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ONSITE WASTEWATER TREATMENT AND THE

USE OF OFF-LOT DISCHARGES

For years, the most popular onsite wastewater treatment system was a "passive" system, composed of a septic tank (for pretreatment) and a tile field (for soil treatment). This process was thought to be a surefire method to prevent pollution of the environment. In simplest terms, whatever waste is generated onsite, is treated onsite. As increased population density has required the use of previously undeveloped areas, seasonal or onsite groundwater has periodically resulted in problems with the design or operation of leaching tile fields and other subsurface wastewater infiltration systems (SWISs). To solve this problem, various types of curtain drains and other subsurface drainage systems have been designed and developed.

The use of subsurface drainage is the intersection where onsite treatment meets off-lot discharge. While not intentionally designed to be an off-lot discharge of untreated or partially treated wastewater, some professionals are convinced that either by their very design or by improper application, this is exactly what they are. Properly designed and installed curtain drains and other subsurface drainage systems are a valuable tool in the design and use of onsite wastewater treatment and disposal systems, and they usually carry only groundwater. USEPA has endorsed their use for decades, both in the 1980 Onsite Wastewater Treatment Systems Manual and in the 2002 update of the same reference. Whether installed and working properly or not, one thing for certain is that three of the four most popular subsurface drainage systems constitute an off-lot discharge according to the new Storm Water Program Rules being implemented by the USEPA. This means they will soon be subject to many of the same monitoring and management requirements as any other off-lot discharge. As such, it is imperative that subsurface drainage systems be understood in their design and function, and managed in their operation.

GENERAL

A subsurface wastewater infiltration system (SWIS) is defined as "an underground system for dispersing and further treating pretreated wastewater. The SWIS includes the distribution piping/units, any media installed around or below the distribution components, the biomat at the wastewater-soil interface, and the unsaturated soil below."[1] Out of necessity, leaching tile fields or other SWISs must sometimes be located in the proximity of seasonal or onsite groundwater. This creates an operational problem as groundwater saturation will impede the normal aerobic function of a soil-based disposal system. "Dissolved oxygen is virtually absent in saturated soil, making degradation of effluent below the water table an anaerobic process."[2] When this potential exists, "curtain drains, vertical drains, underdrains, and mechanically assisted commercial systems can be used to drain shallow water tables or perched saturated zones. Of the three, [subsurface drainage systems], curtain drains are most often used in onsite wastewater systems..."[1]

Although curtain drains have been the most widely used subsurface drainage systems, similar devices are termed perimeter drains, underdrains, vertical drains, french drains, collector drains, interceptor drains, footer drains, overflows, wet weather drains and gradient drains. Unfortunately, some confusion exists about how each of these systems function. Many industry references, and even some regulations, use one or more of these terms interchangeably. However, the USEPA has defined specific applications and provided guidance in the use of several types of subsurface drainage systems. In order to properly apply any "artificially drained system", the source of the groundwater being drained, its particular flow characteristics, the soil characteristics and the topography of the site must first be determined. The correct system can then be selected and applied to address the specific site problem.

Each application of subsurface drainage systems relies on proper functioning of the SWIS and a thorough evaluation of the groundwater in the vicinity. "From a functional point of view, subsurface drainage falls into two classes: relief and interception drainage. Relief drainage is used to lower a high water table which is generally flat or of very low gradient. Interception drainage is to intercept, reduce the flow, and lower the flowline of the water in the problem area."[3]

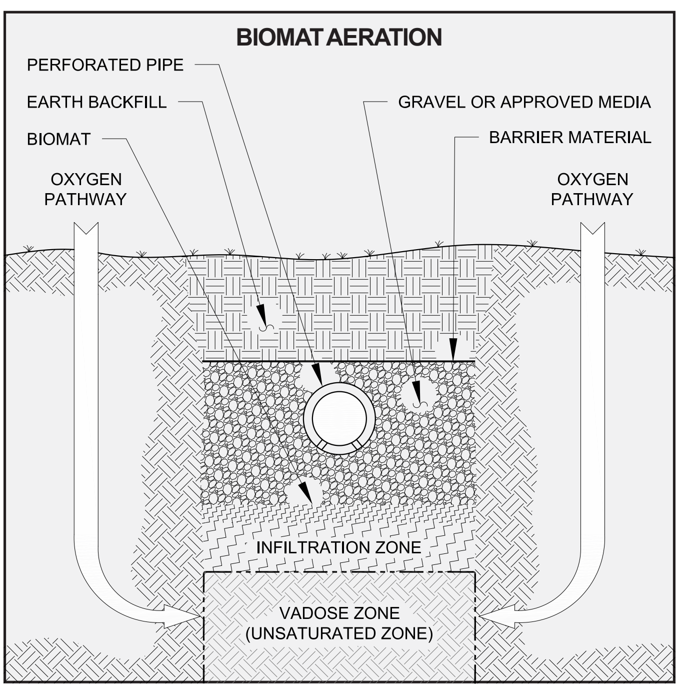
The discharge of a subsurface drainage system is usually directed to a surface waterway or other off-lot discharge. This makes it critical that regulators, designers, installers, inspectors and service providers be properly trained and possibly licensed. If the drainage system is incorrectly designed or installed, bleed-through or outright bypass of the treatment process can result in the discharge of partially treated or untreated wastewater directly off-lot and will pose a threat to the environment. Because of this potential, some regulatory agencies believe that subsurface drainage systems should never be allowed under any circumstances. However, the key to effective use of subsurface drainage systems is management. Periodic service and inspection will characterize any off-lot discharge and potentially avoid any point-source pollution of the environment at its origin.

TREATMENT SYSTEM OPERATION

As subsurface drainage systems play a critical role in the application of onsite disposal systems, understanding the operation of a passive system will insure that both the treatment system and the drainage system will function as designed. In a typical onsite system, the raw sewage is pretreated in a septic tank. This process removes large settleable organic and inorganic solids, and also utilizes anaerobic bacteria to solubilize a portion of the biochemical oxygen demand (BOD). Septic tank discharge contains high concentrations of BOD (typically 120 to 140 parts per million) both in solid and soluble form. When discharged into a SWIS, the flow is distributed throughout the trench via perforated pipe, supported and surrounded by gravel or approved media. As the pretreated effluent cascades through the media, it is distributed along the bottom of the trench. The trench bottom, called the infiltration zone, is the primary infiltrative surface where the wastewater permeates the soil.

The first few centimeters of the infiltration zone is often referred to as the “biomat”. In this zone, the carbonaceous portion of the BOD, referred to as CBOD is quickly degraded by the action of microorganisms. If sufficient oxygen is present, oxidation of nitrogen compounds, primarily ammonia, takes place immediately below the biomat. This process is called nitrification. Whether or not sufficient oxygen is present to maintain the break down of CBOD or nitrogen compounds is dependent on the functioning of the vadose zone.

The vadose zone is often referred to as the unsaturated zone. Under normal operation, the vadose zone is unsaturated. This promotes wastewater percolation into the dry soil, and allows oxygen diffusion to continuously aerate the biomat. The available oxygen permits the faster acting aerobic microorganisms to accomplish the biological reduction.



SUBSURFACE DRAIN OPERATION

All of the biological action in a SWIS is slowed dramatically or arrested altogether if groundwater is present in the vadose zone. Saturation of the vadose zone can occur if groundwater is constantly or periodically at a high enough elevation. Soil saturation prevents any significant transfer of oxygen to the biomat and prohibits the flow of wastewater into the finer pores of the soil. Any biodegradation that takes place must then be from anaerobic microorganisms. The metabolic rate of anaerobic microorganisms is extremely slow compared to aerobic microorganisms, rendering the SWIS, in essence, non-functional. Subsurface drainage systems can redirect the groundwater away from the SWIS. This allows proper oxygen transfer throughout the vadose zone, and permits aerobic biological degradation to take place as designed.

Most subsurface drainage systems fall into the category of either interceptor drains or relief drains. The orientation of the drain as it relates to the groundwater flow is the primary difference between the two designs. An interceptor drain is defined as a “drain located across the flow of groundwater and installed to intercept subsurface flow.”[3] A relief drain is defined as a “drain located at the depth and spacing required for control of the water table where the principal source of groundwater is from the overlying land and the water table is relatively flat.”[3] Curtain drains and vertical drains are types of interception drainage systems. Underdrains and perimeter drains are types of relief drainage systems.

Depending on the topography of the site, both types of drainage systems can be effective at controlling a “perched” water table that often occurs in stratified soil. This condition occurs when groundwater is “held up” by a soil layer of low permeability (heavy clay or even rock) so that the perched water is disconnected from the main body of groundwater.

The rate at which the groundwater moves is also a factor. Even if the stratified soil layer has low to moderate permeability, but the groundwater is rapidly moving laterally, breakout or seepage may occur before the groundwater has the opportunity to percolate down to a lower elevation. This type of lateral movement of groundwater generally requires an interceptor drain. A static water table, or one moving only vertically, generally requires the use of a relief drain. Each type of subsurface drain can be used to insure the proper functioning of a subsurface wastewater infiltration system by redirecting the groundwater off-site or to an elevation where it does not inhibit the transfer of oxygen through the vadose zone of the soil based treatment system.

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CURTAIN DRAINS

Curtain drains are interception drainage systems used in hilly terrain where a water table is permanently located or "perched" above and separated from the normal groundwater table due to an impermeable soil layer above the normal permeable soil. The curtain drain is designed to intercept the lateral movement of the water table and direct the groundwater to a location where it will not affect the continued operation of a SWIS. Prior to installation of a curtain drain, the depth of the impermeable layer should be determined by site evaluation. "If the restrictive layer that creates the water table is thin and overlies permeable soil, vertical drains may be used."[1] However, if the thickness or composition of the impermeable layer turns out to be prohibitive, a curtain drain should be installed.

If the topography of the site allows, the preferential design provides for the curtain drain discharge to be carried by gravity to a downslope location where it can be discharged off-lot. If the difference in grade between the interception location and eventual discharge point is too shallow, the groundwater can be directed to a location where it is collected and then pumped off-lot and returned to the environment. In any case, "the outlet and boundary conditions must be carefully evaluated to protect local water quality."[1]

The curtain drain should be located upslope of the onsite treatment system with the main trench at a right angle to the lateral movement of the groundwater. Depending on the particular site configuration, the curtain drain may need to extend around some portion of the ends of the SWIS. The top of the drain should extend vertically above the anticipated high water table and the bottom should extend vertically downward into the impermeable layer in order to guarantee that all laterally moving groundwater is intercepted.

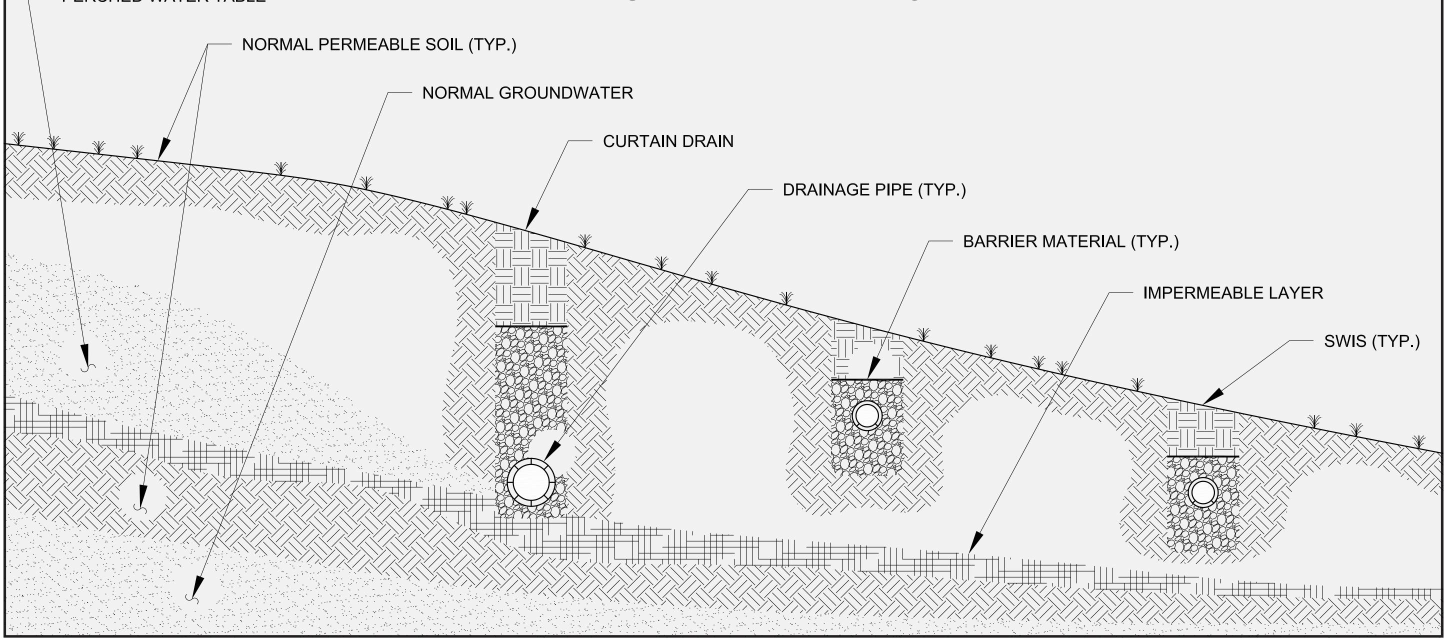
Curtain drains are constructed by installing a trench excavation upslope of the SWIS. The bottom of the trench should contain a slotted or perforated pipe installed with sufficient grade to convey the intercepted groundwater to a location downslope of the SWIS. The drainage pipe should be surrounded with gravel or crushed rock, filling the trench to well above the elevation of the perched water table. Barrier material should be placed on top of the gravel to prevent backfill from infiltrating the curtain drain. Normal site backfill can then be used to fill the trench to normal grade.

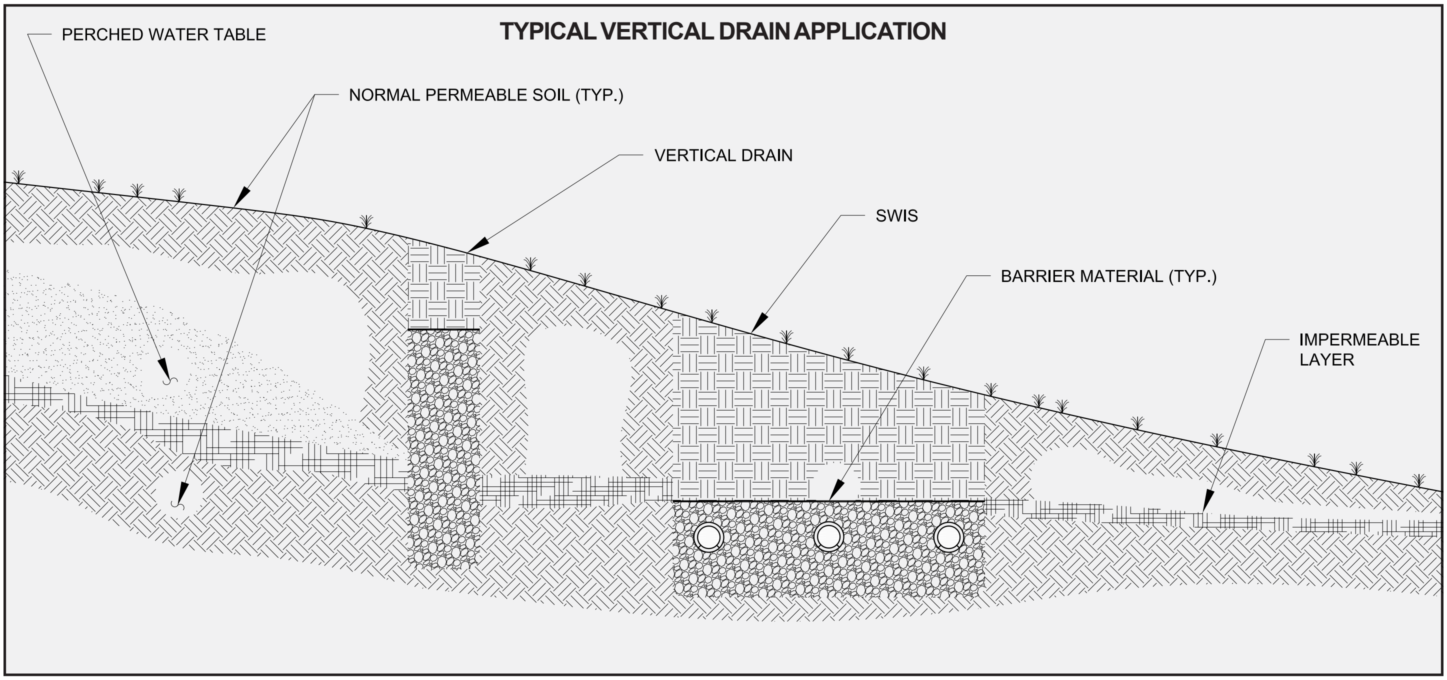
The size of the drain is dependent on several factors, including the permeability of the soil surrounding the drain, the upslope area conveying groundwater to the onsite treatment system and the slope of the drain pipe. The local Soil and Water Conservation office can provide the charts and formulae required for proper design, along with information regarding the permeability of soil in the area of the treatment system.

The drain should be installed deep enough to allow at least three feet of unsaturated soil below the bottom of the SWIS. The horizontal separation distance from the disposal system must be adequate to prohibit the lateral migration of untreated or partially treated wastewater into the drainage system. Typical horizontal separation distances between the curtain drain and the soil disposal system is ten feet. Highly permeable soils, like sand, may not be suitable or may require that fill be placed between the components.

The outfall of the drain should be open with at least six inches of freeboard or equipped with an inspection well. If an inspection well is used, it should extend to grade, be equipped with an access cover and have internal free-fall of water to allow for proper sampling of the off-lot discharge. In any case, all design and construction parameters must comply with all applicable local codes.

TYPICAL CURTAIN DRAIN APPLICATION





VERTICAL DRAINS

Vertical drains are interception drainage systems used if a water table is perched above a thin impermeable layer and the SWIS is at a lower elevation, located in permeable soil. Having the thin impermeable layer allows the vertical drain to extend down into the permeable soil below. A vertical drain located around a portion of, or the entire perimeter of the disposal system will intercept the perched water table if it moves laterally and direct it down through the impermeable soil layer where it can leach into the underlying soil, and eventually into the groundwater table, outside the area of the absorption bed. A vertical drain is the only subsurface drainage system that retains the flow totally onsite.

The topography of the site has less effect on vertical drains than on curtain drains. Even though vertical drains are primarily used in hilly terrain, they can also be used in flatter terrain wherever a perched water table can move laterally into the area of a SWIS. As the vertical drain discharges into the permeable soil layer below the site, there is no requirement for surface discharge downslope or off-lot. Similarly, pumping of the groundwater or other mechanically assisted drainage is not required. If the terrain is hilly, the vertical drain must be located upslope of the SWIS. If the area is more flat, the vertical drain must be located downstream of the laterally flowing perched water table.

The vertical drain should be located with the main trench at a right angle to the lateral movement of the groundwater. Like curtain drains, depending on a particular site configuration, the vertical drain may need to extend around some portion of the ends of the SWIS. The top of the drain should extend above the anticipated high water table and the bottom should extend downward, through the restrictive soil layer and well into the permeable layer below.

A trench excavation upslope of the SWIS or downstream of the perched water table is used to construct the vertical drain. No slotted pipe, perforated pipe or other conveyances are needed to direct the groundwater to another location. The drainage trench is filled with gravel or crushed rock to an elevation well above the perched water table. The size of the gravel media should be chosen to minimize the chance of silt collecting within the media and clogging the operation of the vertical drain. Barrier material should be placed on top of the gravel to prevent backfill from infiltrating the vertical drain. Normal site backfill can then be used to fill the trench to normal grade.

The size of the drain is dependent on several factors including the permeability of the soil surrounding the drain and the amount of area conveying groundwater to the vicinity of the onsite treatment system. "The width and depth of the drain below the restrictive layer is calculated by assuming an infiltration rate for the underlying soil."[1]

"Separation distances between the drain and the bottom of the soil absorption system are the same as for curtain drains to maintain an unsaturated zone under the absorption system."[1] This means that although soil permeability has to be taken into consideration, typical horizontal separation distances between the vertical drain and the soil disposal system is ten feet. However, all design parameters including media type and size, drain width and depth, and separation distances must comply with all applicable local codes.

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UNDERDRAINS

Underdrains are relief drainage systems used where groundwater exists close to the surface in permeable soil. An underdrain provides lowering of the free water table on a continuing basis and directing the groundwater to an off-lot location. Usually, multiple drain trenches are used to lower the free water table not just around the perimeter, but in the total area of a disposal system. "Underdrains must be located to lower the water table to provide the necessary depth of unsaturated soil below the infiltrative surface of the soil absorption system, and to prevent poorly treated effluent from entering the drain."[1]

A free water table differs from a perched water table that often moves laterally due to stratified soil containing an impermeable layer. Free water tables are found in permeable soil and are typically larger in volume and slower in movement than perched or other laterally moving water tables. Also, the top surface of a typical free water table is nearly flat, or with minimal slope.

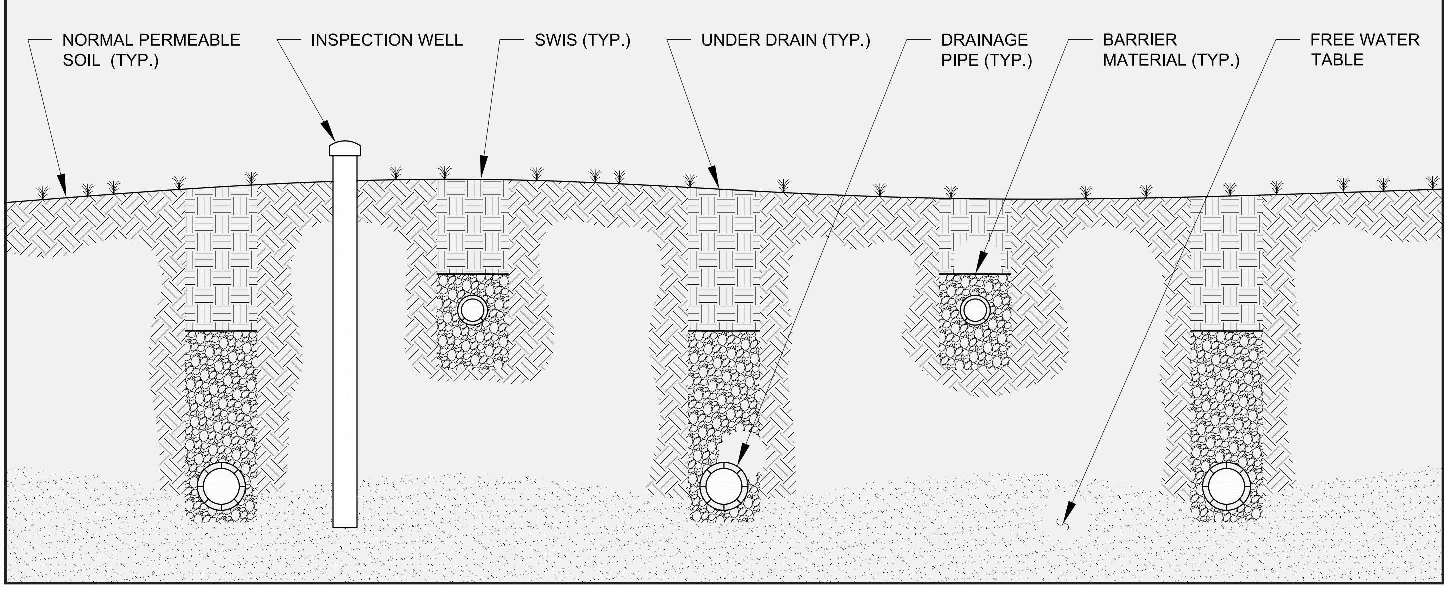
Underdrains are commonly used where the topography of the site is fairly flat. This allows for the depth of the free water table to be relatively static and predictable. Like curtain drains, the preferential design allows for the underdrain discharge to be carried by gravity to a downslope location and then discharged off-lot. While it is possible to use pumps to convey the groundwater to another location when the difference in elevation between the underdrain and the discharge point is too shallow, this practice is discouraged. If a pump was used, any mechanical failure in the pumping system could cause the elevation of the free water table to rise to the level of the SWIS. This could result in partially treated wastewater contaminating the water supply, as well as rendering the SWIS inoperable.

The location and configuration of the underdrain must be carefully calculated. As the permeability of the soil is a significant factor in design and proper functioning of the underdrain, the local Soil and Water Conservation office must be consulted. They can provide not only information on local soil permeability, but references on how to factor the data into the various design parameters. The drain configuration must be sufficient to uniformly lower the free water table below the infiltrative surface of the SWIS. This may require the use of a network of underdrains throughout the area of the wastewater disposal system. As an underdrain functions continuously to lower the groundwater table, an inspection well should be installed adjacent to the disposal system in order to observe the groundwater elevation.

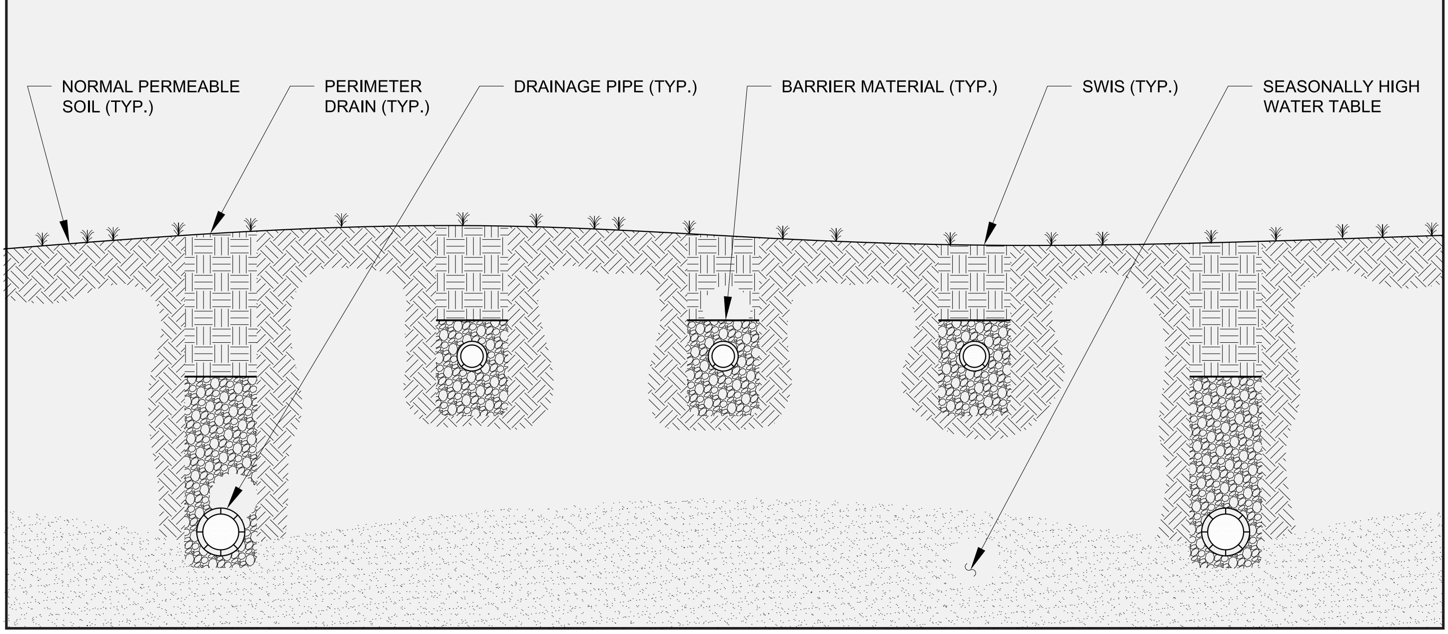
The size of the drainage system, as well as the diameter and slope of the drainage pipe is dependent on the permeability of the soil, the square footage of the area being drained and the distance the free water table needs to be lowered. Underdrains may only be used in soils of moderate to high permeability. In soils of low permeability, including clay and fine textured soil, it is not practical to consider the use of underdrains, and another location for the SWIS should be found and utilized.

Underdrains are constructed by installing a trench excavation around the perimeter of the SWIS and, as needed, in between the laterals of the SWIS. The bottom of the underdrain trench should contain a slotted or perforated pipe, installed with sufficient grade to convey the groundwater to an area of lower elevation away from the SWIS. The drainage pipe should be surrounded with gravel or crushed rock to an elevation above the anticipated high water table. The use of barrier material and backfill to grade are similar to construction of a curtain drain. All design and construction parameters must comply with all applicable local codes.

TYPICAL UNDERDRAIN APPLICATION



TYPICAL PERIMETER DRAIN APPLICATION



PERIMETER DRAINS

Perimeter drains are another type of relief drainage system used by some references that differentiate between a seasonally high water table and a continually high water table requiring underdrains. A perimeter drain provides lowering of the free water table only when the water table is elevated, and directing the groundwater to an off-lot location. Unlike underdrains, perimeter drains would be anticipated to be in operation only several months of the year. As such, drain trenches are primarily used only around the perimeter of the disposal system.

Like underdrains, perimeter drains are commonly used where the topography of the site is fairly flat. Even though the depth of the seasonal water table is not static, it is often predictable. Like other subsurface drainage systems, the preferential design allows for the underdrain discharge to be carried by gravity to a downslope location and then discharged off-lot. Unlike underdrains, the seasonal use of a perimeter drain does allow the use of pumps to convey the groundwater to another location when the difference in elevation between the perimeter drain and the discharge point is too shallow. However, the cost of running the electrical service to the area of the perimeter drain, and the cost of the electro-mechanical equipment must be compared with the cost of running additional drainage pipe to a location that may allow gravity discharge.

The permeability of the soil is also a significant factor in the design and proper functioning of the perimeter drain. As such, the local Soil and Water Conservation office should be consulted for information on local soil permeability and references on how to factor the data into the various design parameters. As the top of the infiltrative surface of the perimeter drain needs to be well below the bottom of the SWIS, topography of the site becomes a significant factor. Also, it is important to remember that the seasonally high water table between the perimeter drain lines will rise higher than the bottom of the drainage pipe. Perimeter drains are constructed by installing a trench excavation around the entire perimeter of the SWIS. The bottom of the perimeter drain trench should contain a slotted or perforated pipe, installed with sufficient grade to convey the groundwater to an area of lower elevation away from the SWIS. The drainage pipe should be surrounded with gravel or crushed rock to an elevation well above the seasonally high anticipated water table. The remaining construction details, (including the diameter of the drainage pipe, the characteristics of the surrounding media, the use of barrier material and backfill to grade), is similar to construction of other types of subsurface drainage systems.

The size of the perimeter drainage system, as well as the diameter and slope of the drainage pipe is dependent on the permeability of the soil, the size of the area being drained and the depth of the seasonally high water table that needs to be maintained at a lower elevation. Like underdrains, perimeter drains may only be used in soils of moderate to high permeability. In soils of low permeability, including clay and fine textured soil, it is not practical to consider the use of a perimeter drain, and another location for the SWIS should be found and utilized. As with any type of onsite treatment system, all design and construction parameters must comply with all applicable local codes.

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OTHER OFF-LOT DISCHARGES

The different types of subsurface drainage systems used in conjunction with SWISs, constitute off-lot discharge. While not always obvious, even a roadside ditch can be an off-lot discharge. A roadside ditch is actually a relief drain, which carries surface and subsurface water. Agricultural field tile is another type of off-lot discharge that conveys groundwater from beneath the surface of a large area. Certainly, the direct discharge of effluent from various types of aerobic or advanced treatment units would fall into a similar category. This would be true whether they are self-contained (pretreatment, aeration and clarification in a single tank) or a series of components such as a recirculating sand filter. Even a passive system such as pretreatment followed by constructed wetlands would likely be an off-lot discharge. As enforcement of regulations becomes more widespread, all of these systems will likely require compliance with the National Pollutant Discharge Elimination System (NPDES) program and the recently implemented Storm Water Rules.

ONSITE SYSTEM MANAGEMENT

The USEPA's Response to Congress on the Use of Decentralized Wastewater Treatment Systems in 1997 promotes the use of onsite wastewater treatment systems. As a necessary part of this endorsement, management programs for all onsite systems must be used to insure continued proper operation. The Draft Handbook for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems has been developed by the USEPA. According to the Handbook, a critical element of management programs is routine inspection and monitoring of onsite systems. This would require that a "responsible management entity" conduct periodic site inspections to insure the continued proper operation of all onsite wastewater treatment systems. It would follow that, when used, all subsurface drainage systems should also be routinely inspected by qualified personnel to insure proper operation.

Management for a passive onsite wastewater treatment system would include a physical inspection, a functional inspection and a site inspection. The physical inspection would insure that all components are in good working order, including structural integrity. A functional inspection would be to check the system for slow flushing drains or the need for removal of accumulated solids. The site inspection would check for wet areas or poor drainage.

Management of any subsurface drainage system that discharges off-lot would include a physical inspection, a functional inspection and a site inspection. A physical inspection would be checking for any crushed drain lines, any changes in the discharge pipe (where applicable), structural integrity of any inspection well and any other obvious physical changes. A functional inspection would include checking the discharge point for areas of ponding and making sure the discharge is conveyed appropriately and, (where applicable) checking the operation of pumps or any other mechanical devices used to assist in the discharge. Any ponding or groundwater in the area of the SWIS would prompt a more detailed site inspection to determine the specific failure cause of the subsurface drainage system. As curtain drains, underdrains and perimeter drains all constitute an off-lot discharge, sampling and analysis must be performed in order to determine if partially treated or untreated wastewater has percolated from the subsurface wastewater infiltration system to the subsurface drainage system and is being discharged off-lot. If sampling of the off-lot discharge indicates the drainage system effluent contains characteristics that are not consistent with groundwater, a full evaluation of the SWIS and drainage system must be conducted and the problem corrected.

NPDES PROGRAM

"The Clean Water Act prohibits anybody from discharging 'pollutants' through a 'point source' into a 'water of the United States' unless they have an NPDES permit. In essence, the permit translates general requirements of the Clean Water Act into specific provisions tailored to the operations of each person discharging pollutants."[4] Pollutants are defined broadly after twenty-five years of litigation. Examples of defined pollutants include materials that one might expect, such as sewage, sludge and biological materials. The definitions have also included some rather unexpected materials such as rock, sand and cellar dirt. "Point source" is also currently defined specifically. "It means any discernible, confined and discrete conveyance, such as a pipe, dish, channel, tunnel, conduit, discrete fissure or container."[4] However, the practical application of "point source" is also becoming broader. The "Draft Handbook for Management for Onsite and Clustered (Decentralized) Wastewater Treatment Systems" refers to compliance with NPDES program requirements. "This requirement also covers systems that discharge to ditches, pipes or other conveyances that ultimately discharge to waters of the US."[5] In addition to issuing permits for individual point sources that discharge pollutants, a policy statement has been issued by the USEPA for Watershed-Based NPDES Permitting. "A holistic watershed management approach provides a framework for addressing all stressors within a hydrologically defined drainage basin instead of viewing individual sources in isolation. In establishing point source controls in a watershed-based permit, the permitting authority may focus on watershed goals, and consider multiple pollutant sources and stressors, including the level of nonpoint source control that is practicable."[6]

The ever widening scope of the NPDES program leaves little doubt of the future of all types of off-lot discharges. At some point in time all off-lot discharges, (whether from individual home aeration systems providing primary, secondary, tertiary and advanced treatment or from subsurface drainage systems in conjunction with primary and secondary treatment systems), will likely be subject to NPDES permits.

PHASE II STORM WATER PROGRAM

Storm Water Rules promulgated by the USEPA call for phased NPDES requirements for storm water discharges. Phase I of the new rules focused on discharges from municipalities of 100,000 population or more and the final rules were published in August 1995. Phase II Rules were published in the Federal Register on December 8, 1999 and became effective March 10, 2003. Phase II Rules were designed to cover small municipal systems and construction activity disturbing between one and five acres of land. Many people notice that rural areas frequently use one acre as the required lot size for an individual home site. Even though the general stance of the USEPA is not to require permits of individual homeowners, "the Rule [Phase II] allows for the exclusion of certain sources from the national program...as well as inclusion of others based on a higher likelihood of localized adverse impact on water quality."[7]

"One measure in a Phase II storm water program is the detection and elimination of illicit discharges. USEPA has determined that many onsite and cluster systems (typically those that discharge to surface waters) illicitly discharge effluent to storm ditches, which drain to storm sewers. In these cases, there must be a permit approach to protect the MS4 [municipal separate storm sewer system] from pollutants associated with the onsite and cluster system."[5] There is no doubt this could eventually be interpreted to mean any off-lot discharge. Therefore, any off-lot discharge from an individual home, whether it is from an advanced treatment system that actually improves the waterway; a subsurface drainage system that directs groundwater off site; roof gutter/foundation drains from a home; or even an agricultural drainage ditch are all subject to coming under the umbrella of the Phase II Rules. There will likely be interpretation required during implementation of these Rules, especially as they filter down to a state and/or local level, but it is clear that any "illicit discharge" not covered by an NPDES Permit will likely be subject to prosecution.

SUMMARY

For decades, subsurface drainage systems have been used to guarantee that the movement of groundwater does not interfere with the treatment process occurring in a soil-based disposal system. Even though some regulatory officials disagree, the use of curtain drains and other subsurface drainage systems may not be detrimental to the environment, as the USEPA still references them in the February 2002 update of the 1980 Onsite Wastewater Treatment Systems Manual. Independent field studies have shown that the use of a properly engineered and installed subsurface drainage system can provide a safe, effective method of insuring that groundwater will be directed off-lot and will not have a negative effect on the treatment system operation or the environment. In one such study, county and state regulators in cooperation with agricultural engineers concluded: "In using a poorly drained Henry soil as the initial worst case situation, we found that with rainfalls at or near average, groundwater could be drained by a simple manner and at a reasonable cost."[8]

In similar fashion, many state and local authorities have also allowed the off-lot discharge of several types of advanced treatment systems, where acceptable effluent quality has been verified by an independent third party. As many advanced treatment systems provide pretreatment, secondary treatment, tertiary treatment and disinfection, the effluent quality is often better than the water quality of the receiving environment. Properly designed and installed, subsurface drainage systems and other off-lot discharges are safe and effective. The logical first step in protecting the environment is to provide pretreatment and secondary treatment to any wastewater before it has the potential to move off-lot. The logical second step is a comprehensive management program to insure that all systems, passive and advanced, employing off-lot discharges are operating as designed.

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