# GENERAL DESCRIPTIONS

**OF**

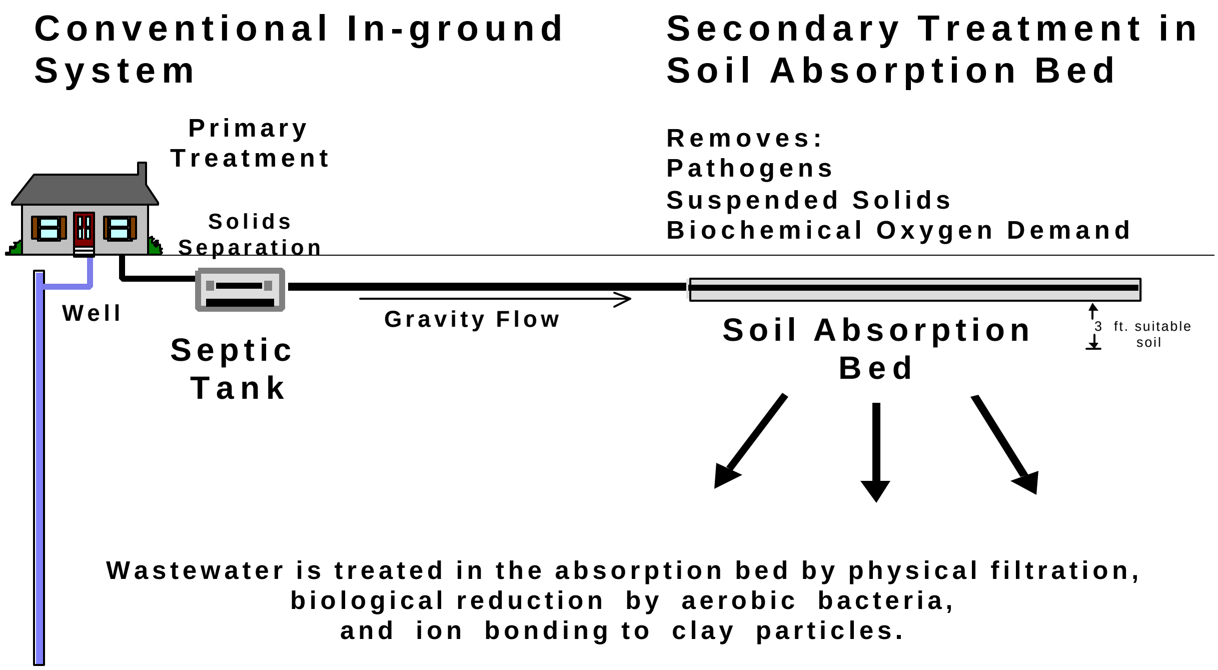
# COMMON TYPES

**OF**

# ONSITE SEWAGE SYSTEMS*

***Some of the systems described are not permitted for new construction under the current code in Wisconsin. See individual descriptions for details.

*Prepared by the State of Wisconsin Department of Commerce, Division of Safety and Buildings.Version date 8/17/99*




A conventional in-ground septic system consists of a septic tank and a subsurface soil absorption bed. In the septic tank, solids settle out of the waste stream and anaerobic bacteria facilitate the partial breakdown of organic matter (primary treatment). Clarified effluent from the septic tank discharges via gravity to a soil absorption bed.

The soil absorption bed removes pathogens, organic matter, and suspended solids from the septic tank effluent via physical filtration, biological reduction of contaminants by aerobic microorganisms, and ion bonding to negatively charged clay particles. The soil serves as a fixed porous medium on which beneficial aerobic microorganisms grow. These organisms feed on organic matter present in the wastewater and help eliminate pathogens. Research indicates that 3 feet of suitable soil between the distribution trench and bedrock or high groundwater is sufficient to protect public health and groundwater quality. Because a conventional system includes a gravel distribution trench and overlying fill material, the system requires about 5 feet of suitable native soil.

The conventional system is a passive system that relies on gravity flow. The flow volume entering the septic tank controls the volume discharge to the soil. The discharge enters the distribution pipe via gravity, and usually drains out of the first few holes in the pipe, creating areas of favored distribution. This type of distribution can result in localized clogging along the trench as solids and bacterial biomass accumulates in these areas of preferential flow. The effectiveness of a conventional system depends on the type and permeability of native soils and the slope and drainage pattern of the site. The septic tank requires periodic pumping of accumulated solids, as well as inspection to determine that the tank remains watertight.

The conventional system is typically the least expensive system in use in Wisconsin and it is also the most common. These simple, passive systems that rely solely on unsaturated soil for wastewater treatment have been codified in Wisconsin since 1969 and could be used on 47% of the state's land area. They are also in use in most other states. In Wisconsin, they still constitute approximately 63% of all new systems installed and 57% of all replacements.

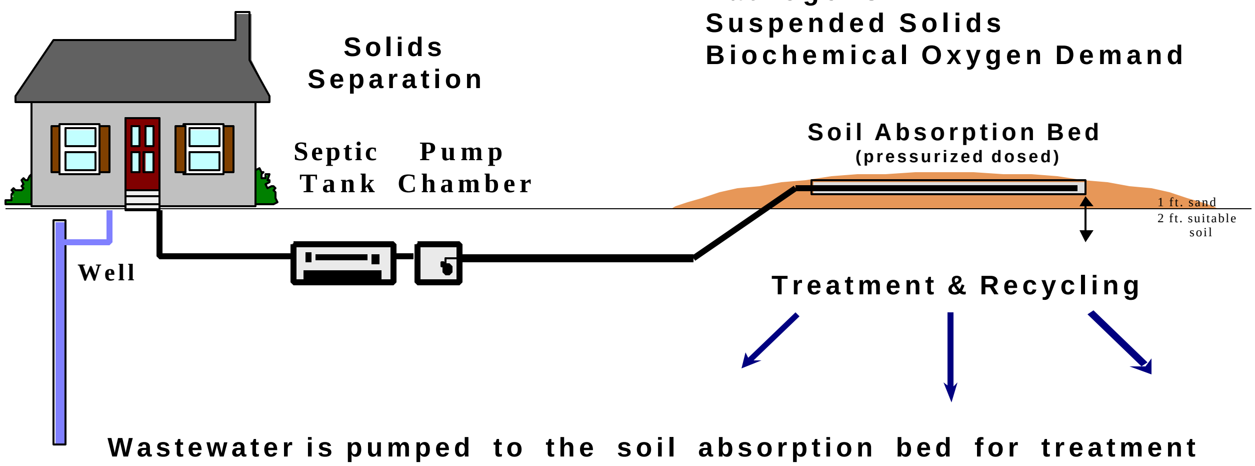
# Wisconsin Mound

## Secondary Treatment in Soil Absorption Bed

**Removes:**
**Pathogens**
**Suspended Solids**
**Biochemical Oxygen Demand**

**Primary Treatment**

**Solids Separation**




**Wastewater is pumped to the soil absorption bed for treatment by physical filtration, biological reduction by aerobic bacteria, and ion bonding to clay particles.**

A mound system, like a conventional system, consists of a septic tank and a soil absorption bed. In the mound system, however, sand is added where suitable native soil is insufficient. Clarified effluent from the septic tank is pumped, in controlled pressurized doses, to an aboveground, free-standing sand layer. The sand layer, placed upon a specially prepared area of native soil, serves as the medium on which aerobic bacteria facilitate much of the secondary treatment.

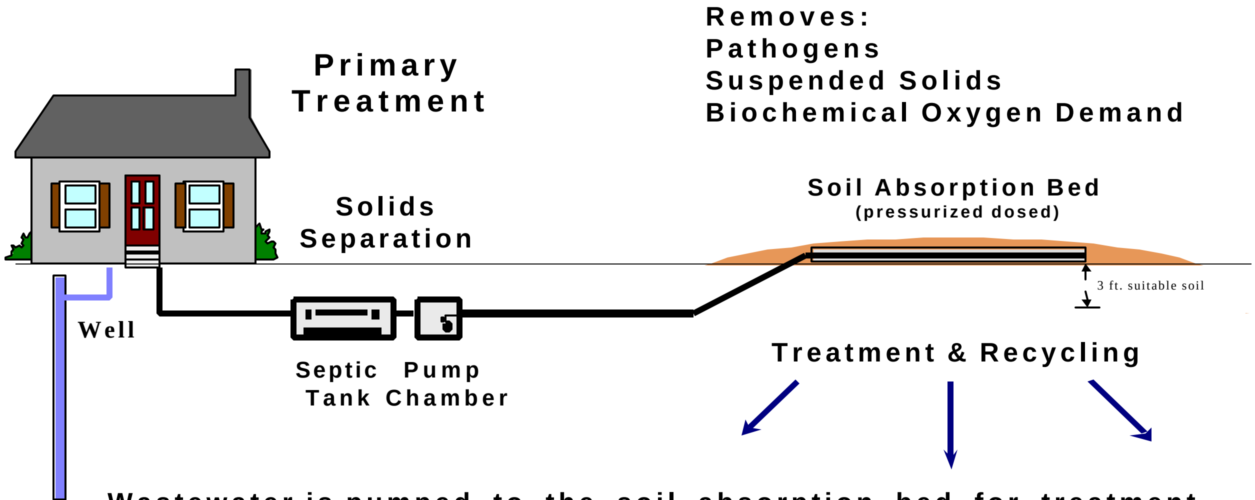
In a mound, the sand layer and native soil combined provide 36 inches of soil depth for treatment. Thus treatment is at least as effective as a conventional system. Delivering effluent to the soil absorption bed in controlled pressurized doses has some additional advantages. Wastewater is equally distributed, which reduces the chances for localized clogging. And the absorption bed has a "rest period" between doses that can result in superior pathogen and nutrient removal. Additional research over the past 20 years has provided increasingly effective specifications for mound geometry, sand characteristics, dosing frequencies, and loading rates.

Solids must be periodically pumped from the septic tank, as well as from the pump chamber to insure proper functioning of the pump mechanism. Proper site preparation protocols must be taken to prevent the leakage of effluent at the base of the mound.

The use of sand as a medium for wastewater treatment, rather than native soil, is more than 100 years old. In Wisconsin, beginning in 1971, the legislature funded research intended to provide effective systems for sites where a lack of native soil prohibited a conventional system. The mound system using sand as a medium became available for general use in 1980, but new construction was restricted to sites with 24 inches of native soil. This increased the suitable land area by 10 percentage points. There are no technical or public health reasons for this restriction. The proposed code will allow mound systems on sites with 6 inches of native soil, which will increase the suitable land area by another 25 percentage points. Currently, in Wisconsin, mound systems constitute approximately 20% of all new systems installed and 23% of replacements. These systems are also used in many other states.

# At-Grade

## Secondary Treatment in Soil Absorption Bed



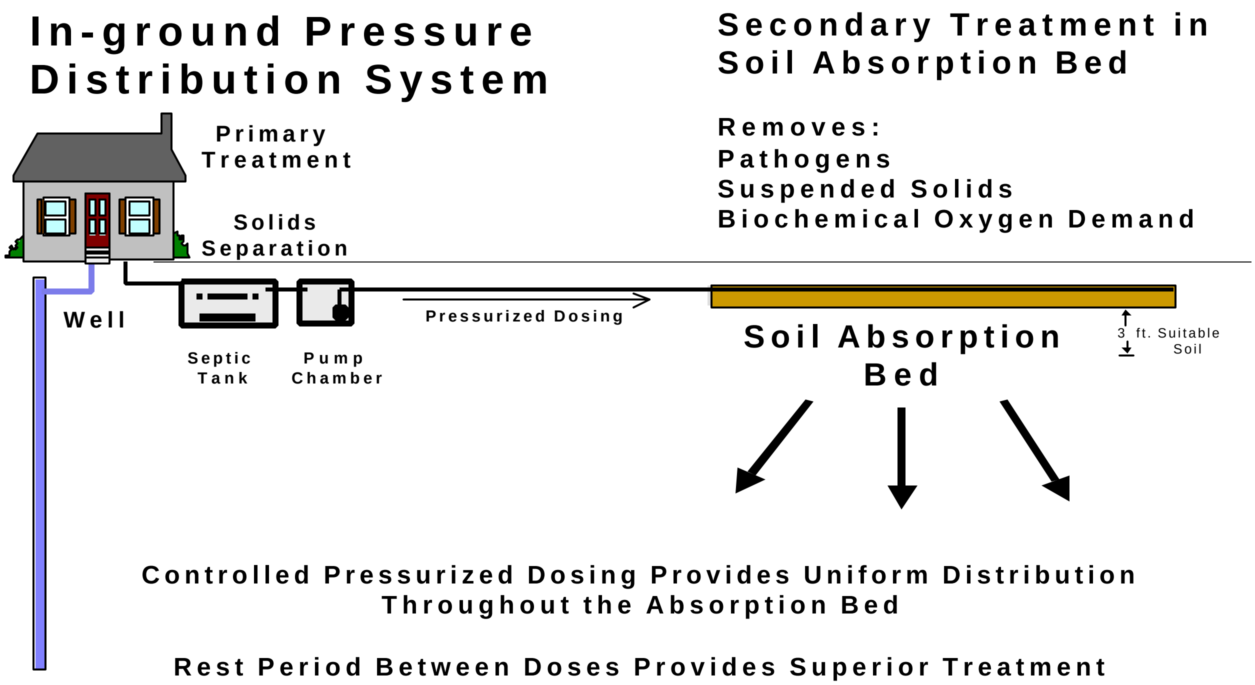

**Wastewater is pumped to the soil absorption bed for treatment by physical filtration, biological reduction by aerobic bacteria, and ion bonding to clay particles.**

An at-grade system consists of a septic tank, pump chamber, pressure distribution system and a soil absorption bed. In the septic tank, solids settle out of the waste stream and anaerobic bacteria facilitate the partial breakdown of organic matter (primary treatment). Clarified effluent from the septic tank is typically discharged via gravity to a pump chamber from which it is pumped, in controlled pressurized doses, up to the soil absorption bed. At-grades are unique in that the distribution piping is placed on a prepared gravel bed at the ground surface, literally “at-grade”. The distribution piping is covered with sand and soil to protect it from freezing.

Because the effluent is pumped upward to be dispersed just below the ground surface, the at-grade can be used on sites with 36 inches of suitable native soil, rather than the 56 inches required for conventional systems (which disperse effluent approximately 20 inches below the surface). And, since the amount of above-ground sand fill needed is less, these systems tend to be less expensive than a traditional mound.

Solids must be periodically pumped from the septic tank, as well as from the pump chamber to insure proper functioning of the pump mechanism. Proper site preparation protocols must be taken to prevent the leakage of effluent at the base.

The at-grade design was developed in Wisconsin about 10 years ago, however, most components from which it is assembled, septic tank, pump and 36" soil absorption bed, have a long history in the state. Under the current code, at-grades are approved as experimental systems. The proposed code will approve them for general use. At-grade systems are estimated to constitute approximately 5% of new systems and 5% of replacements in Wisconsin.




An in-ground pressure distribution system consists of a septic tank, pump chamber, and a sub-surface soil absorption bed. Including space for the drain tile, gravel trench and overlying fill, the minimum native soil requirements range from 49 to 53 inches depending on the diameter of the distribution pipes. Like a conventional system, 36 inches of suitable native soil above bedrock or groundwater is required for the absorption bed.

The treatment mechanisms of in-ground pressure distribution systems are very similar to those of conventional systems, that is, 36 inches of native soil constitute a fixed porous medium on which aerobic bacteria provide secondary treatment of wastewater. The principle difference is the addition of a pump chamber that delivers septic tank effluent to the soil absorption bed in controlled timed doses. Delivering septic tank effluent in controlled pressurized doses ensures that the wastewater is equally distributed across the soil absorption bed, thus reducing the potential for the localized clogging that often occurs in conventional gravity dosed systems. Research has also shown that discharging effluent in controlled, properly timed doses gives the absorption bed a drying period between doses that can result in enhanced treatment with regard to pathogen and nutrient removal.

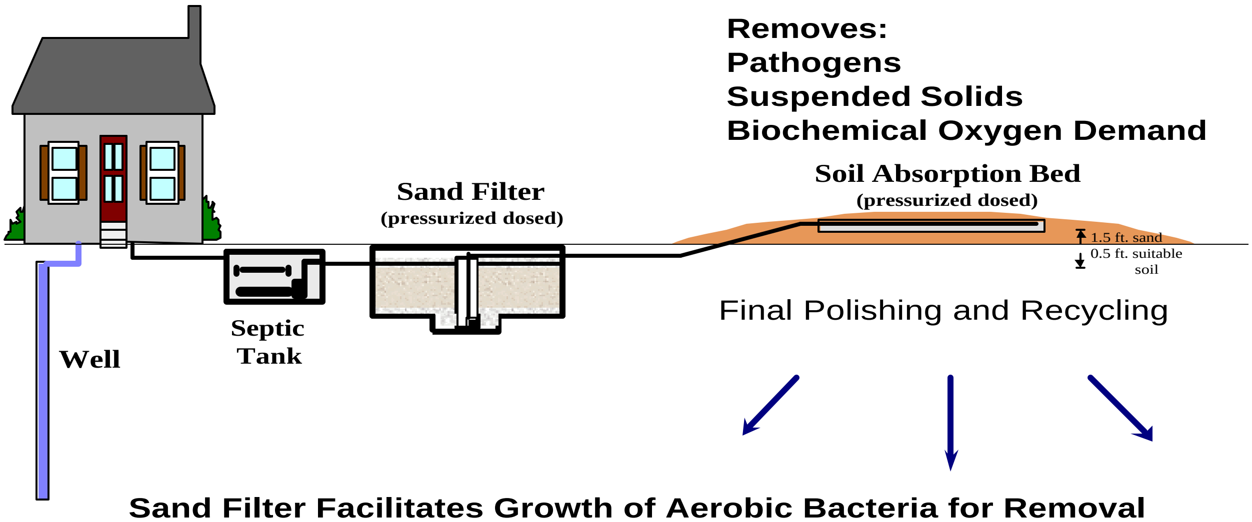
Septic tanks require periodic pumping of accumulated solids, as well as inspection to determine that the tank remains watertight. Solids must also be removed from the pump chamber periodically to insure proper functioning of the pump mechanism.

The components of these systems are not different than those of conventional and mound systems, which have a long history in Wisconsin. They are used under the current code. Their advantage is the potential of less clogging of the soil absorption bed. In Wisconsin, permits for in-ground pressure distribution systems constitute a very small number of the new systems and replacements--less than one-half of one percent.

## Sand Filter
**(Single-Pass)**

## Secondary Treatment From Sand Filter & Soil

**Removes:**
**Pathogens**
**Suspended Solids**
**Biochemical Oxygen Demand**




**Sand Filter Facilitates Growth of Aerobic Bacteria for Removal of Pathogens, BOD, and Suspended Solids**

**Further Treatment is Achieved in the Soil Absorption Bed**

A single-pass sand filter consists of a septic tank, sand filter and soil absorption bed. In the septic tank, solids settle out of the waste stream and anaerobic bacteria facilitate the partial breakdown of organic matter (primary treatment). Pressured doses of clarified effluent from the septic tank are discharged to the sand filter. The sand filter, commonly referred to as a “mound in a box”, is a buried chamber containing at least 24 inches of sand between layers of gravel. It serves as the fixed porous medium on which aerobic bacteria provide much of the secondary treatment. The effluent from the sand filter is then discharged, in pressurized doses, to a soil absorption bed.

Because the effluent from the sand filter has already been treated by passage through 24 inches of sand of an approved size and consistency, the soil absorption bed is reduced to 24 inches of suitable soil (minimum 6 inches in-situ soil). And, because the sand layer is underground, the potential landscaping disadvantages of an above ground mound are alleviated. Also, since the sand filter treats wastewater within an enclosed structure, the sand can be replaced easily should the need arise.

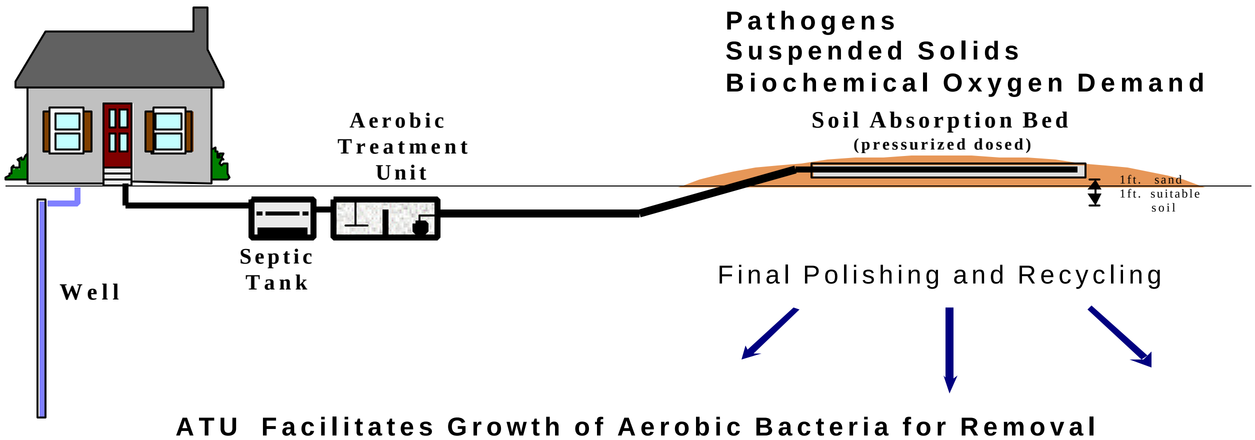
As in all systems, septic tanks require periodic pumping of accumulated solids, as well as inspection to determine that the tank remains watertight. Solids must also be removed from the pump chambers periodically.

Sand filters have been used to treat domestic wastewater over a hundred years. About 45% of the health departments nationwide that responded to a recent survey stated that they permitted the use of sand filters. The industry estimates that there are approximately 15,000 systems in use nationally. Close to 100 systems are in use in Wisconsin on an experimental basis. The version described in the figure above has been used extensively in Wood County, Wisconsin with very satisfactory results. The proposed Comm 83 code would make it available for general use in the state.

# Aerobic Treatment Units (ATU)

## Secondary Treatment From ATU & Soil

**Removes:**
**Pathogens**
**Suspended Solids**
**Biochemical Oxygen Demand**




**ATU Facilitates Growth of Aerobic Bacteria for Removal of Pathogens, BOD, and Suspended Solids**

**Further Treatment is Achieved in the Soil Absorption Bed**

An Aerobic Treatment Unit (ATU) is a self-contained unit that uses blowers or propellers to aerate the wastewater. They may also have filters to remove suspended solids. The additional electrical components are no more complicated than those commonly used in mound systems. An onsite sewage system that incorporates an ATU has either a septic tank or contains a septic compartment for solids separation, followed by the ATU, and a soil absorption bed.

ATUs are initially seeded with bacteria to provide a suspended medium for the growth of aerobic microorganisms that remove organic materials from the wastewater. Wastewater is dispersed to a soil absorption bed. Depending on the amount of treatment the wastewater receives in the ATU (quality of the effluent leaving the ATU), treatment required of the soil absorption bed will be reduced, providing the potential to reduce the size of this bed. Thus, ATUs can be used where there is insufficient soil for the standard 36 inch vertical separation to groundwater or bedrock. Since effluent from the ATU is an aerobic product with low concentrations of BOD, it can also be used to rehabilitate an existing soil absorption bed that is clogged with microbial biomass.

Solids must be periodically pumped from the septic tank and the pump chamber. The ATU unit itself must be pumped at regular intervals to maintain a balance in the microbial fauna. Events such as a prolonged disruption of electrical service could disrupt the balance and require the tank to be pumped, reactivated, and re-seeded. These units should be inspected by a professional every six months or whenever an alarm is activated.

Although the use of suspended media is relatively new for small scale onsite sewage systems, municipal plants have used suspended aerobic media for successful secondary wastewater treatment since the early 1900s. Under the current code, over 200 ATUs have been used in Wisconsin for approximately 10 years with currently approved systems, experimental systems and to rehabilitate existing systems. Tens of thousands of ATUs are in use nationwide in such states as Washington, Oregon, Massachusetts, Pennsylvania, Ohio, Illinois, and Texas. The proposed Comm 83 would allow systems that use ATUs with proven treatment capability to reduce the vertical separation of the soil absorption bed to 24 inches.

# Constructed Wetlands

**Secondary Treatment From Wetland & Soil**

**Removes:**
**Pathogens**
**Suspended Solids**
**Biochemical Oxygen Demand**


**Wetland Cell Provides Additional Removal of Phosphorous and Nitrogen via Plant Uptake, and Biological - Chemical Transformations**

A constructed wetland system consists of a septic tank, one or more wetland treatment cells, and a subsurface soil absorption bed. In the septic tank, solids settle out of the waste stream and anaerobic bacteria facilitate the partial breakdown of organic matter (primary treatment). Septic tank effluent is pumped, in controlled pressurized doses, to a discrete wetland cell which is designed to create and incorporate the treatment processes of natural wetlands. Effluent from the wetland treatment cell is then discharged to a soil absorption bed.

A typical wetland cell consists of an underlayer of pea gravel, overlain by soil that will support submergent and emergent wetland vegetation. The cell is lined with a layer of impermeable material to separate it from native soils and hydrological conditions. The water level is maintained below the gravel surface, thus preventing odors and public exposure to the wastewater being treated. In some cases, the cell is covered with a greenhouse. The wetland treatment cell removes organic matter, suspended solids, pathogens and nutrients through biological transformations, plant uptake and adsorption to soil particles. Some disinfection is achieved by exposure to UV light from the sun.

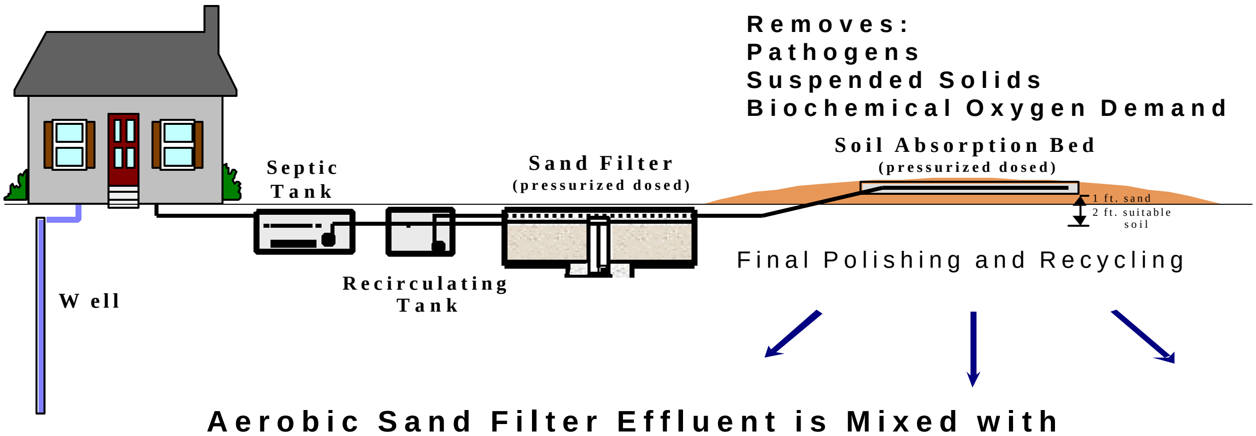
Costs for constructed wetlands vary significantly. They tend to be more expensive than most other onsite sewage systems because of the earthwork, land, structures, and design. However, depending on plant selection and design, they can also be very aesthetically appealing.

Solids must be periodically pumped from septic tanks and pump chambers and the treatment cells must not be overloaded. Minimum flow conditions are required to maintain the proper flora and fauna, and plants must be carefully selected to thrive in the specific conditions.

Development of constructed wetlands for wastewater treatment began in the early 1970s. They are recognized by the Environmental Protection Agency as effective treatment system and are used successfully in states such as Minnesota, Iowa, Kentucky, Indiana, and Texas. Thousands of these systems are in use nationwide serving both individual residences and small communities. There are over 5000 wetland treatment systems in operation in Kentucky alone. Experience with constructed wetlands in northeastern Minnesota has shown their effectiveness during the harsh winters of the Upper Midwest. Two nature centers in the Upper Midwest, one in Iowa and one in Wisconsin, are also using these systems with great success. These systems will be approved individually under the proposed code. No design has yet been submitted for general use.

# Recirculating Sand Filter

## Secondary Treatment From Sand Filter & Soil




**Aerobic Sand Filter Effluent is Mixed with Anaerobic Septic Tank Effluent to Remove Nitrogen**

**Removes 40% - 70% of Total Nitrogen**

A recirculating sand filter consists of a septic tank, recirculating tank, sand filter and soil absorption bed. In the septic tank, solids settle out of the waste stream and anaerobic bacteria facilitate the partial breakdown of organic matter (primary treatment). Pressured doses of clarified effluent from the septic tank are discharged to the recirculating tank and from there to the sand filter. The sand filter is a buried chamber containing at least 24 inches of sand between layers of gravel. It serves as the fixed porous medium on which aerobic bacteria provide much of the secondary treatment. Pressurized doses of a portion (typically 20%) of the effluent from the sand filter are dispersed to the soil absorption bed, while the remainder (80%) is returned, mixed with incoming septic tank effluent, and passed through the sand filter again. This design takes advantage of the high concentration of organic matter and anaerobic conditions of the septic tank effluent; conditions which are necessary for nitrogen removal.

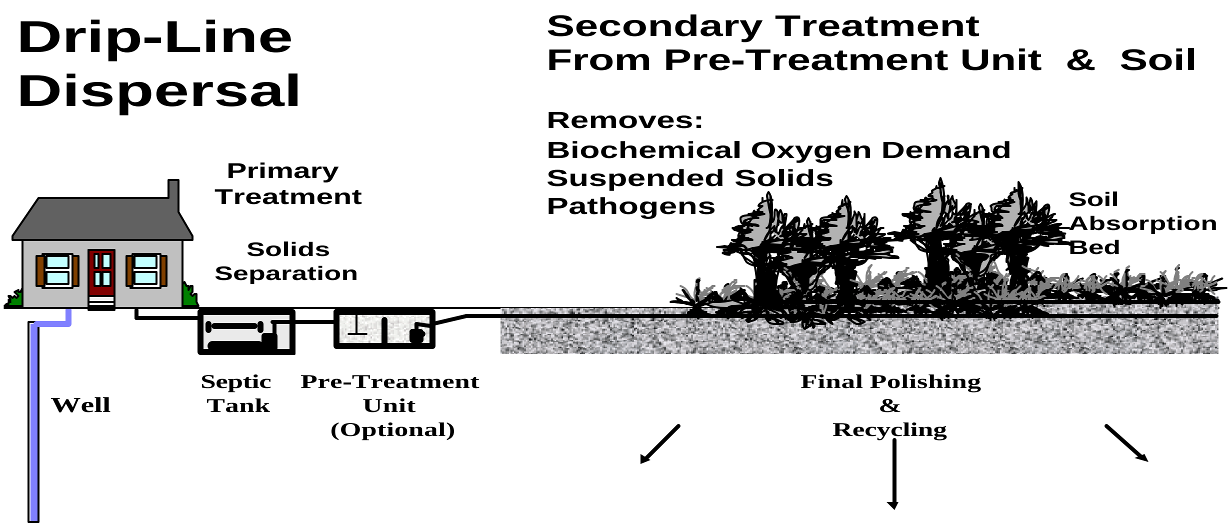
Some designs eliminate the recirculation tank by using a “split bed” sand filter. Effluent distribution (to the septic tank and soil absorption bed) is achieved in this dual compartment tank. This results in less total area needed for system installation.

The primary advantage of these recirculating sand filters is that they are capable of removing from 40 to 70% of the total nitrogen present in the septic tank effluent. Although effluent from the sand filter will have been treated by passage through 24 inches of sand, due to the recirculation step the coliform level of the effluent is higher than that of the single pass filter. The soil absorption bed could potentially be reduced, but the amount of reduction would depend on the quality of the effluent. Because the sand layer is underground, the potential landscaping disadvantages of an above ground mound are alleviated. Also, since the sand filter treats wastewater within an enclosed structure, the sand can be replaced easily should the need arise.

Septic tanks and pumps require periodic pumping of accumulated solids. For optimum treatment and nitrogen removal, the adjustment of the proper recirculation ratio and sand filter loading rates is critical.

Sand filters have been used for wastewater treatment over a hundred years. Development of recirculating systems, however, began in the 1960s in an effort to remove more nutrients such as nitrate from domestic wastewater. Close to thirty of these systems are in use in Wisconsin on an experimental basis. Approximately ten thousand (residential and commercial) are in use nationwide, including in coastal regions such as the Chesapeake Bay where nutrient discharge is an acute environmental issue.

# Drip-Line Dispersal




## Drip Line Tubing Is Installed With Minimal Site Disruption
## Shallow Installation Facilitates
## Uptake Of Wastewater and Nutrients By Plants

A drip line effluent dispersal component is a mechanical element of the soil absorption system. As with all onsite treatment technologies, primary treatment in a septic tank is required prior to discharging wastewater to the soil. A pump chamber delivers effluent to the drip lines in timed pressurized doses through a distribution network that contains a series of filters. The filters are flushed periodically to prevent clogging. The lines and emitters are impregnated with inhibitors to prevent solids build up and root intrusion. Frequent automatic flushing of the lines helps ensure trouble free operation.

While subsurface drip–line dispersal provides obvious benefits for arid regions of the country, these systems offer advantages to Wisconsin homeowners and communities as well. Drip lines offer an alternative to rigid effluent piping, aggregate, leaching chambers, and excavation in the distribution field. By using flexible tubing, a shallowly placed drip line network can be installed with minimal site disturbance. This flexible tubing can be "plowed" around obstructions (trees and boulders) that might otherwise need to be removed. These systems allow the delivery of smaller more frequent doses using pressure compensating emitters. By allowing smaller more frequent dosing, and spacing the lines two feet apart, drip-line irrigation better facilitates the use of slowly permeable soils for wastewater distribution. By discharging effluent directly to the root zone, wastewater can also be a source for irrigation and fertilization. Studies have shown that nutrient absorption by plant uptake can reduce the concentration of nitrogen and phosphorous in the effluent that enters groundwater.

Drip-line technology is a proven and efficient means of dispersing domestic wastewater that has been in use in the United States since the late 1980s. Industry representatives estimate that there are thousands of systems currently in use throughout the country, with approximately 3,000,000 linear feet (2,000 linear feet / household) of dripline sold annually for the purpose of wastewater distribution. These systems have undergone extensive research in the State of Minnesota to examine their operation in cold climates. Results from Minnesota and Wisconsin have shown that properly designed and maintained systems successfully resist freezing at depths of six inches below grade, the minimum depth required by the proposed Comm 83. There are approximately two dozen systems in operation in Minnesota. At present, eight systems are in use in Wisconsin on an experimental basis. Drip line systems are in use in other northern states including Michigan, Washington, and Pennsylvania. The proposed Comm 83 will give Wisconsin homeowners and businesses access to this innovative and effective means of wastewater dispersal.