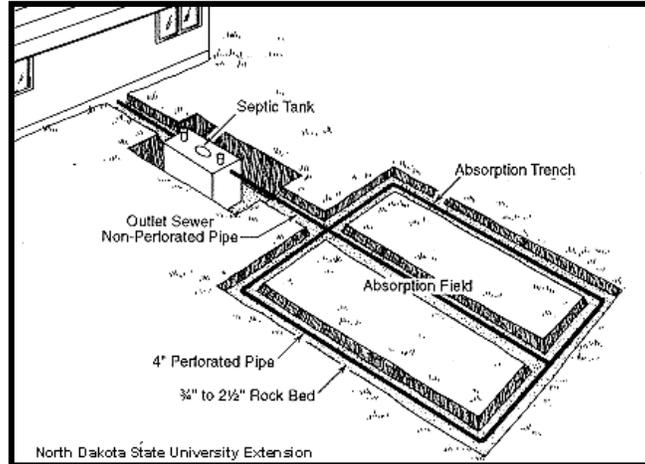
**Figure 37. Parallel distribution network with laterals at different elevations**



**c. Other pertinent information**

- (1) Each lateral should follow the contour lines, with the bottoms being flat.
- (2) Multiple laterals served by the same flow-splitting device are required to have equal lengths if it is part of a parallel distribution network. This is because each lateral is designed to receive the same amount of effluent.
- (3) Even if equal quantities of effluent flow into the beginning of each lateral, uniform distribution of the effluent throughout the length of each lateral does not occur.
- (4) Many jurisdictions try to overcome the distribution problems by using a distribution network of multiple laterals at the same elevation in which the piping is connected or looped. See **figure 38**.
- (5) The flow splitting device should be accessible for ease of monitoring and maintenance. Monitoring and maintenance activities include assessment of equal flows to each lateral, shutting off one lateral if it has been overloaded, observation of effluent quality, and grabbing a sample.
- (6) Because of the problems with parallel distribution in assuring equal flows from the traditional flow-splitting devices, there are jurisdictions that limit the use of this technology.

**Figure 38. Typical loop distribution network in a bed**



## 2. Serial distribution

### a. What is it and what does it consist of?

- (1) A network of laterals designed to 1) receive flow by gravity from a pretreatment component and 2) sequentially distribute flow to laterals of a pretreatment or final treatment/dispersal component. See **figure 39**.
- (2) A typically 4-inch diameter non-perforated pipe extending from the upstream pretreatment component connected to the first lateral in the serial distribution network or a drop-box, depending on the flow-control device that is used.
- (3) A flow-device which causes effluent from one lateral to pond above the infiltrative surface to a predetermined elevation before it spills over to the next downstream component

#### (a) Relief line

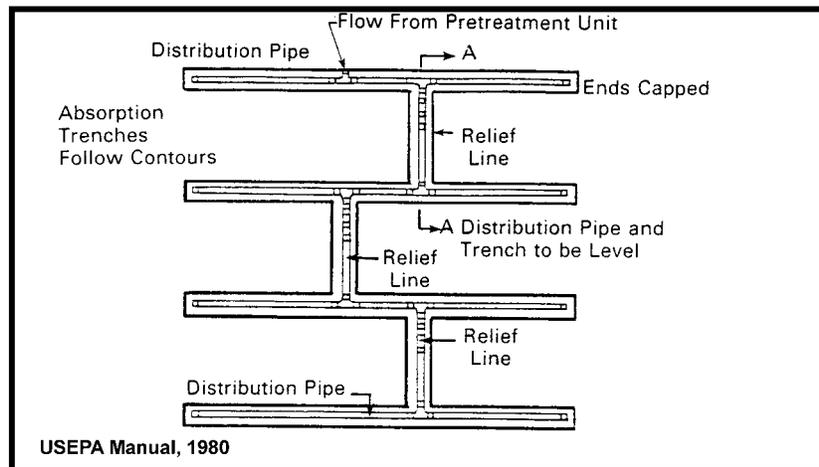
##### i. What is it and what does it consist of?

- Simple overflow pipe connecting one lateral to the next downslope lateral. See **figure 40**,
- Consists of solid, non-perforated, usually 4-inch pipe.
- In many jurisdictions, it is also called a stepdown.

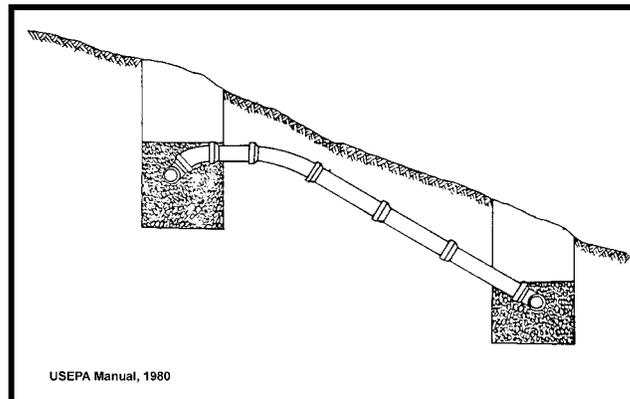
##### ii. How does it work?

- Effluent flows into the uppermost lateral from the pretreatment unit.
- The relief line forces the effluent to pond in a trench before it will allow effluent to spill over to the next downslope lateral. The sequence begins again in that lateral.

**Figure 39. Typical serial distribution network**



**Figure 40. Typical relief line (stepdown)**



**iii. Other pertinent information**

- Can be located anywhere along the lateral.
- The invert elevation of the uppermost relief line must be at an elevation lower than the outlet of the preceding pretreatment component.
- The relief line must be installed on original soil so no settling occurs that can change the elevations and so no short-circuiting of flow can occur between trenches.
- There are no accesses in the relief line to check if it is functioning properly. Observation ports in each trench are needed to help determine this.

- There is no capability to block the flow to any trench, allowing it to rest and dry out.
- Must be of a minimum of schedule 40 pipe to resist crushing.

(b) Drop box

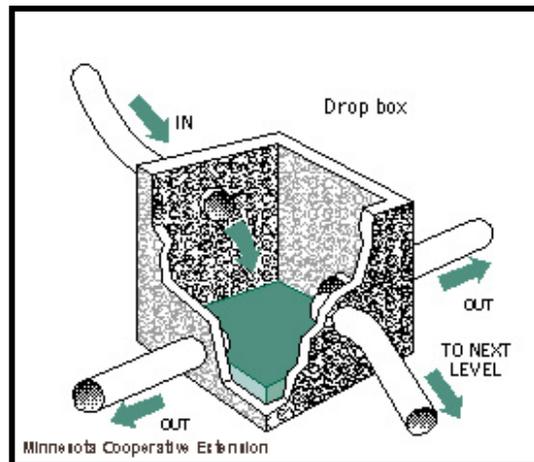
i. **What is it and what does it consist of?**

- A concrete, plastic, or fiberglass box.
- The box has one inlet, one or two outlets to a trench (the drop box may be located at the end of the trench or in the middle), and one outlet to the next downslope drop box. See **figure 41**.

ii. **How does it work?** See **figure 42**.

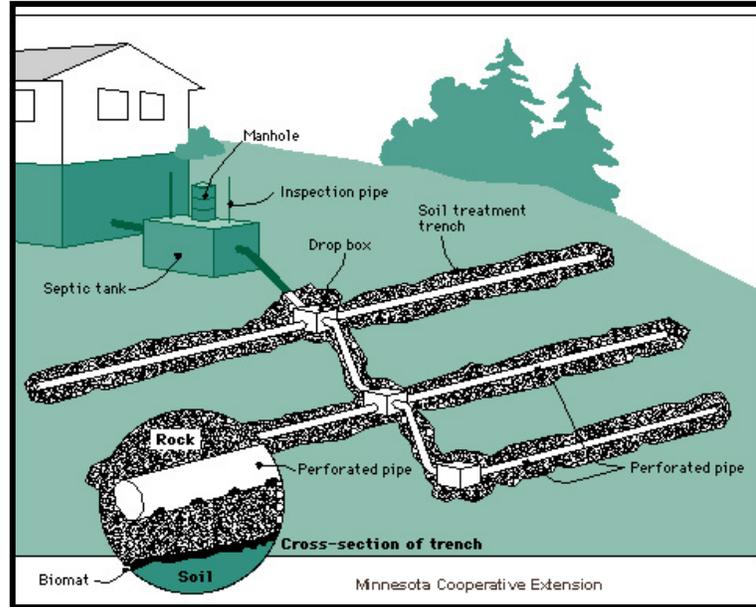
- The flow from the preceding pretreatment unit flows into the uppermost drop-box.

**Figure 41. Typical drop box**



- Liquid builds up in the drop-box and flows out the outlets (either one or two) to the perforated laterals.
- As the uppermost laterals start ponding because they can't handle the entire daily flow, the liquid level in the drop-box builds up to some predetermined point where it then spills to the next downslope drop box where the sequence begins again.

**Figure 42. Serial distribution using drop boxes**



### iii. Other pertinent information

- The inlet elevation of the uppermost drop box must be at an elevation lower than the outlet of the preceding pretreatment component.
- The inlet elevation for each drop box is higher than the invert of its outlet discharging effluent to the next downslope drop box.
- Must be watertight to prevent intrusion of any ground/surface water and placed on a stable base.
- There should be some undisturbed soil between the drop box and where the infiltrative surface in the trench begins.
- It is important that the lines between drop boxes be constructed so short-circuiting of effluent from the upslope trench to the downslope trench can occur.
- Should be installed with an access to final grade to facilitate monitoring and maintenance.
- The primary advantage of a drop box is that an individual trench or trenches can be taken out of service. This can create some semblance of an alternating system. This can be done by either plugging up the drop box's outlet(s) to a lateral or by attaching a 90 degree ell to the lateral outlet that rises above the invert level of the discharge to the next downslope drop box.

**b. How does it work?**

- (1) As noted in the discussions of serial relief lines and drop-boxes, a network of independent trenches are sequentially loaded.
- (2) As the first trench becomes fully ponded flow to the next downstream trench will occur. With septic tank effluent this happens because the biomat rapidly forms on the bottom and sidewall infiltrative surfaces of the trench because it is receiving the entire flow from the wastewater source.

**c. Why and where is it used?**

- (1) To make full hydraulic use of the bottom and sidewall infiltrative surfaces.
- (2) To force the biomat to rapidly form on the infiltrative surfaces reducing the period of time for concerns with saturated flows in the soil below the infiltrative surface.
- (3) To increase the hydrostatic head to assist in forcing water into the surrounding soils through the biomat that will rapidly form.
- (4) To overcome the distribution problems encountered with a parallel distribution network.
- (5) Usually on sloping sites, typically greater than 5%, so that there is a flow gradient from one trench to the next. However, they can be used on relatively level sites where there is the capability of installing laterals at elevation differences of at least 2 inches, without the installation becoming too deep.

**d. Other pertinent information**

- (1) As noted, the elevation of the “spill over” level in the uppermost trench must be below the invert of the outlet in the preceding component.
- (2) Each lateral can be of different lengths, giving the design professional some flexibility.
- (3) Can be used in drainfields containing either gravel or gravelless technologies..
- (4) The elevations of the installation are critical.
- (5) This technology is primarily useable for septic tank effluent where a biomat will form quickly to provide unsaturated flow below the trenches. There are concerns with this technology if the pretreatment component removes sufficient organics and solids to minimize the formation of a biomat. Saturated flow may result which will have an adverse impact on the treatment provided by the soil.
- (6) Some jurisdictions that don't permit or encourage this type of gravity distribution system.

## **II. DOSED-FLOW DISTRIBUTION**

### **A. Description**

1. Predetermined volumes of effluent are held in a chamber and dosed out to the pretreatment or dispersal component.

2. The dosing provides:
  - a. Better distribution over the infiltrative surface than gravity-flow distribution options.
  - b. Intervals between doses when drying and resting can occur.
  - c. Reductions in the rate of biomat formation
  - d. Help to maintain unsaturated conditions in the treatment zones in soil.
  - e. More uniform loading to pretreatment units such as media filters and ATUs.
  - f. As will be seen, the potential of uniform distribution over both space and time.

#### **B. Other pertinent information**

1. Can be used to distribute effluent in almost any application.
2. Many believe this is the distribution method of choice.
3. This improved method of distribution, however, is a mechanical process, adding to both the cost and need for monitoring and maintenance.
4. On-going monitoring and maintenance is very important.
5. Alarms are necessary to indicate problems with pump, circuitry, or rate of inflow. Alarms need to be audible and visible to system users and supplied on a circuit separate from the pump circuit. Alarms that call operators or management entities are available.
6. Other optional control panel accessories may be specified depending on the designer. These may include pump elapsed time meters, pump event counters, alarm event counters, surge protection, and remote telemetry.
7. For components like many media filters, frequent, small doses are preferred over the historic 1-4 doses per day. However, especially with final treatment and dispersal components using pressure distribution, they should not be so frequent that the doses aren't large enough to adequately pressurize the distribution network for the bulk of the dose cycle. If this happens, the uniformity of the distribution is reduced.
8. Dosing method
  - a. Demand dosing
    - (1) Dosing occurs when a sufficient volume of sewage has been collected to activate the dosing device.
    - (2) The dose continues until the level has been reached where the dosing device is deactivated.
    - (3) The pump-on and pump-off levels stay constant
    - (4) Typically, there is no control on how much effluent is dosed daily.
  - b. Timed dosing
    - (1) An analog or digital timer, located in a control panel, controls the dosing device.
    - (2) The timer controls the number of doses per day (rest time between doses) and the dose volume (time the dosing device works).
    - (3) The pump-on and pump-off levels move up and down in the chamber, due to

surges, though the distance between them remains the same. A larger chamber is usually required to allow for days with big flows.

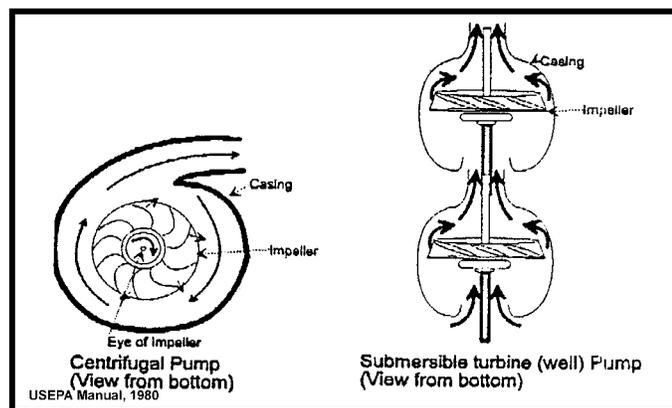
- (4) Will allow a known volume of effluent to be distributed to the next downstream component every dose and every day. This results in considerable flexibility and control.
- (5) Is more costly and slightly more complicated than demand dosing.
- (6) Protects downstream components from hydraulic overloading. When properly set up for a specific design waste flow, these systems can be used as an indicator of plumbing leaks and excess flows from a facility. These panels should be fitted with pump override and/or a high level alarm.
- (7) Timer controlled dosing, in combination with a large equalization or storage tank can be utilized for facilities that do not operate every day of the week such as churches, flea markets, or race tracks. When properly designed, this may allow for a much smaller drainfield than would otherwise be required for the peak flow resulting from the day of operation.

## 9. Dosing devices

### a. Pumps

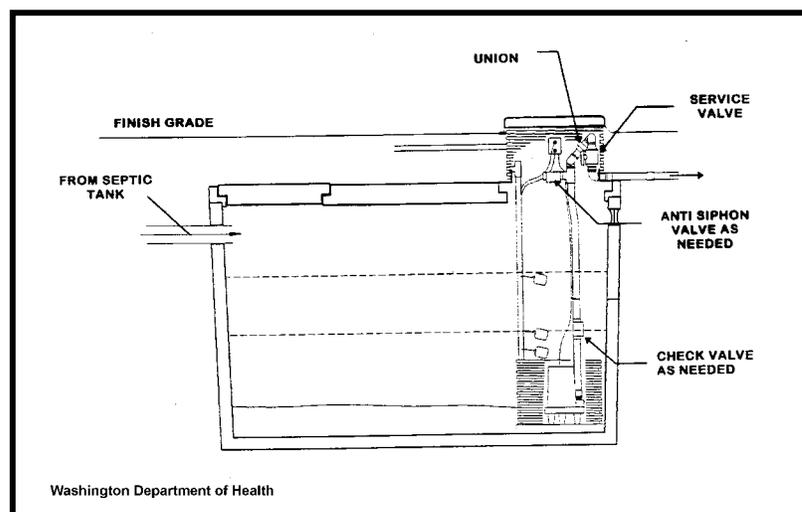
- (1) A variety of pumps are available. The pumps typically used are the turbine and centrifugal effluent pumps. See **figure 43**.
- (2) Must be made to handle effluent or sewage
- (3) Can dose to one or more independent networks using multiple, alternating pumps or automatic valves.
- (4) Located in a chamber with a sufficient volume to collect the proper dose volume, containing other subcomponents that make the dosing system function properly.
- (5) Can be part of either demand or timed dosing method.
- (6) Can pump to pretreatment or dispersal component at higher or lower elevations.

**Figure 43. Typical pumps used in dosed-flow distribution networks**

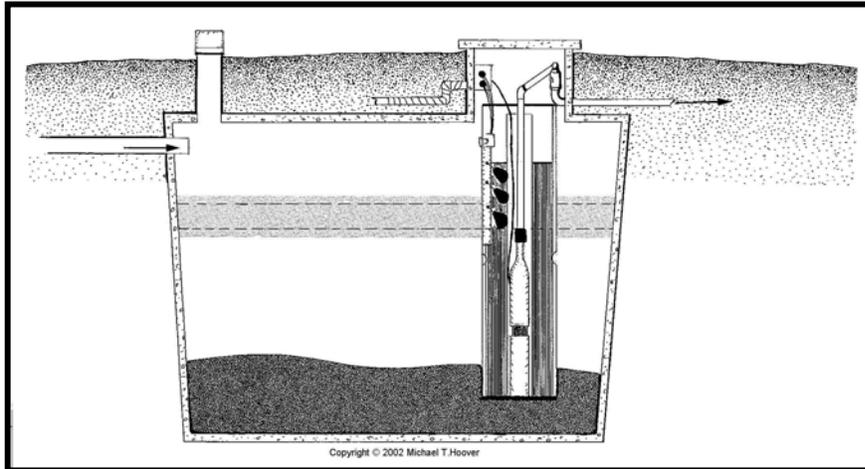


- (7) Other subcomponents of dosed-flow distribution network using pumps.
- (a) The pump or timer is controlled either by floats or other mechanisms that operate on pressure differentials.
  - (b) Alarms, which are activated either by floats or pressure differentials, indicate if there are problems with the pump, the power supply, or the volume of the influent.
  - (c) Many of the subcomponents of a pump system are contained in a tank. In a timed system, the tank is frequently called a surge tank or a flow equalization tank. This tank may be a separate tank or a separate compartment in a pretreatment tank. The pump chamber should be watertight and have access to the final grade. **Figure 44** depicts a typical pump tank.
  - (d) These are typically the same size as the septic tank unless for specialized systems. They usually provide for at least 24 hours of emergency storage in the case of pump failure.
  - (e) Constructed similarly to septic tanks, most are precast concrete tanks.
  - (f) The same specifications regarding structural integrity and water tightness apply here.
  - (g) A secure access riser must be provided above grade for purposes of monitoring and access for maintenance.
  - (h) The same functions are sometimes performed via a vault in a pump chamber or even in a single compartment septic tank, using either a centrifugal or turbine pump. See **figure 45**.

**Figure 44. Typical pump tank**



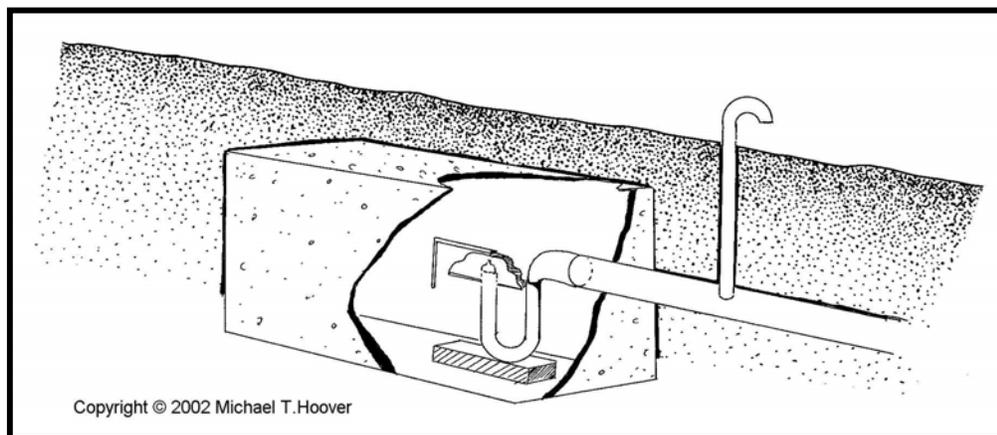
**Figure 45. Typical pump vault in a pump tank**



b. Siphons

- (1) Passive dosing device that discharges a set dose when liquid levels in a chamber displace the air in the trap of a siphon. See **figure 46**.
- (2) Can only be part of a demand system.
- (3) Two siphons in a chamber can be used to alternate dosing to different systems.
- (4) Proper installation and maintenance is critical to proper operation.
- (5) Does not require power.
- (6) Will only function if the pretreatment or dispersal component receiving the dosed flow distribution is at a lower elevation than the siphon discharge by at least several feet.

**Figure 46. Typical siphon in a chamber**



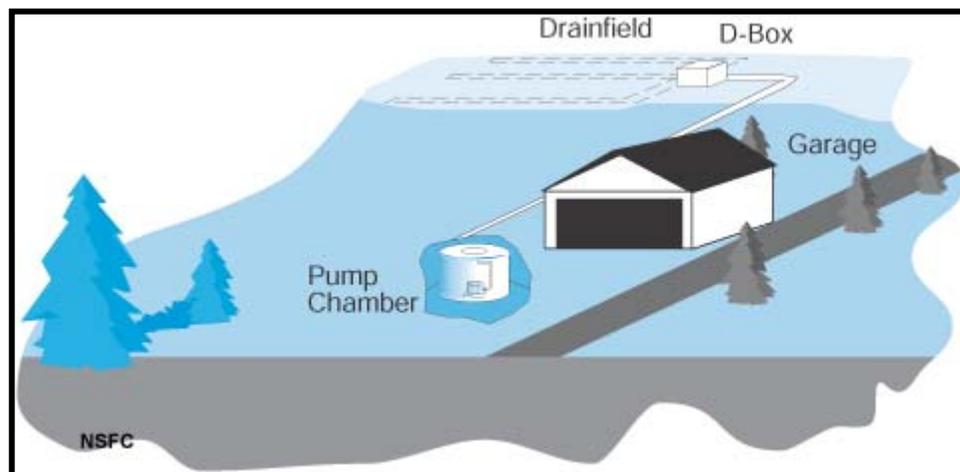
C. Options

1. Dose to gravity flow distribution

a. **Description**

- (1) The pump or siphon discharges a predetermined dose to a 4-inch perforated pipe network that is designed using one of the gravity-flow distribution network options. See **figure 47**.
- (2) The dose then flows down the pipe, though not uniformly throughout the piping network.

**Figure 47. Typical dose to gravity system**



b. **Other pertinent information**

- (1) Many of the advantages of a dosed-flow distribution network are lost due to the reduced uniformity of distribution throughout the length of the piping network.
- (2) The piping network may consist of pipes in independent trenches or it may be looped.
- (3) Typically used where the component being dosed is located at a higher elevation than the pump dosing the system.

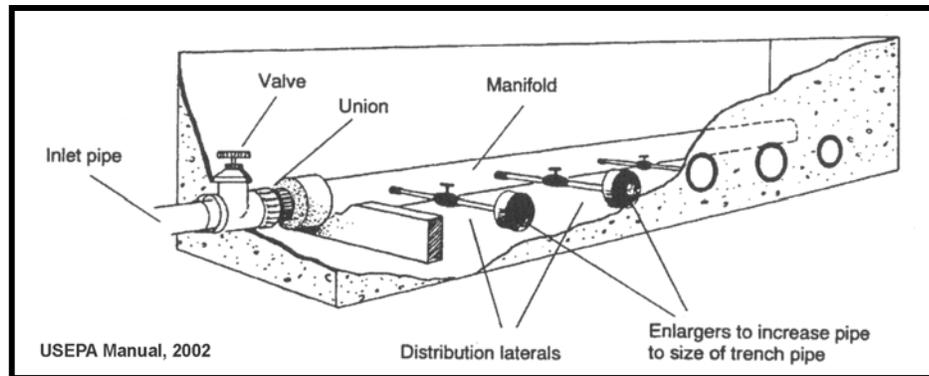
2. Pressure manifold

a. **Description**

- (1) Consists of a several inch diameter pipe (manifold) tapped with small diameter outlet pipes. See **figure 48**.
- (2) The small diameter outlet pipes allow the large diameter pipe (manifold) to become pressurized, which results in equal amounts of flow out of each of the outlet pipes.

- (3) The small diameter outlet pipes discharge to a typical gravity-flow distribution network.

**Figure 48. Typical pressure manifold**

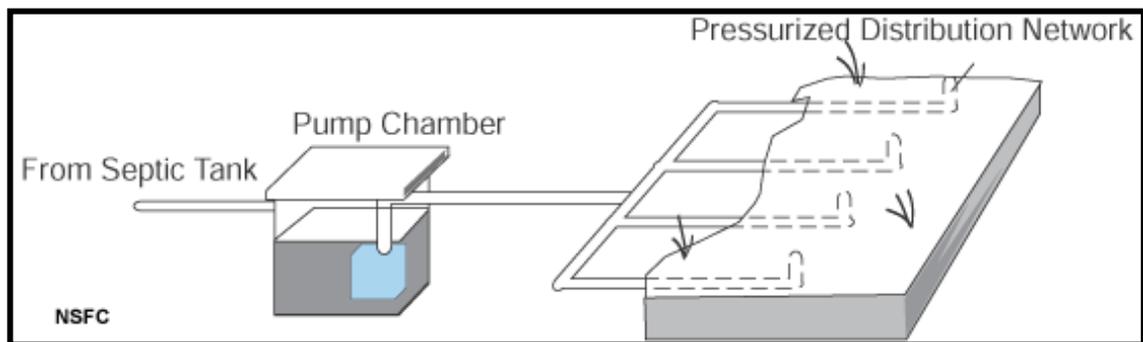


- b. **Other pertinent information**
  - (1) The manifold must be located at a higher elevation than the laterals to which it drains.
  - (2) This dosed-flow distribution option provides more accurate and consistent division of flows to each of the distribution pipes than does a distribution box.
  - (3) Because flow in the piping network in the final treatment and dispersal trench or bed then occurs by gravity, this method has similar shortcomings to gravity-flow systems.
  - (4) The piping network may consist of pipes in independent trenches or it may be looped.
  - (5) A version of this can be used in a pressure distribution network.
  - (6) Valves may be placed on each outlet pipe allowing the opportunity to rest or repair individual lines.
  - (7) In areas with cold climates, the pressure manifold may drain back to the dose tank after each dose or be protected from freezing.
  - (8) There are public domain and commercially available products available that perform this function.
3. **Pressure distribution**
  - a. **What is it?** A method of distributing effluent to a pretreatment (such as a media filter) or final treatment/dispersal component that results in similar amounts of effluent being discharged to each square foot of infiltrative surface. See **figure 49**.

b. **What does it consist of?**

- (1) The normal components of a dosed flow distribution process that provide the capability for dosing a predetermined volume and pressurization of the distribution network. The dosing device is measured in gallons per minute.
- (2) Transport line, force main, manifolds, valves, laterals, lateral turn-ups and cleanouts, and orifices in the laterals
  - (a) Transport and manifold lines are typically 1 ½ to 3 inches in diameter.
  - (b) Laterals are typically 1 to 2 inches in diameter.
  - (c) Orifices are typically 1/8 to ¼ inches in diameter and are typically oriented in the 6 o'clock or 12 o'clock position.
  - (d) Spacing of the orifices and laterals vary depending on how uniform the distribution has to be. Typically, there are 4-15 ft<sup>2</sup> of infiltrative surface per orifice.

**Figure 49. Typical pressure distribution network**



c. **How does it work?**

- (1) A predetermined quantity of effluent is collected in the pump tank.
- (2) At a predetermined volume or time frame, a pump or siphon discharges the effluent to a distribution network.
- (3) Because of the smaller diameter pipe and orifices, the distribution network pressurizes rapidly allowing most of the dose volume to be discharged when the network is fully pressurized.
- (4) The greater the uniformity of distribution by the network, the greater is the uniformity of the loading on each square foot of infiltrative surface. This results in unsaturated flows in the soil or other media occurring at a shallower depth.

d. **Why and where is it used?**

- (1) Where uniformity of distribution is vital. Examples would include, a drainfield located in coarse or shallow soils or in a pretreatment process using a coarse media.

- (2) Some locations allow a shallower depth of unsaturated, permeable soil than what would be required for a gravity-flow system.

e. **Design considerations**

- (1) These are low-pressure systems, with typical residual heads of two to five feet.
- (2) The design needs to assure the vast majority of a dose volume is discharged when the network is fully pressurized. Thus, steps should be taken to minimize volumes redistributed throughout the network when the system is pressurizing and after the dosing device has stopped discharging effluent.
- (3) Maximum differentials in flow from orifices at different locations in the distribution network exist to help assure uniformity of distribution. Careful design considerations must be taken when designing these systems on a sloping site.
- (4) The smaller the orifices, the greater the potential of plugging. To help counteract, as the orifice diameters approach 1/8 inch, the required residual pressure is usually increased to increase velocities to help keep the orifices clean. It is recommended that the effluent be refined with high capacity effluent filters or pressurized filters prior to dosing the laterals.
- (5) The smaller the orifices and the greater their spacing, the faster the distribution network will pressurize. Also, the pump and dose volume requirements will decrease.
- (6) When the orifices face the 12 o'clock orientation, the network will pressurize more rapidly. However, unless the system is designed to drain back to the pump chamber, as is routinely done in many cold weather areas, the orifices will plug more readily due to build-ups of biological growth and effluent standing in the lateral. This will require more frequent cleaning. When oriented in the 12 o'clock position, orifice shields or a perforated sleeve must be used.
- (7) Valves of different types (ball valves, check valves, etc.) have been increasingly used. The valves offer significant control and flexibility. However, they provide potential "weak points" if on going needs for monitoring and maintenance are not met. Concerns with valves include: they may freeze and crack in cold weather areas, solids may get hung up on edges of the valves, valve boxes provide a route of access in which someone may inadvertently or on purpose adjust the system hydraulics.
- (8) Various motorized and non-motorized valves are available to split flows into two or more distribution networks in order to help keep the required pump or siphon capacity reduced.
- (9) The allowable lateral lengths can be, depending on the choices the design professional makes and the area available, much longer than those typically

permitted for non-pressurized laterals.

- (10) Can be used to dose multiple trenches of unequal length.
- (11) Effluent filters are commercially available that filter solids under pressurized conditions. They typically are connected to the discharge of the pump when used.

f. **Installation considerations**

- (1) The devices that activate the pump and alarms must be set properly.
- (2) If valves (for example, ball or gate valves) are used to equilibrate flows throughout the distribution network, they have to be properly adjusted as part of the installation process.
- (3) Pressure testing of the network should be done to assure both the construction and design are accurate.

g. **Operation, monitoring & maintenance considerations**

- (1) The functioning of the dosing device and the devices that control it and the alarms need to be monitored and maintained by a well trained and certified professional.
- (2) Determination of drawdown times and distances, residual pressures, the number of doses or pump-run time since the last inspection are routine activities during monitoring inspections.
- (3) Periodically, the laterals will have to be cleaned out, so access to the surface for each individual line is critical. Failure to flush out laterals on a regular basis (sometimes as frequently as 6-12 months) will result in orifice plugging and unequal distribution.

4. Drip distribution

a. **What is it?** A pressure distribution network that delivers small, precise volumes of pretreated wastewater at slow controlled rates (measured in gallons per hour) directly to the soil.

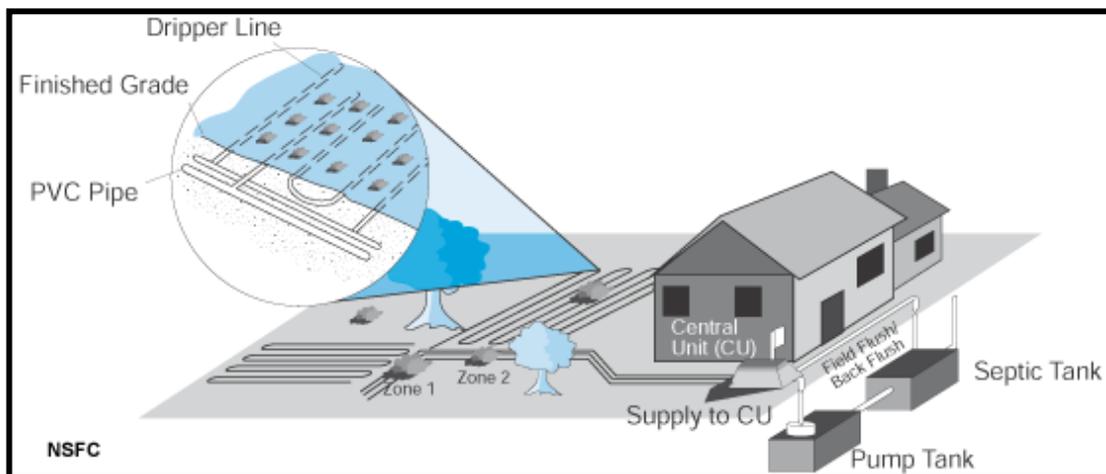
b. **What does it consist of?** See **figure 50**.

- (1) A set of mechanical components including:
  - (a) A pump.
  - (b) A filter to remove solids bigger than 100 microns - disk filter, spin filter, pressurized sand filter.
  - (c) A pressure regulator, when a non-pressure compensating (turbulent) emitter is used in the drip line.
  - (d) A controller – mechanisms that control pump operation, alarms, and flushing of filters and lines.
- (2) Drip dispersal components
  - (a) Supply line and manifold – extends from the pressurization device to a

drip zone's manifold to the drip lines that are arranged in one or more zones.

- (b) Drip line – ½ inch diameter polyethylene tubing.
- (c) Emitters – devices with orifices in them that are embedded along the inside of the drip line at a set distance. There are two types of emitters - turbulent flow (non-pressure compensating) out of which the flow increases as the pressure increases or pressure compensating out of which the flow remains relatively constant as the pressure changes.
- (d) Vacuum breakers/pressure relief valves to minimize the suction of soil into the pipe through the emitter when the pump shuts off.
- (e) Return line and manifold to collect liquid from the drip lines and return the liquid to the pretreatment unit.

**Figure 50. Typical dripline network layout**



**c. How does it work?**

- (1) Wastewater is drawn from the pump chamber by the pump to dose the system. Preferably, this is on a timed cycle. Depending on the system size and the design flow, there are usually two or more drip zones.
- (2) Before entering the network, the effluent passes through a filter to remove solids so they won't plug the emitters. Some of the filtering mechanisms have backflush mechanisms built in that help keep the filter open.
- (3) A supply line takes effluent and discharges it to one or manifolds, each serving one zone. The manifold discharges the effluent to the driplines connected to it. Effluent then flows out of the emitters directly into the soil.
- (4) Periodically, a valve on the return manifold is opened, either manually or automatically, and effluent flushes through the dripline to keep it and the

emitters open. Effluent then flows into a return line carrying flow back to the pretreatment mechanism. Some designs will have individual return lines for each of the driplines.

**d. Why and where is it used?**

- (1) This distribution method is the most efficient for achieving uniform distribution.
- (2) May be used anywhere pressure distribution or other distribution means are required or desired, including mounds and sand filters.
- (3) May be used for sites not suitable for other systems, because soils are too shallow or slowly permeable, as long as sufficient area exists.
- (4) May be more useable than other distribution methods on difficult sites, sites that are wooded or irregularly shaped, or have steep slopes, compacted soils.
- (5) Used for reuse applications, for example landscape irrigation.
- (6) Causes less site disruption during construction.
- (7) Because of its shallower installation lack of a need for any media below the pipe, uses more of the soil depth for treatment.

**e. Design considerations**

- (1) The effluent must be treated/filtered to reduce the potential for emitters to clog.
- (2) Time dosing is usually required.
- (3) High head, low flow pumps are typically used.
- (4) Routine system functions (timed dosing, filter backflush, lateral flushing) can be performed manually, but are easily automated with electric solenoid valves and automatic controllers.
- (5) Certain depths of unsaturated soil are required below the driplines to provide an adequate treatment zone below the pipe. This depth is maximized, as there is no gravel below the pipe.
- (6) Pressure compensating emitters provide more uniform distribution while under pressure than turbulent flow emitters. However, they are more expensive.
- (7) The hydraulic loading is expressed in terms of footprint area, as in gallons/day/ft<sup>2</sup> over the entire surface area, not square feet of infiltrative surface.
- (8) Long lateral runs are possible if needed. However, head losses due to friction are great because of the small diameter dripline with its in-place emitters. Manufacturers limit lateral length to approximately 250-300 feet.
- (9) Check valves are used to isolate zones if one common return line is used.
- (10) In colder climates, it is recommended that the driplines be placed a bit deeper, with a good growth of turf grass established over it. Dripline

networks have performed successfully in cold climates at installation depths of 6-8 inches.

**f. Installation considerations**

- (1) Dripline is commonly plowed or inserted into the soil with minimal disturbance of the soil. No media, such as gravel is placed in the narrow trench in which the dripline is placed.
- (2) The installer needs different equipment to install this system.
- (3) The driplines are connected to the supply and return manifolds with a flexible PVC pipe or tubing. A dripline should not be connected directly to a manifold, as the potential for kinking is significant.
- (4) The minimum installation depth is typically 6 inches, though the installation may be a few inches deeper in areas with freezing concerns. After the initial installation in a cold climate area, mulching over the network may be considered, at least until the turf grass is established.

**g. Operation, monitoring & maintenance considerations**

- (1) Manufacturers try to minimize the clogging of emitters with emitter design features. Some use biocide impregnation of the dripline. The dripline must be flushed on a regular basis. Flushing can be done on a continuous or on an intermittent basis.
- (2) Periodic residual pressures and water flow measurements are important to check for emitter and filter clogging.
- (3) Recommended monitoring devices available include pressure indicators and flow meters. Mechanisms are available that will allow a management entity to access system performance information via the internet.

## FINAL TREATMENT/DISPERSAL COMPONENTS

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**Component Purpose:** After sufficient pretreatment has been provided, the treated effluent must be assimilated back into the water cycle and environment in such a way that public health and environmental quality are not compromised. In most cases, this component provides additional treatment (may be where the bulk of treatment occurs) prior to discharge to the receiving environment. It is the final component in an OWTS. There are several options available:

- a. Subsurface application.
- b. Atmospheric application.
- c. Surface application onto the surface of the land and into surface water. Little detail will be given on these options since other manuals and training materials already exist for these options.

### Component Options:

#### I. SUBSURFACE DISPERSAL

- A. These options utilize application/distribution components that discharge pretreated effluent into the soil. In most cases this is into original, undisturbed soil. In other cases, the discharge is into properly prepared soil or select sand media that then discharges treated effluent into original undisturbed soil. It is this native or selected soil media that provides additional treatment prior to dispersal into the subsurface receiving environment.
- B. As the levels of treatment in components preceding the drainfield increase, the drainfield's purpose becomes more "dispersal" or discharge oriented.
- C. The point of application into the soil should be in the top two or three feet to assure it is

located in the aerated zone of the soil to allow aerobic microorganisms and other aerobic treatment processes to better occur.

- D. Typically, a specified depth of original, undisturbed unsaturated soil is required for the effluent to travel through. This distance is measured vertically from the point of application into the soil. For a drainfield this is the trench or bed bottom. For a subsurface drip component using a dripline distribution network, this is the bottom of the dripline. The characteristics of this soil help the design and regulatory professionals determine what the system requirements will be, including what level of pretreatment is needed and how big the drainfield will be. Most current onsite wastewater regulations or codes require a vertical distance of at least 18 inches from the infiltrative surface (point of application into the soil) to a restrictive layer, bedrock, a high water table or an unsuitable soil horizon.
- E. Typically, an area containing the same soil and site requirements must be set aside so that a repair or replacement system can be installed if needed. This is usually called a reserve or replacement area.
- F. This is the preferred and most frequently used option for assimilating the effluent into the receiving environment.

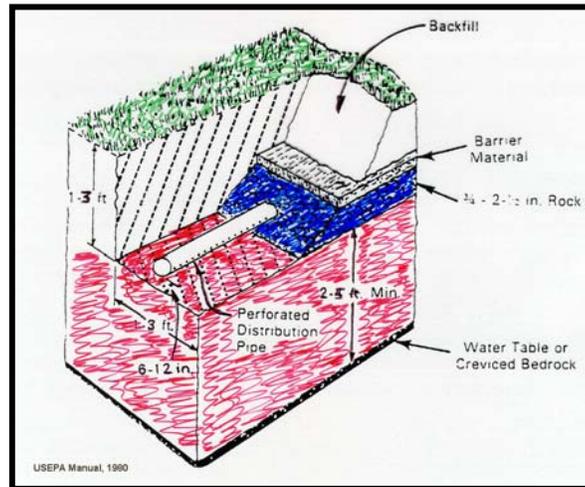
1. **In ground components**

a. Drainfield

(1) **What is it and what does it consist of?**

- (a) A network of trenches or beds containing gravel and pipe or one of the gravelless products – See **figure 50**. It is designed to distribute pretreated effluent to the infiltrative surface at the soil interface at the bottom of the trench/bed where the final treatment starts occurring prior to final discharge to the subsoil environment. A trench is typically three feet wide or less and a bed is typically greater than three feet in width. The width definitions for trench and beds will vary from jurisdiction to jurisdiction.
- (b) The point of application into the soil or infiltrative surface, from which the required vertical distance is measured, is the bottom of the trench or bed.
- (c) Gravel or one of the gravelless products – the interface with soil at bottom of the trench or bed should be as shallow as possible, with the desired depth to be less than 3-4 feet of soil to assure the soil remains aerated. This interface is to be level throughout any one trench or bed with the length of the trench being parallel to the contour lines.
- (d) A network of piping in gravel or one of the gravelless products. If gravel is used, a trench will contain one distribution pipe. A bed will contain multiple distribution pipes laid typically three to six feet apart.
- (e) Effluent can be distributed by gravity or dosed flow to the infiltrative surface (See Application/Distribution Component section).

**Figure 51. Cross-section of typical drainfield**



- (f) Barrier –Barrier material placed over the aggregate (gravel) in a trench or bed prevents soil fines from migrating from the back fill down to the infiltrative surface at the bottom of the gravel and plugging the pores in the soil. Historically this has consisted of building paper, straw or hay, which should no longer be used. Synthetic filter fabric (geotextile) is strongly recommended, as it doesn't decompose over time.
- (g) The backfill should allow water and air to move through it. No depressional spots should remain after settling to collect surface water.

**(2) How does it work?**

- (a) Effluent flows from the pipe (or gravelless technology) down through the gravel or gravelless technology into the soil. Effluent movement through the soil is designed to occur in an unsaturated flow, maximizing the potential for treatment in the soil via physical, chemical and biological means.
- (b) Especially when gravity distribution is used, a biomat is expected to develop due to physical, biological and chemical reasons. Initially, most of the effluent flows to just a short part of the drainfield, the biomat quickly forms forcing the liquid to flow outward until the entire bottom infiltrative surface has a biomat. The effluent flows through the biomat and receives treatment in the process. Additional treatment occurs in the soil below the biomat.

**(3) Why and where is it used?**

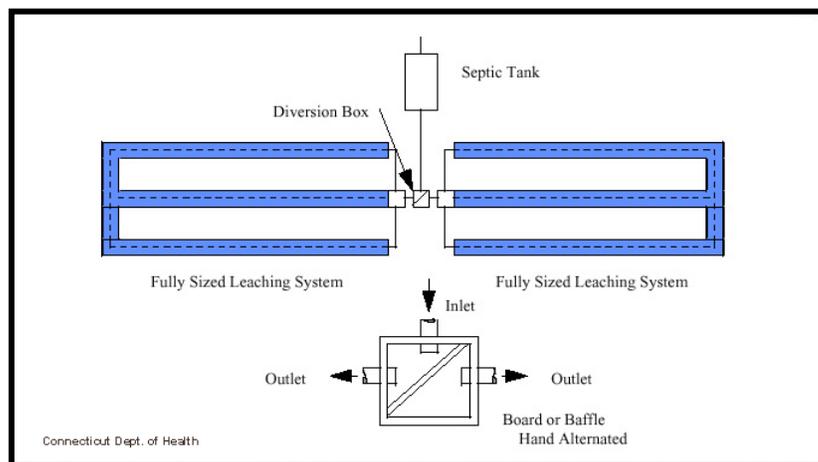
- (a) Where the soils are deep enough to provide adequate treatment.

- (b) They typically are the simplest and least inexpensive final treatment/dispersal component.
- (c) Where gravity-flow or pressure distribution is useable.

**(4) Design considerations**

- (a) The infiltrative surface consists of the bottom and/or sidewall areas of the trench or bed. It is sized using the soil characteristics and the daily design flow. Recently, wastewater quality has been added to the parameters that may affect sizing of the infiltrative surface.
- (b) Depending on the shape of the available area and the method of distribution used, drainfield configuration will differ substantially, including the number, length and configuration of the drainfield trenches/bed.
- (c) Usually, an additional area with acceptable soil and site conditions must be set aside (often referred to as the reserve or replacement area). This is for installing a replacement drainfield in case the initial drainfield fails.
- (d) The reserve drainfield can be installed at the same time as the primary drainfield, especially where the reserve area may be difficult to get to. If this is done, the flow can be periodically diverted from one field to the other. This is called an “alternating drainfield” system. While this is usually done with a drainfield served by gravity-flow distribution, it can also be done with any dosed-flow distribution network. See **Figure 52**.

**Figure 52. Typical alternating drainfield**



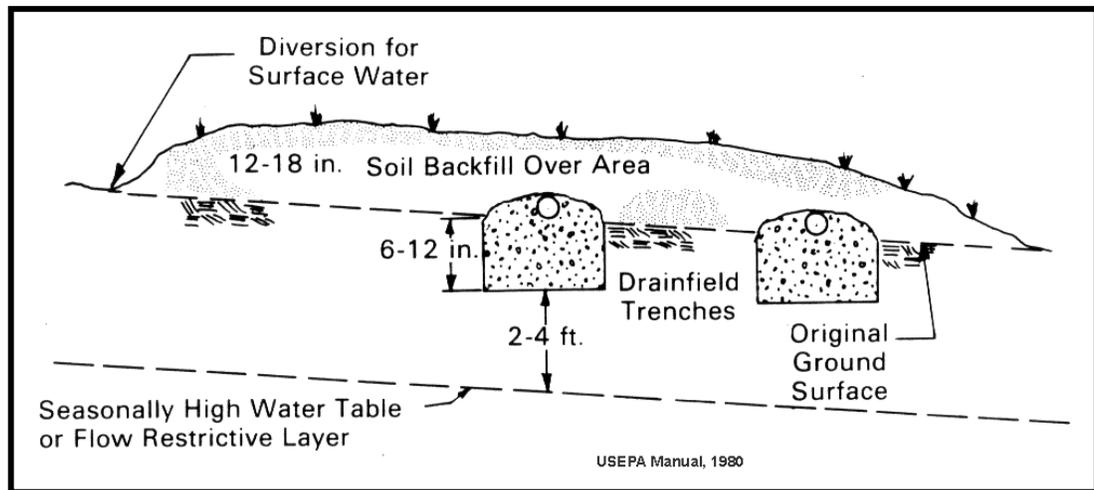
- (e) Soils may be too shallow to allow installation of a drainfield at the normal depth. However, many jurisdictions permit a drainfield to be installed in

the upper portions of the soil profile with a capping fill used to cover the system, if sufficient soil depth permits. **Figure 53** depicts a typical capping fill or shallow placement drainfield when a trench being fed by gravity or dosed distribution is used.

**(5) Installation considerations**

- (a) The bottoms of each independent trench/bed in a drainfield must be relatively level and placed on the contour in order to utilize the total infiltrative surface area and to minimize the potential localized overloading.
- (b) It is critical that trench installation does not occur in saturated soil conditions as smearing and compaction will occur. Thus, the moisture content of the soil and the installation techniques used during the installation are critical.

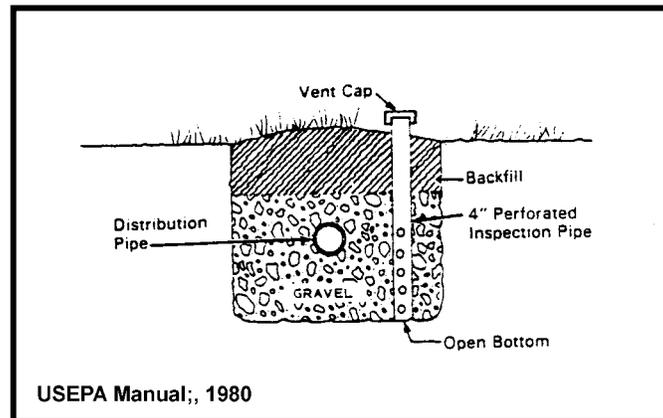
**Figure 53. Typical capping fill or shallow placement drainfield**



**(6) Operation, monitoring & maintenance considerations**

- (a) Inspection ports can be installed from the final grade down to the infiltrative surface, which will allow an observation to be made about the performance of and ponding in each trench or bed. See **Figure 54** for an example of an observation port.

**Figure 54. Typical observation port**

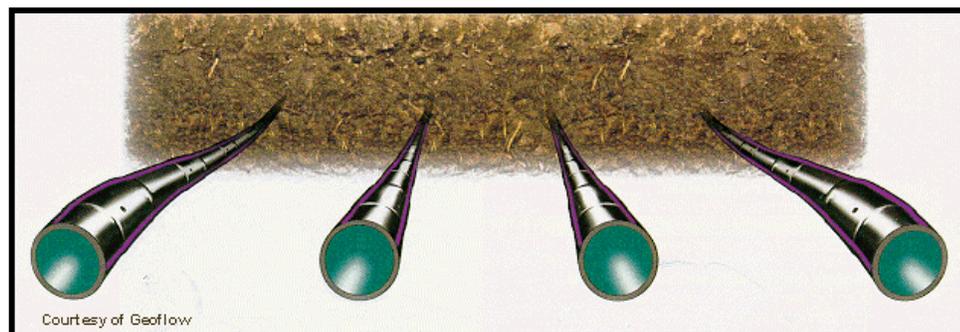


(b) Inspection ports can be installed from the final grade to a restrictive layer, which will allow an observation to be made the level of groundwater rise above the restrictive layer.

b. **Drip field - Additional pertinent information**

- (1) This component consists of a drip distribution network being placed into the original, undisturbed soil. Most of the detail on this option was presented when drip distribution was discussed in the “Application/Distribution Component” section. The detail will not be restated. Used in this way, this component becomes a final treatment/dispersal component.
- (2) Consists of a network of small diameter pipe (drip distribution network) inserted into the soil and the soil. Effluent discharges from the emitters directly into the soil. Neither gravel nor any of the gravelless products are part of this option. See **figure 55**.

**Figure 55. Cross-section of typical drip field**



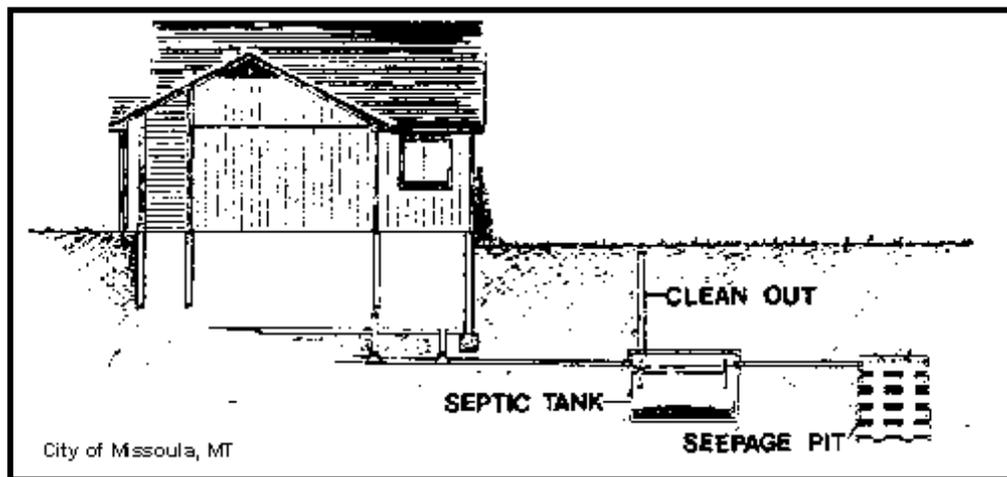
- (3) The point of application into the soil, from which the required vertical distance is measured, is the bottom of the dripline, where it contacts the soil.

c. Seepage pit

(1) **Description:**

- (a) A deep excavation where the sidewall of the excavation is designed to be the infiltrative surface through which the effluent will be discharged into the soil.
- (b) Covered, porous chambers are placed in the excavation and surrounded by crushed rock or gravel.
- (c) Effluent flows from a pretreatment component into the chamber where it is stored until it seeps out through the chamber wall through the sidewall of the excavation. See **figure 56**.
- (d) They are sometimes called “dry wells.”

**Figure 56. Typical seepage pit system**



(2) **Other pertinent information:**

- (a) They are generally discouraged in most locales in favor of other final treatment/dispersal components.
- (b) The primary uses have been:
  - i. Where lots are too small to place a drainfield or a drip system.
  - ii. Where the top several feet of a soil profile are not acceptable, but are underlain by non-water bearing acceptable soil materials.
- (c) Higher levels of pretreatment should be obtained prior to discharge to the seepage pit. Periodically, seepage pits are installed as a repair when nothing else will fit.

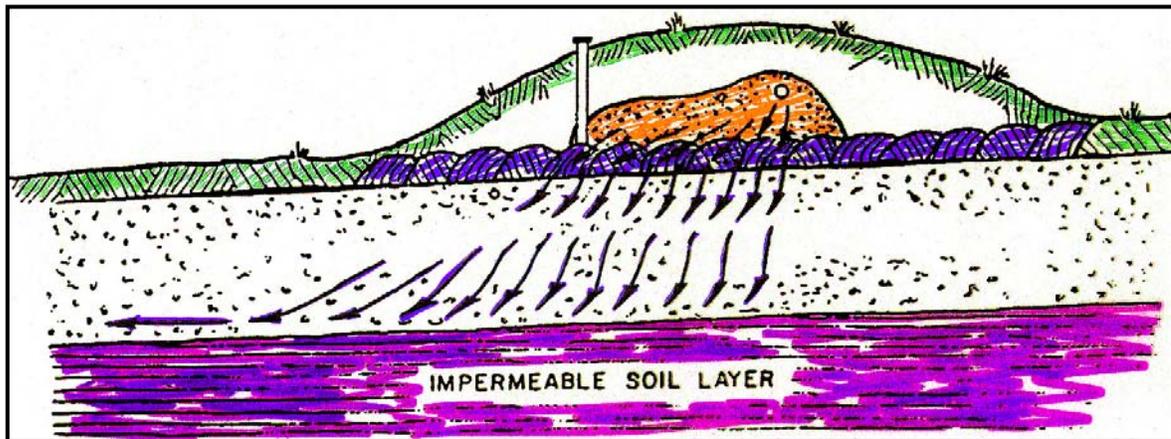
- (d) Maintaining sufficient separation between the bottom of the pit and a high water table or other restrictive layer is mandatory.

2. At-grade

a. **What is it and what does it consist of?**

- (1) A component that uses the total available soil profile as the treatment zone because the point of application/infiltrative surface is at the original grade.
- (2) The at-grade component consists of: (see **figure 57**)
  - (a) A properly prepared original soil surface.
  - (b) A layer of gravel or drain rock in which a distribution network is placed. At least 6 inches of gravel/drain rock are below the distribution pipe.
  - (c) A distribution network being fed by gravity or dosed flow.
  - (d) A barrier (geotextile is strongly recommended) placed on top of the gravel/drain rock.
  - (e) Suitable cover material with grass growing on it.

**Figure 57. Cross-section of typical at-grade component**



J. Converse, Small Scale Waste Management Project

b. **How does it work?**

- (1) Effluent flows from a pretreatment component into the distribution network. Usually, pressure distribution is used.
- (2) The effluent flows downward through the gravel to the infiltrative surface.
- (3) The effluent flows into the original soil for final treatment and dispersal into the subsoil environment. On a sloping site, the flow will be down the slope across the infiltrative surface until the effluent has been fully infiltrated into the original soil.

c. **Why and where is it used?**

- (1) An at-grade component is used where the soils are too shallow to permit a drainfield but deep enough so a mound is not required. In other words, it is used where the available soil depth is at least equivalent to the required depth of vertical flow to assure satisfactory treatment.
- (2) It allows the use of native, original soils for final treatment and dispersal, including the typically more permeable surface soils.

d. **Other pertinent information**

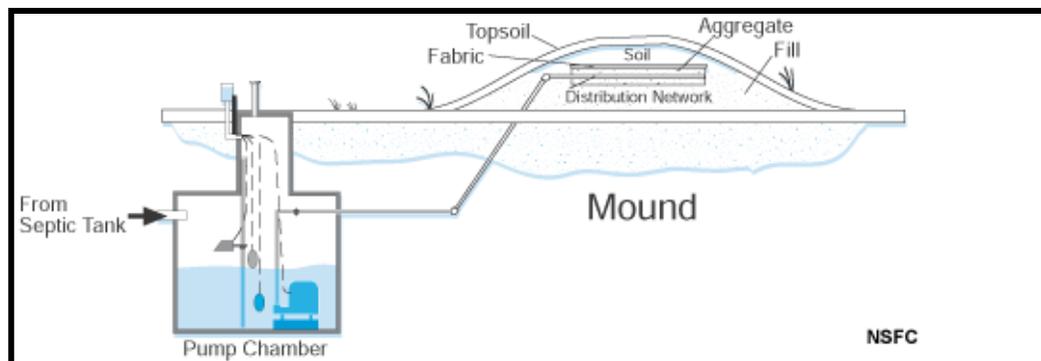
- (1) All systems should be as long and narrow as possible. Maximum linear loading rates of eight to ten gallons/day/lineal foot are typical, though linear loading rates are dependent on soil type and depth. As the flow becomes more horizontal due to shallower soils, the linear loading rates are reduced. The greater the spreading of the effluent across the width of the slope, the better the potential treatment in the soil should be.
- (2) On both sloping and flat sites, the preferred configuration is one single absorption area, rather than multiple absorption areas downslope from each other. Where the slope width is too narrow to permit long, narrow absorption area, multiple absorption areas can be built downslope from each other, each of them being parallel to the contours. In this situation, having sufficient separation between adjacent absorption areas is critical.
- (3) Siting and sizing requirements are similar to drainfields.
- (4) The maximum slope is typically 25% due to construction concerns. On a sloping site, the distribution pipe is typically located at the upslope end of the gravel/drain rock.
- (5) Pressure distribution is strongly recommended, especially on slopes greater than 15%.
- (6) The backfill used to cover the at-grade component should be a sandy loam to silt loam. It doesn't have to be the same clean sand used for mounds. Clay loams may also be used but may restrict oxygen transfer.
- (7) The cover should be carefully graded (usually a maximum slope of three or four feet horizontal run to one foot of vertical drop. Seeding with grass and mulching should then be done to help stabilize the material.
- (8) Proper construction of the at-grade component is critical. The original surface must be properly prepared by breaking up the surface without pulverizing it. This must be done when the moisture content is not too high or the original soil will be compacted. Additionally, care must be taken when placing the gravel or gravelless technology on the properly prepared surface.
- (9) It is imperative that surface waters be diverted away from the at-grade component.

### 3. Mound

#### a. **What is it and what does it consist of?**

- (1) A component that is typically constructed above the original layer of soil providing a zone where treatment can occur prior to dispersal or discharge into the underlying original soil. The point of application/infiltrative surface is in the media that makes up much of the mound. (See **figure 58** for cross-section of a typical mound.)
- (2) A “mound” of specific sand is placed on top of a properly prepared original soil surface.
- (3) Either a pressure distribution network in a bed or trenches or a dripline distribution network lay on top of the sand.
- (4) If a bed or trenches are used, either gravel or a gravelless technology can be used. If gravel is used, a barrier material is again used to prevent soil fines from the overburden migrating down through the gravel to the infiltrative surface.
- (5) A cap of suitably permeable soil that can be crowned and grow grass tops the mound.

**Figure 58. Typical cross-section of mound system**



#### b. **How does it work?**

- (1) Effluent is pumped to a pressure distribution network located in a bed or trenches or a dripline distribution network.
- (2) The effluent flows into the sand material where it receives a high level of treatment.
- (3) The treated effluent then flows into the underlying soil where additional treatment occurs before it disperses into the subsoil environment.
- (4) Effluent will either flow vertically downward in deeper coarse soils or laterally through a site’s shallow soil. Thus, it is important to assure there are sufficient setbacks from various features that can intercept the lateral flows.

c. **Why and where is it used?**

- (1) To provide treatment and discharge where insufficient soil depth exists to install a drainfield or drip system.
- (2) This technology is typically used at sites with shallow soil conditions over a restrictive layer, such as a ground water table, seasonally saturated soils, and bedrock.
- (3) It is also used on sites with either slowly permeable or excessively permeable (coarse) soils. Performance on such sites has been variable, ranging from acceptable to unacceptable.
- (4) A “mound” of sand is placed above properly prepared original soil.

d. **Other pertinent information**

- (1) Some jurisdictions allow a gravity-flow distribution network, but it is not recommended.
- (2) Some jurisdictions allow fill material other than sand, but it is not recommended.
- (3) Most jurisdictions require pressure distribution or dripline distribution to assure uniformity of distribution. This is required to assure unsaturated flows in the sand media and the resulting good treatment. Timed-dosing is increasingly being required.
- (4) Requires a variable depth of sand, typically 1-2 feet.
- (5) Has very specific siting and setback requirements that may differ from normal drainfields. In some jurisdictions setbacks are measured from the mound’s toe, where the side slope intersects the original soil surface.
- (6) Requires very careful site preparation, design, and installation techniques.
- (7) As with drainfields, long, narrow systems are more desirable than short, wide ones. This is especially true on slopes, where the length of the mound must be parallel to the slope contours.
- (8) The expected effluent qualities at the bottom of the sand for a mound using pressure distribution are:

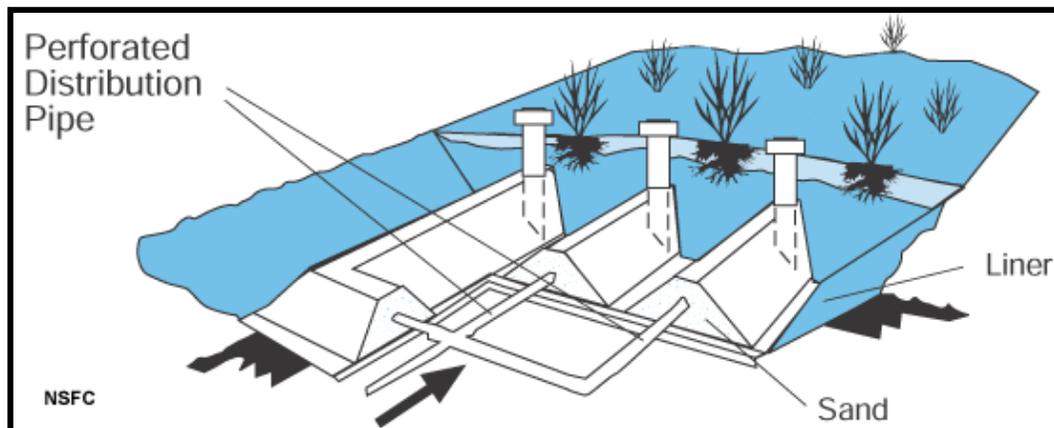
- i. BOD<sub>5</sub> - < 5 mg/l
- ii. TSS - < 5 mg/l
- iii. Fecal coliform - < 500 fecal coliform/100 ml

II. **ATMOSPHERIC DISPERSAL**

- A. Occurs through evaporation and transpiration by plants.
- B. Significant quantities of water can be dispersed into the atmosphere, especially during hot, dry and windy seasons.

- C. For year around use, only those areas where the annual evaporation exceeds annual precipitation can use this option. In the United States, this is going to be in parts of the Southwest. However, seasonal use of this dispersal option, especially during those hot, dry and windy seasons can significantly reduce the loading on subsurface dispersal components.
- D. While they don't account for it, other final treatment and dispersal options are designed to maximize the potential losses of liquid by evaporation and transpiration by placing the component in areas exposed to the sun and advection currents.
- E. Evapotranspiration beds
  - 1. **What is it and what does it consist of?**
    - a. A dispersal component designed to totally remove the liquid portion of a wastewater stream by direct evaporation and by plant transpiration into the atmosphere. This is called an ET system. See **figure 59**.

**Figure 59. Typical evapotranspiration (ET) bed**



- b. Sometimes, if soils are slowly permeable and infiltration poses no risk of contamination to the receiving environment, absorption into the soils is also an attribute of this component. This is called an evapotranspiration-absorption (ETA) or evapotranspiration-infiltration (ETI) system.
      - c. A method of pretreatment to remove most of the solids from the wastewater stream is required.
      - d. A bed containing a sand and/or gravel medium.
      - e. A liner, except for the ETA/ETI system.
      - f. A distribution network (typically gravity-flow).
- 2. **How does it work?**
  - a. Effluent from the pretreatment unit flows through the distribution network at the

bottom of the bed.

- b. Liquid wicks upward through the medium so it can be evaporated or transpired by plants.
- c. Effluent is stored in the bottom of the ET system until it is evaporated and transpired into the atmosphere.
- d. For an ETA system, some of the effluent infiltrates into the soil below the bed, reducing the amount of effluent, which must be discharged into the atmosphere.

### **3. Why and where is it used?**

- a. ET beds are used because they pose minimal risk to the environment because there is no discharge to the soil or subsoil environment.
- b. ET beds are only suited for an arid environment where potential evapotranspiration exceeds precipitation in most or all months of the year.
- c. ETA beds typically used where the soils are fine textured and/or compacted (have a slow permeability) and where no water table is close to the bottom of the bed.
- d. Used for seasonal homes/facilities where year-round use of an ET or ETA bed is neither appropriate nor practical.

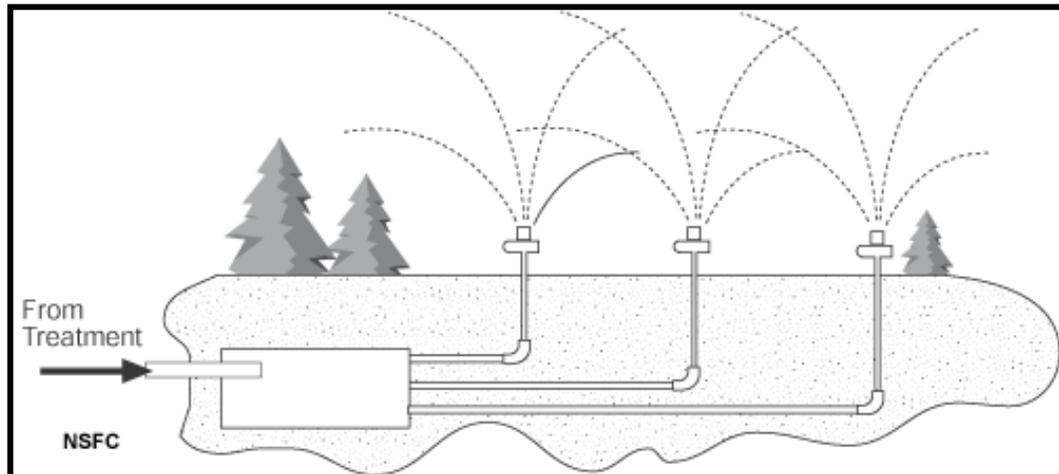
### **4. Other pertinent considerations**

- a. The depth of media must be shallow enough to allow wicking of the wastewater up through the media so evaporation can occur. A maximum of 2 to 2 ½ feet of typically fine sand overlain by a shallow layer of topsoil or loamy sand mix and underlain by up to a foot of gravel make up the media depth.
- b. Sand is used for the upper media to facilitate more wicking due to the greater surface area as compared to gravel.
- c. The surface of the bed may be planted with vegetation that is tolerant of moisture extremes to facilitate transpiration.
- d. The liner for ET beds is typically 20 or 30 mil PVC, though concrete has also been used. Also, evapotranspiration beds can have a natural liner, consisting of naturally occurring very slowly permeable soils.
- e. Placement of the ET or ETA bed to maximize exposure to wind currents and the sun is important to facilitate evapotranspiration.
- f. There have been historic problems with the integrity of the liner in ET beds.
- g. Poor design and construction can result in perforated liners, poor placement, use of incorrect wicking medium, compaction of the medium and inadequate protection from surface waters.
- h. An observation port should be installed from the final grade down to the bottom of the bed to allow periodic observations of the liquid depth.
- i. Most studies of ET systems have shown very unfavorable results. This has largely been due to errors in the design assumptions and/or installation errors.

### **III. SURFACE DISPERSAL**

- A. In most states, this option for the final treatment/dispersal of effluent is not permitted. However, in other states, these options, especially dispersal onto the surface of the ground, are widely used.
- B. Because of the increased potential for exposure of treated effluent to humans and animals, increased preventive precautions must be taken.
- C. Options:
  - 1. Surface of the ground
    - a. **What is it and what does it consist of?**
      - (1) A distribution network with some distribution means for spreading the pretreated effluent evenly on the ground.
      - (2) The soil through which the effluent must pass for final treatment/dispersal. Because the effluent is discharged onto the ground's surface, the entire assimilative capacity of the soil's profile can be used.
      - (3) Usually, some means of fencing or other protective measure.
    - b. **How does it work?**
      - (1) Effluent from pretreatment units flows through some type of distribution network.
      - (2) While there are a variety of surface of the ground dispersal methodologies available, the one most frequently used is spray irrigation. This will be the only ground surface dispersal option discussed in this publication. See **figure 60**.
      - (3) Spray nozzles are designed to evenly distribute effluent over the surface of the ground.
      - (4) Effluent sprayed from the nozzles and onto the ground is exposed to the sun and winds, with some of the effluent being treated and dispersed into the atmosphere. The bulk of the effluent infiltrates into the ground and is treated there, prior to dispersal into the subsoil environment, while another portion of the effluent is taken up by vegetation. Some may run off, especially during times of precipitation.
    - c. **Why and where is it used?**
      - (1) Where the soil and site conditions won't permit the use of a subsurface dispersal component.
      - (2) Where sufficient area exists to permit this option.
    - d. **Other pertinent information**
      - (1) Pretreatment, typically requiring aerobically treated effluent, together with disinfection, is required.
      - (2) On-going monitoring and maintenance, including required sampling in some cases, is required to assure the system is functioning as intended. Maintenance will include periodic inspection and cleaning/replacement of the sprinkler heads.

**Figure 60. Typical spray irrigation**



- (3) Fencing, or some other protective measure, is usually required to prevent humans or animals from entering the spray irrigation area.
- (4) Another option used to minimize the potential of exposure of humans or animals to effluent is to activate the spray irrigation network only during those times of the day when few, if any, humans or animals will be in the vicinity of the spray irrigation area. Sufficient storage area must exist to allow this, as well as to allow emergency storage if when there are electrical or pump malfunctions. This option will use a timer to control the dosing.
- (5) The requirements to be met to use this option make this an expensive system.
- (6) Usually a relatively large area is needed for the spray field and the substantial buffers. The area is determined by a thorough soil and site investigation. A hydraulic loading rate is selected depending on the anticipated infiltration rate of the soil.
- (7) While important for all OWTS, having a landscaping plan for this option is critical, including the type of vegetation to be planted. Prior to putting a spray irrigation system into use, the vegetation should be established, or at least planted or sodded.
- (8) Uniform distribution of the pretreated effluent over the ground's surface is critical. Both the uniformity of distribution and the timing of the doses are designed to prevent runoff.
- (9) Specific sprinkler nozzles are used that keeps the spray stream low and minimizes the creation of aerosols.
- (10) Having the piping network buried below the surface of the ground is recommended. For components above the ground, using permanently colored pipe (usually purple) will help identify the network as carrying non-potable

liquid (reclaimed wastewater).

- (11) Because of the difficulty in providing regulatory oversight and surveillance of the individual, privately operated discharges, this option is frequently discouraged or not permitted in most jurisdictions.
- (12) Effluent should not be applied during rainy or wet periods. Therefore, automatic dosing is not always feasible unless rain sensors deactivate the dosing cycle. Storage lagoons or large tanks may be needed to store effluent during the wet periods.

## 2. Surface water

- a. Prior to final discharge into surface water, the effluent must be pretreated to meet water quality criteria. The quality limitations vary depending on the specific use of the surface water resource.
- b. In the United States, a permit issued under the National Pollutant Discharge Elimination System (NPDES) is required. These permit systems, in the vast majority of cases, are issued by states.
- c. Because of the difficulty in providing regulatory oversight and surveillance of individual, privately operated discharges, surface water dispersal is usually discouraged, and in most jurisdictions, not permitted. Thus, this option will not be discussed further. If further information is desired, documents produced by the USEPA on this topic are available.

**Further sources of general information on technologies:**

Burks, B.D. and Minnis, M.M. Onsite Wastewater Treatment Systems. Hogarth House, Ltd., Madison, Wisconsin, 1994

Crites, Ron and Tchobanoglous, George. Small and Decentralized Wastewater Management Systems. WCB McGraw-Hill. 1998.

United States Environmental Protection Agency. 2002. Onsite Wastewater Treatment Systems Manual. February 2002. EPA/625/R-00/008.

United States Environmental Protection Agency. 1980. Onsite Wastewater Treatment and Disposal Systems Design Manual. October 1980. EPA/625/1-80-012.

A variety of other material (fact sheets, guidance documents, handouts, rules, regulations) from the National Small Flows Clearinghouse, USEPA, local training centers and local and state government. Many of the pictures and diagrams in the instructor's materials are from a variety of sources and individuals, including Dr. Jim Converse, Mike Davis, Dr. Mark Gross, John Higgins, Dr. Bruce Lesikar, Bill Stuth Sr., and Steve Wecker, who forwarded pictures to the writing team. Many of their pictures came from many other sources throughout North America, including various web sites and other individuals.