University Curriculum Development for Decentralized Wastewater Treatment

Subsurface Drip Dispersal

Module Text

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Subsurface Drip Dispersal

Chapter 1: Introduction

Decentralized Wastewater Management

Two-thirds of the US's land area is unsuitable for acceptance and treatment of wastewater from traditional septic systems (Perkins, 1989). On-site wastewater treatment and disposal in areas with soils having limited treatment capability and site conditions restricting system placement have come under close scrutiny by agencies protecting water resources. These sites may require advanced wastewater pretreatment and dispersal technologies with a capability to more uniformly distribute wastewater. The need for improved technologies for both treatment and distribution has promoted the emergence of an accountable, reliable industry that is addressing cost-effective, environmentally friendly solutions.

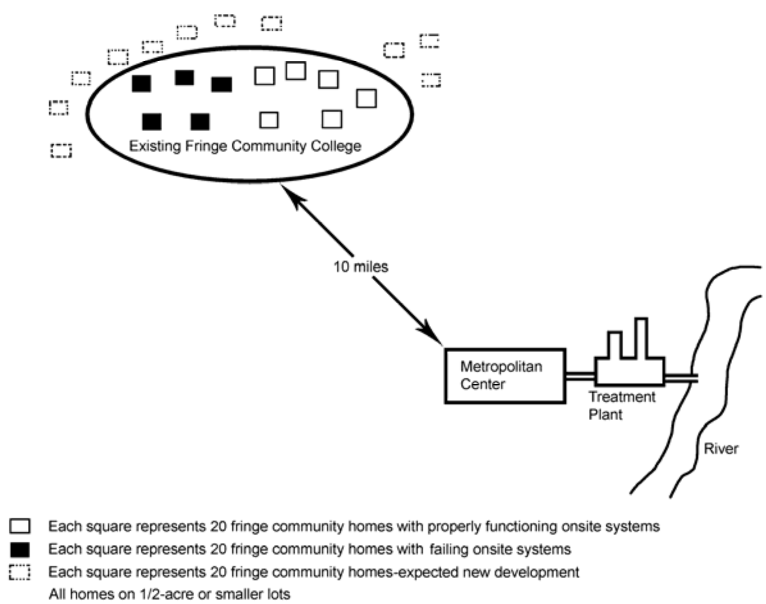

Figure 1.1: Decentralized Wastewater Management Scenario

The advancement and acceptance of the decentralized wastewater management concept has continued to increase as the profession develops. Through the development of uniform rules, certification, regulation and practical experience, we now understand the vital inputs to our selection and design process. We must match the technology to the site condition to achieve proper wastewater treatment for protection of public health and the environment. Drip dispersal is one technology that should be considered when selecting the most land efficient, cost-effective system for a site.

Even Distribution

Drip systems have continued to increase in popularity over the past few years. Proper siting, design, installation and maintenance are the only way that this technology can be implemented with success. The use of drip dispersal provides flexibility in design and application areas and also helps address the issue of problematic soils through an ability to precisely place a specific quantity of water where it can be accepted and treated. Finally, drip dispersal can be incorporated into the landscape as a supplemental water supply, thus conserving fresh water sources for drinking water.

Water Recycling

Water is an important resource for maintaining our lives. Many areas in the United States are facing water demands that exceed the fresh water supplies. Wastewater is one resource available to meet part of our water demand and its utility increases as the population grows.

The drip dispersal technology is ideal for wastewater reuse. Drip systems are installed in the active soil zone and thus provide wastewater for use by landscape plants. The uniform application distributes the reclaimed water across the landscape. Because application rates for residential systems are based on long-term water acceptance rates of the soil and peak loading from facilities, the actual wastewater application rate may only provide supplemental irrigation rather than meeting the full water requirements of landscape plants.

Wastewater application rates vary with soil type and site conditions. In sandy soils with greater water application rates or where wastewater dispersal/groundwater recharge is the main design criteria, vegetation may have to tolerate periods of excessive wetness. In clay soils with lower long-term acceptance rates, selection of drought tolerant plants will allow optimum utilization of the wastewater and nutrients. Supplemental irrigation may be needed for maintenance of plants with relatively high water requirements. Municipal systems application rates, however, can be designed based on the water requirements of the plants. If this approach is used, wastewater storage will be required during periods with lower evapotranspiration rates. Municipal systems have an additional requirement of checking for nutrient loadings to a site. When the system is designed for water dispersal, both hydraulic and nutrient loads are checked and the most limiting loading rate is used for the final design.

Wastewater can also be used for stabilization of residential house slabs constructed on heavy clay soils. Shrink-swell clays move when exposed to subsequent wet and dry periods. Wastewater application around the house slab provides uniform moisture content and reduces the risk of soil movement. The ability to implement the practice of application of water close to the building foundation is a function of state regulation and a variance from setback distances or a secondary quality effluent may be required

Application to Sites Requiring Uniform Distribution

Subsurface drip dispersal is a land application technology suitable for most sites. However, selection practices have historically implemented this technology on sites with a limited potential for wastewater treatment and acceptance. Some of these are highlighted in this section.

Small Lots

Small lots are a challenge for installation of any on-site wastewater treatment system. However, many regulatory agencies allow drip dispersal systems to have the lowest horizontal set-back distance of the subsurface application systems. Because of the flexibility in placement of fields, drip drainfields can be placed in irregularly shaped areas and in segmented locations. Placing drip systems in these land-limited locations increases the system complexity and the need to truly understand the system hydraulics and soil acceptance. Attention must be given to balancing water flow during field flushing. Another consideration is mass water movement out of the application field. Water movement through the soil profile must be evaluated to prevent saturation of the soil. (See Hydraulics, Soils, Water Movement and Soil Treatment)

Vertical Separation Issues

The vertical separation distance to both groundwater and restrictive horizons is generally less for drip irrigation than for gravity dispersal technologies. These reduced separation distances are justified because of the uniformity of wastewater application and implied greater residence time in the soil. However, when using drip systems in areas with high groundwater, consideration must be given to how the water leaves the soil treatment area: evaluating water movement is a key to a successful system.

The presence of shallow groundwater below the drip field reduces the ability of water to move out of the drip field. The wastewater moves into the soil and down into the groundwater and water must then move laterally through the soil profile to exit the site. Generally, the groundwater must mound under the drain field and develop the head to move the water laterally away from the drain field. When shallow groundwater is present, extensive evaluation of the site conditions is required to determine how the water will be drained from the system.

Steep Slopes

Sites with steep slopes provide a unique opportunity for drip dispersal because they have a high gradient for downslope movement of water. Because pressure compensating drip emitters have a uniform application rate above a minimum pressure, the lines can be placed on the contour and "stair-stepped" down the slope. However, the emitters do not provide uniform application during depressurized flow (when the pump is off). The design must prevent movement of the wastewater to the bottom of the drip field during this time or take this redistribution into account. A long narrow field should be used which distributes the water across a greater amount of the slope face. Installation on sloping sites can also be challenging. In some cases, a drip system may be placed at the ground surface with very little to no cover, thus preventing use of equipment on steep slopes.

Shallow Soils

Shallow soils also introduce a challenge for treatment and acceptance of the wastewater. Some sites with shallow soils may have insufficient depth to meet the vertical separation distances below the drip tubing and the required soil cover over the tubing. Drip systems can function in a mound system. Soil is imported to create a mound that provides the required separation distance. This imported soil treats the wastewater before it reaches the restrictive layer or groundwater.

Clayey Soils

Clay soils provide effective treatment of wastewater and Drip systems can function well in these soils. However, the hydraulic capacity of the soil is limited and water movement through and away from the site must be evaluated in the design process. Some designers have chosen to modify the soil to increase dispersal while others have modified emitter and lateral spacing. Addition of sand to the clay can increase the permeability of the soil thus assisting in water dispersal. Use of sand to increase lateral dispersal of effluent is not universally accepted within the industry. It has been used with success in some areas. However, the designer must evaluate both lateral and vertical dispersal of effluent. Drip emitter spacing within the drip line and between adjacent drip laterals can be decreased. Decreasing the emitter and lateral spacing while maintaining the areal footprint assists with dispersal of the water into the soil treatment volume by increasing the emission points and decreasing wastewater travel distance through the soil. However, the total drip field surface area, areal footprint, remains the same to keep the landscape loading rate the same. Therefore, decreasing spacing between lines increases the amount of drip line and will affect the hydraulic design of the system.

Design Concerns with Drip Dispersal

Wastewater contains physical, chemical and biological agents that pose a risk of emitter plugging and must be addressed in the design process to allow the use of drip dispersal as a method for application (Ravina et. al, 1991). Since drip dispersal's efficiency relies heavily on maintaining uniform water dispersal, emitter clogging is a major point that must be addressed. In fact, Nakayama and Bucks (1981) have shown that a small percentage of clogged emitters can greatly reduce the uniformity of water application. Therefore, a need to incorporate methods for reducing clogging is essential to the long-term use of drip dispersal of wastewater.

Bioslime buildup in laterals, supply lines and supply manifolds is also a concern. This material can reduce flushing efficiency and exacerbate emitter clogging/flow uniformity. Field flushing or chemical treatment removes these materials from the piping.

The prevention of drip emitter clogging has been addressed in two different ways. First, drip manufacturers have developed emitters that are self-cleaning through the use of wide, turbulent-flow labyrinthine passageways ("Trickle", 1984). The other approach is to improve water quality prior to entering the emitter, and use a shorter and wider labyrinth as in pressure compensating emitters. (Nakayama et. al., 1978). Tajrishy et. al. (1994) concluded that the successful operation of drip dispersal over the long term required the consideration of both emitter design and water quality.

Water redistribution in the field can be a challenge for proper system operation. The designer must consider where the water drains after the pump shuts off. Isolation of lateral lines using horizontal manifolds or check valves can limit water redistribution. Placement of lines on the contour can assist in reducing drainage to the bottom of the slope. Also, temporary saturation in the dispersal field can cause the drip tubing to serve as a subsurface drainage system. Water will flow into the emitters when soil is saturated around the lateral. Water can enter the drip laterals and redistribute in the field.

Chapter 2: System Components

A subsurface drip dispersal system distributes wastewater to the landscape through a network of drip tubing installed below the ground surface. It generally consists of four main components: 1) wastewater pretreatment components, 2) pump tank, 3) dosing controller, 4) filtration device and 5) drip dispersal network with one or more zones consisting of supply lines, supply manifolds, drip laterals, return manifolds and return lines.

Wastewater Pretreatment Devices

The minimum pretreatment required is primary treatment or settling of the solids in a septic tank. This septic tank effluent is passed through a filter producing *mechanically filtered septic tank effluent*. However, most States require secondary pretreatment of the wastewater before it enters the filtering system (*aerobically treated effluent*). Many pretreatment devices are available (including aerobic treatment units, media filters or constructed wetlands) for improving the quality of the effluent. The choice of treatment device depends on the type of drip tubing being used and the manufacturer's recommendations. This manual focuses on the drip system; therefore, the pretreatment systems will not be discussed further aside of disinfection. Other modules are available addressing pretreatment (See Constructed Wetlands, ATUs and Packed Bed Filter Modules.)

If effluent is applied beneath the surface, disinfection is generally not necessary. Evaluation of soil conditions will determine the potential for soil treatment of pathogens present in the wastewater. Secondary quality effluent may be applied to gravelly sand soils or fractured rock provided that the effluent is disinfected. Disinfection should be incorporated if the emitters discharge to the ground surface. Chlorine or UV light disinfection units are commercially available for wastewater treatment. (See Disinfection.)

Pump Tank

Function and Volume Considerations

The next component of a drip dispersal system is the pump tank fitted with a pump, a pressure regulation device (pressure regulation is required when using turbulent flow emitters), and controller. Pump tanks serve as a storage system to hold the effluent until it's dosed into the soil treatment area. The pump tank provides flow equalization, and emergency storage during periods of pump failure or electrical outage. The volume of the pump tank can be divided into three separate segments: static water volume, dose volume, and emergency storage. Systems designed with flow equalization need a volume designated to store diurnal peaks in the pump tank.

The static water volume is the tank volume needed to maintain pump submergence and prevent the pump from sucking air and causing cavitation. To accomplish this, the water level must remain at least six inches above the pump inlet screen. Submersible pumps are also typically placed on a pedestal or concrete block to keep the pump above any accumulation of solids. As a general guideline for onsite systems, the water level in the pump tank should be sufficient to keep the pump motor submerged to keep the pump cool during operation. For systems using turbine pumps, the required static volume may be greater due to the height of the intake and motor. Suction pumps that are located outside the pump tank do not require as much static volume but the inlet hose should be held off the bottom to minimize any uptake of solids that may accumulate in the bottom of the tank. Additionally, four to six inches of effluent above the inlet of the intake pipe must be maintained at all times to prevent losing the pump prime.

The pump tank dose volume stores the water to be dosed into the soil treatment area. This volume can be as little as the volume of a single dose, enough to supply an on-demand dosing system, or equivalent to almost the daily flow. Systems designed for flow equalization over a daily or longer period require a greater storage capacity.

The pump tank emergency storage or alarm volume stores additional effluent generated after the alarm float is activated. This storage volume allows the facility to operate until the system is repaired and may be set by the regulatory agency. Measures such as back up pumps used in conjunction with override controls may reduce the emergency storage volume required.

Pump Tank Components

Pumps

Criteria for selecting a pump are generally dictated by system type. This discussion will be general and the manufacturer's design recommendations should be followed.

For a mechanical filtration unit, the pump is sized to handle the flow (both dosing and flushing rates) and pressure required for the filters and for forcing the effluent through the dispersal lines. Typical pressures in the dispersal lines range from 15 to 60 psi with filter flush pressures from 15 up to 150 psi. The pump must also be sized to provide adequate flow volume and pressure for flushing the filters and forward flushing of the drip laterals. The pump may be required to be capable of providing a minimum of 2.0 fps of velocity in the drip tubing for regular flushing of the laterals to minimize build-up of bacterial growth on the tube lining. The flush water is generally returned to the pretreatment unit. The designer should consider the hydraulic loading of the flush water on the pretreatment unit by evaluating the volume of flush water and frequency of flushing Automatic filter flushing must be used on systems dispersing mechanically filtered septic tank effluent. (See the tube manufacturer's recommendations).

For the aerobically treated effluent units, the pump must be sized to handle the flushing flow and pressure requirement of the dispersal unit. In-line pressures, in the range of 15 to 20 psi, are common with flow rates dependent upon the number of emitters. Flushing velocities as specified by the tube or system manufacturer must be satisfied and are generally in the range of 1.0 to 2.0 fps. Automatic flushing should be incorporated and this will require a control panel. Alternately, flushing can be done manually by opening the valve and turning on the pump with discharge to the pretreatment unit. Again, the designer should evaluate the hydraulic loading by the drip lateral flushing water on the pretreatment unit.

Pressure Regulation

Pressure regulation is needed to prevent damage to the drip tubing and to ensure uniform distribution within the dispersal field when using non-pressure compensating emitters.
If the pressure in the drip lateral becomes too large, the tubing or connections may burst. Appropriate field pressures can be achieved through proper pump sizing or pressure regulation. When using non-pressure compensating emitters, pressure dictates the amount of wastewater discharged from each emitter. By using a pressure regulator, the desired discharge rate can be set. Extreme pressures can cause the plastic tubing to flex during operation and resting cycles.

A pressure regulator must be selected based on the desired field operating pressure and operating flow rates for the system. An appropriate flow range is needed to meet both the normal dosing flow and the dosing plus field flushing flow. A by-pass line around the pressure regulator may be needed if a pressure regulator is not available to meet both flow requirements. This by-pass line would be opened during field flushing to allow the system to convey the desired flow.

Some designs incorporate a recycling valve in the supply line to control system pressure. Flow rate is maintained, but a portion of the volume is recycled back to the pump tank, thus reducing the pressure in the system.

Dosing Controller

To regulate the quantity of wastewater dosed to a dispersal field during each pump cycle, some form of dosing controller is needed. The controller can be as simple as an on-off float. A system utilizing an on-off float is generally referred to as an "on-demand" system because whenever the float activates the pump and a dose of water is sent to the dispersal field. The on-demand system does not allow control of dosing frequency nor volume; thus, the soil at an on-demand site must be able to accept periodic high volumes of water due to variation in water flow patterns in the facility. To facilitate control of both dosing volume and frequency, use of a time dosing panel is recommended for all installations; however, it is critical on all sites exhibiting shallow soils, clay soils, high ground water, steep slopes, and small lots, because of a greater need to control the hydraulic loading to these sites. The addition of a programmable logic controller allows control of dosing volume and frequency, alternation between zones where applicable, automatic flushing of lines and backflushing of filters.

Control system features such as auto-dialing, and remote monitoring/operating capabilities become more economically feasible as the system size increases. Diagnostic controls can provide for monitoring pump starts, run times, number of doses, number of flush cycles, and flow rate to each zone during the dosing cycle. Monitoring zone flow rates facilitates checking for variance from design/initially recorded flow rates. (See Instrumentation and Controls.)

Pre-Filtration

Filtration is one of the most important components of any drip system. The filters are needed to remove all particles greater than 100 microns in size and thus reduce the risk of plugging the emitters. Screen filters, disk filters and small sand filters are all filtration units used in drip dispersal. In most cases these filters are either backflushed or scoured to ensure long-term use of the system through automatic cleaning.

Selecting the filter type and cleaning method is important for the success of the system. The type of filter and the method for cleaning is a function of the pretreatment system and the susceptibility of the system to flow upsets. Complex filtration systems generally include automatic backflushing of filters and pressure sensors that can indicate filter plugging. These systems are essential if pretreatment is limited to a septic tank. If additional pretreatment such as an ATU or media filter is part of the treatment train, simpler filtration systems may be sufficient. However, if the pretreatment system can be hydraulically or organically overloaded, a more complex or robust filtration approach is indicated.

Types of Filters

The filters are essential to any drip dispersal system and are especially critical for the mechanically filtered units. The filter protects the emitters by removing the solids from the effluent stream. The filter opening, measured in microns, is usually 7-8 times smaller than the emitter opening. There are several types of filters available.

Disk Filters

Disk filters consist of a stack of disks with a hollow core with a very narrow space between the disks. The filters are available in various sizes (gpm) and spacing (microns) between the disks. Typical groove spacing for drip dispersal is 100 to 150 microns. Wastewater passes from the outside to the inside and larger solids accumulate on the outside of the disk while smaller solids are collected in the grooves on the disks. Periodically, the flow is reversed with water from an adjacent filter, flushing the solids off the surface, and returning them to the inlet pipe of the septic tank. Filters must be inspected periodically and hand cleaned if necessary.

Spin/Screen Filters

Spin filters consist of a screen cylinder enclosed in a casing. For small drip systems the filters range in size from 3/4" to 1.5" with a typical mesh size of 150 and micron rating of 100. Other sizes and openings are available. The flow enters one end of the cylinder at an angle to create a turbulence which helps keep the screen clean. There is a small ball valve at the end opposite the inlet which is opened periodically (manually) with the accumulated solids flushed out of the cylinder and returned to the pretreatment unit. With a solenoid valve and controls, the unit can be set to automatically discharge solids on a predetermined schedule. The screen may need to be removed periodically for hand cleaning, especially if it filters septic tank effluent.

Types of Systems Based upon Pretreatment

Mechanically filtered septic tank effluent systems:
These consist of forcing septic tank effluent through 100 - 150 micron filters under high pressure. Filters are automatically back flushed with the solids discharged to the septic tank. The filters (usually disk filters) are part of a hydraulic unit that includes a pump, water meter, solenoid valves and a control panel. For typical residential systems the units are contained in a heated insulated box located near the pump chamber with the pump located in the pump chamber or in the insulated box. For larger units serving commercial facilities, the hydraulic unit is usually located in a small, insulated building with the pump(s) located in the unit

Figure 2.1 shows a complete system utilizing a mechanical filtration unit (American Manufacturing, 1999). The system requires a septic tank, sized for the establishment, and a pump tank. The pump tank must have surge capacity for flow equalization as these units are time dosed, not demand dosed. The effluent in the pump tank is pumped to the mechanical filter assembly, housed in a box or small building depending on size. The disk filters, two or more depending on size of the unit, remove the solids as the effluent passes through the filter. Spin filters have also been used in this application.

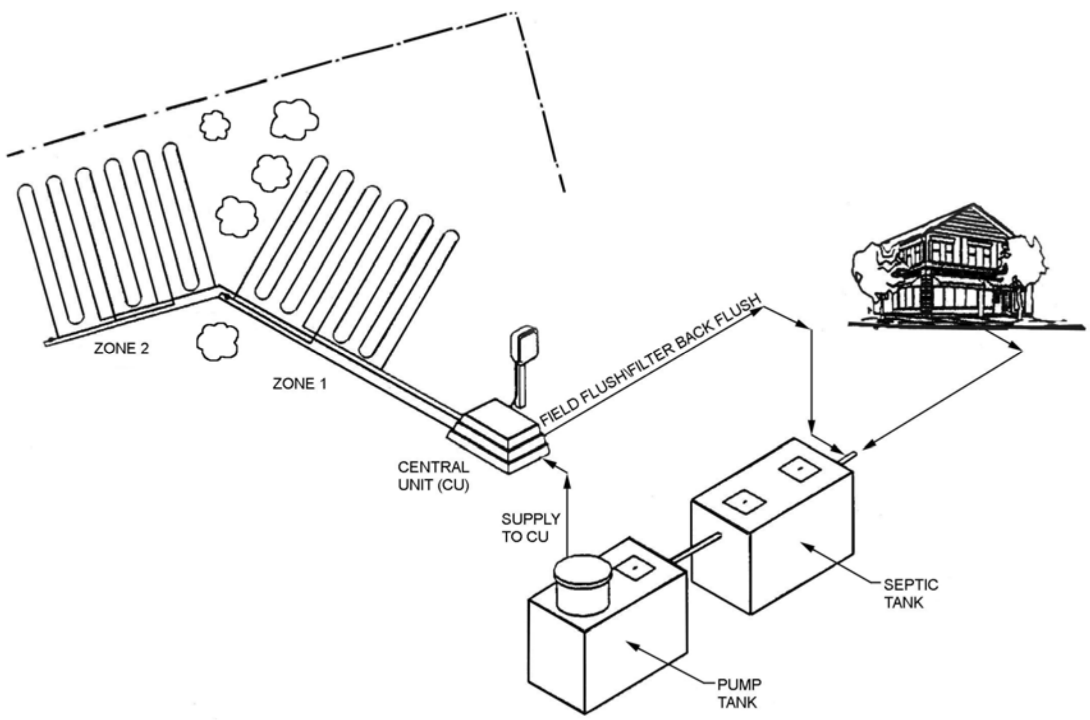

Figure 2.1: Drip dispersal system utilizing a mechanical filter showing two zones (American Manufacturing, 1999)

The mechanical filtration system is instrumented to back flush the filters either before, after or when the pressure differential across the filter increases by a predetermined amount. The solids-laden flush water enters the house waste line upstream from the septic tank inlet. The filters are designed to remove the suspended solids to protect the downstream emitters from plugging. There is very little change in BOD, nitrogen, fecal coliform concentrations and other parameters. Because of the relatively high oxygen demand (BOD and nitrogen) there is the potential for soil clogging around the emitters if the oxygen demand is not met. Experience has shown that this is normally not a problem but it can be if the loading rates and/or BOD are high.

Aerobically treated effluent systems

These consist of a septic tank followed by a sand filter, peat filter, biofilter or one of the many types of ATUs commercially available. Figure 2.2 shows an example of such a unit (Geoflow, 1996). There are numerous variations depending on the manufacturer. Also, the unit described above for mechanically filtered effluent can be used with aerobically treated effluent. When properly operated and maintained, the effluent entering the drip system will have very low BOD and TSS (less than 20) and normally lower fecal coliform counts than the mechanically filtered septic tank effluent. The effluent is then normally passed through a 100- 150 micron disk filter or a small pipe sand filter to remove any solids that may pass through the treatment unit or are inadvertently introduced into the dosing tank. Low amounts of organic matter entering the soil reduce the oxygen demand and reduce or eliminate soil clogging around the emitters. The systems can be demand-dosed or time-dosed. The latter scenario will require surge capacity in the dose chamber.

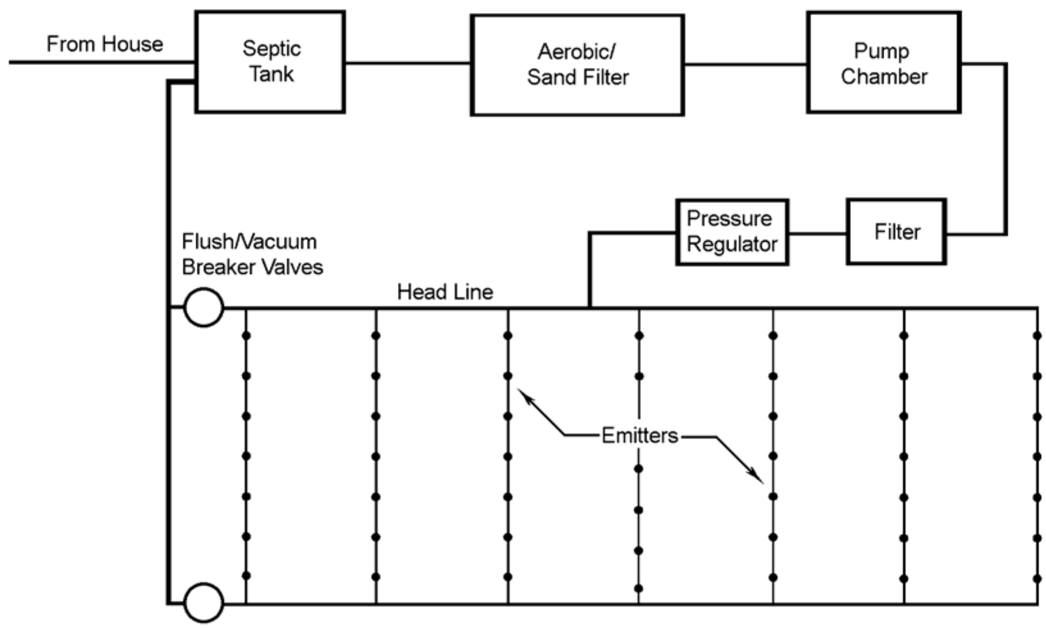

Figure 2.2: Drip dispersal system utilizing aerobically treated effluent (Geoflow, 1999).

Drip Dispersal Unit

The drip dispersal unit consists of a zone control valves, supply line, supply and return manifolds, emitter lines, check valves, common return line (field flushing line), air relief valves/vacuum breakers, cleanouts and pressure monitoring points. System configuration is dependent upon the area available for dispersal. This discussion will be more generic and limited to the essential components. Refer to the manufacturers' literature for alternatives such as looped systems and zone loading with equal and unequal absorption fields. Figures 2.1 and 2.2 provide an example of the various components.

Unit Components

A ***pressure regulator*** is often used in systems using non-pressure compensating emitters. However, drip fields using pressure compensating emitters can be controlled with either a pressure regulator or a return flow valve in the pump tank. A pressure regulator is selected based on the desired field operating pressure and the flow requirements for the system. Alternatively, pressure in the system may be set by observing the return pressure before the flush valve and then opening the flush valve until the desired pressure is achieved. This provides a continuous field flush, which may be advantageous particulary for systems which are manually operated.

The ***supply line*** extends from the pump/hydraulic unit to the supply manifold of a given zone. The size will be dependent upon length and design flow rates. Most residential systems use ¾” to 1 ½” PVC pipe. The design flow rate must be based on the emitter flow rates and the flushing flow rates expected to enter the field to prevent excessive pressure loss during normal operation or during flushing events. Each zone either has its own supply line, or there will be a common supply line to multiple zones with a solenoid control valve at the beginning of each zone.

The ***return line*** connects the return manifold to the pretreatment unit. The purpose of the return line is to convey the flush water, as discussed above, to the pretreatment unit during the flushing cycle. To provide proper scouring of the drip lines, flow rates which yield scour velocities of 1-2 feet per second at the distal end must be provided during flushing cycles. For typical ½” drip tubing, this requires a flow rate of at least 1.6 gpm flow at the outlet end of the laterals (Wastewater Systems Inc., 1999). If there are 5 laterals per zone, the minimum flushing flow rate is thus 8.0 gpm (this minimum flushing flow rate must the added to the dosing flow rate to determine minimum pump flow rate). Depending on the configuration, the supply line and the return line can be at the same end of the zone or at opposite ends. A common return line can serve several zones with the proper location of check valves. The size of the return line is usually the same as the supply line. The return line could be a greater diameter to minimize friction loss and/or utilize gravity to return the flushing flow to the pretreatment unit.

An ***air relief valve or vacuum breaker*** is one of the most crucial components in any drip system. An air relief valve/vacuum breaker allows air to enter into the drip laterals after the pump shuts off. This prevents siphoning of soil back into the emitters and potentially clogging the emitter holes. The air relief valve/vacuum breaker must be placed at the highest point on both the supply and return manifolds to ensure proper operation. A small meter box should be placed around the vacuum breaker to allow free flow of air and access for repair or replacement. In climates with freezing conditions, the housing for the vacuum breaker must be insulated to minimize heat loss.

The air relief valve/vacuum breakers should be placed in a vertical 4" PVC pipe (a greater size will allow cleaning/replacement without excavation) with cap or valve box. Insulating the pipe or valve box will minimize freezing in cold weather systems. Vacuum breakers come in various sizes and shapes. Inexpensive breakers may not be as reliable as larger more expensive breakers. Breakers may occasionally stick open allowing the effluent to flow out of them. Periodic observation is critical.

The ***supply manifold*** connects the supply line to a series of drip laterals. The return manifold connects the same series of drip laterals to the return line. Figures 2.3 and 2.4 shows two types of manifolds. One is a single line with drip laterals connected along its length (Figure 2.3). The other unit consists of a short manifold with small diameter (½ to 3/4") PVC pipe connecting the manifold to each drip lateral (Figure 2.4). This manifold configuration is for horizontal manifolds that are used with pressure compensating emitters on sloping sites to control internal drainage before and after each dose. The return manifolds in both cases are similar to the supply manifold. The single line manifold interconnects all drip laterals within the zone and is usually larger with more volume while the top-down manifold isolates drip laterals from one another (located on the up slope edge) and has a smaller volume. The advantage of the short manifold is that it eliminates flow from one drip lateral to a lower lateral thus reducing overloading in the lower portion of the system when the supply and return manifolds are installed at the upper edge of the zone.

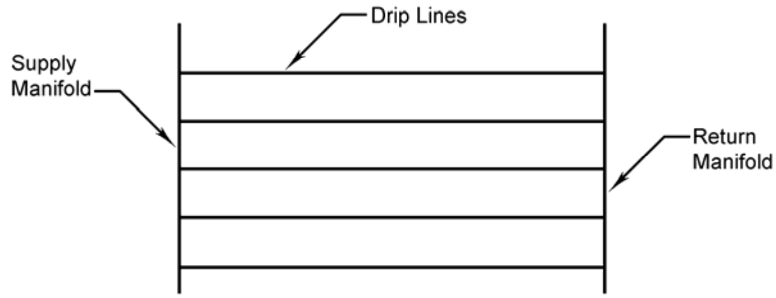

Figure 2.3: Single supply and return manifold with drip lateral connecting along its length

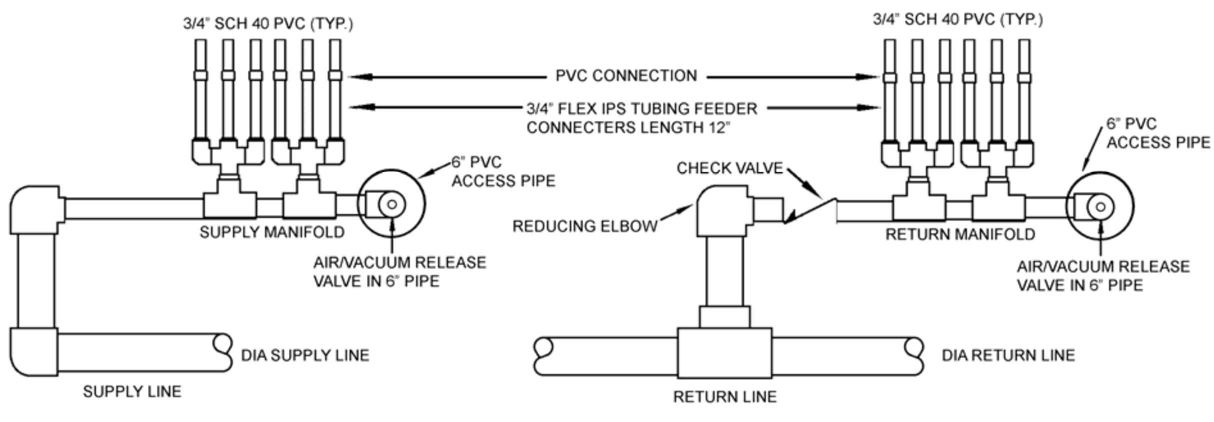

Figure 2.4: Top-down supply and return manifold (Wastewater Systems Inc, 1999).

The ***drip line*** is typically a ½" diameter polyethylene tube that is easily plowed into the soil. Internal emitters are embedded every 24" along the length of the tube. Drip lines with emitters spaced at 6 and 12" are available and may be appropriate for use with higher strength BOD wastewater or when soils are clayey with extremely low conductivity. Drip line can be purchased with or without an internal coating designed to minimize bacterial growth. Emitters are also available with impregnated herbicide to reduce root penetration into the emitters.

As with any tube or pipe, each type has its friction loss characteristics. The friction loss in a drip line is a function of the tubing diameter, the profile of the emitter, and emitter flow rates. Length of laterals is limited at any given flow rate to maintain a certain pressure in the lateral. Curves (Figure 2.5) (an example for a specific product) and tables are available for estimating pressure loss along the length of the tubing. For example, the head loss in a drip lateral 400 feet long is approximately 4 psi when the drip line diameter 0.51 ID and a 0.62 gph emitter is used.

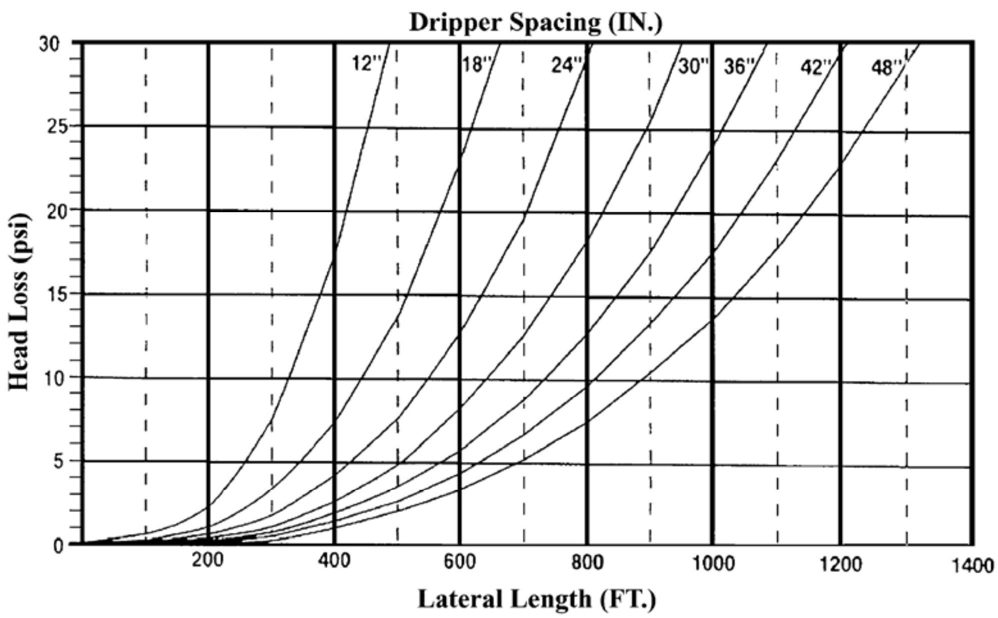

Figure 2.5: Head loss as a function of lateral length for Netafim 0.51 ID drip line and 0.62 gph emitters (Netafim USA, 2002)

Friction loss in a drip lateral increases during flushing because the flushing volume is carried through the lateral in addition to the emitter discharge volume. For example, the pressure loss at the distal end of 250 linear feet of tubing during flushing at 2 fps (1.6 gpm) is 26 ft (American

Manufacturing, 1999).

Drip line/Manifold Connections

When connecting the drip lines to the supply and return manifold the drip lines should not be connected directly to the manifolds. It is recommended that this connection be made with flexible PVC pipe or tubing (preferred) or with rigid PVC. Connecting the drip lines directly to the manifolds may result in the development of kinked lines and separation due to settling which will result in improper function. When installing laterals with loops, flexible PVC should be used. The drip line itself should not be looped as it will likely kink, unless there is a wide loop. If the drip lines are spaced 12" apart, it may be difficult to loop even with flexible PVC tubing. One design approach used to overcome this is to loop the first run with the third or fourth run to avoid the sharp curvature created when trying to connect closely-spaced adjacent runs.

Drip Dispersal Unit Terminology

Zones

The drip laterals are configured into zones with the number of zones dependent on the design flow and size of system. Zones can be configured in several ways with the supply manifold and return manifold on opposite ends of the zone or on the same end. Figure 2.1 and 2.2 illustrate these scenarios. A minimum of two zones is recommended in most cases, especially for mechanically filtered septic tank effluent systems.

Run

A run is a single length of drip line installed along the contour.

Lateral

The lateral is defined as the length of tubing extending from the supply manifold to the return manifold. If manifolds are on the opposite end of the zone, then the run equals a lateral with no looping. If both manifolds are on the same end of the zone and the drip tube extends out and loops back to the return manifold, then the lateral equals two runs (Figure 2.6). The tubing can be looped several times with the length limited only by the requirement to avoid unacceptable pressure loss along its length.

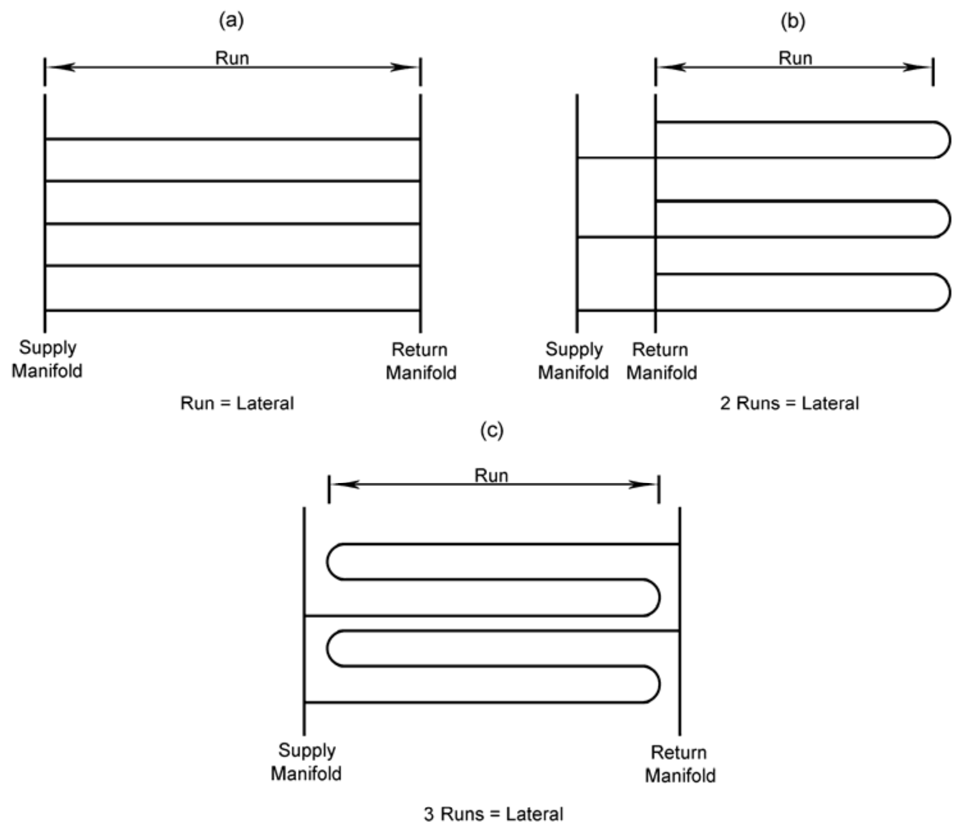

Figure 2.6: Run is Identified as one drip line the length of the zone while a lateral is defined as one drip line from the supply manifold to the return manifold

Types of Emitters

Pressure compensating emitters

This emitter is designed to maintain a constant discharge rate over a range of pressures. One commonly used pressure compensating emitter has a discharge rate that is the same for pressures of 7 psi to 70 psi (Netafim, 2004) (Fig.2.7). The performance curve is flat for pressures ranging from 7 to 70 psi with the discharge rate dropping off as pressure drops off below 7 psi. During low flows the pressure compensating emitter acts as a turbulent flow emitter. A typical flow rate is 0.62 gph but emitters are available for higher or lower discharge rates. Pressure compensating emitters will provide uniform application, when the dripline is pressurized, on both sloping and level sites.

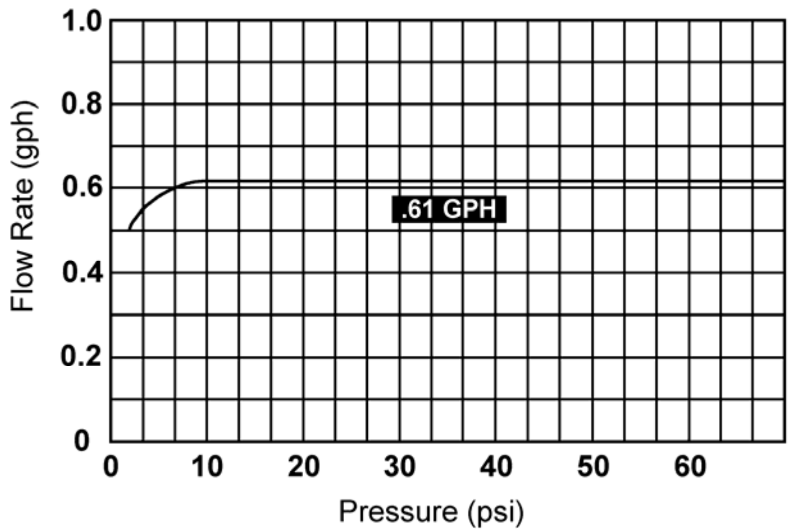

Figure 2.7: Flow rate vs. pressure for pressure compensating emitters (Curve presents a general relationship, not a specific emitter).

Turbulent or non-pressure compensating emitters

With this type of emitter, the discharge rate will vary with the in-line pressure (Figure2.8). Table 2.1 gives the discharge rate for various pressures for one type of non-pressure compensating emitter. Other emitters will have different discharge rates. If emitters are installed at different elevations, the discharge rates will be greater in emitters at the lower elevations than those at higher elevations. However, the difference may be minimal if the in-line pressures are high and the elevation difference is small. For example, if all things are equal except elevation, a 10 ft elevation difference would be a 4.3 psi difference in pressure resulting in approximately 15-20% variation in discharge rate depending on the in-line pressure.

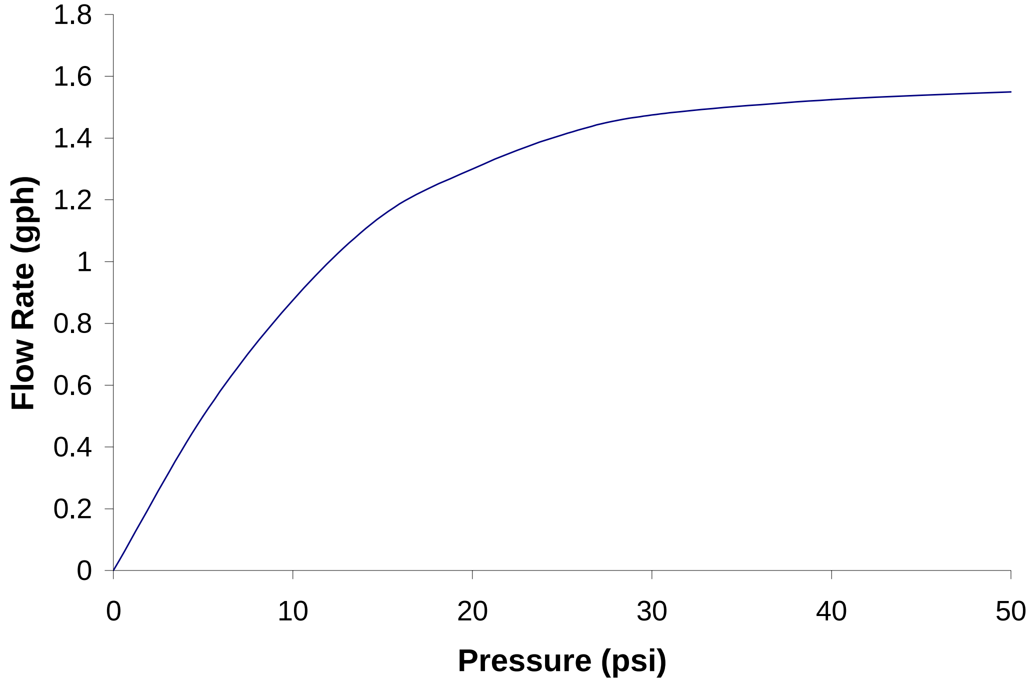

Figure 2.8: Flow rates vs. pressure for turbulent emitters (Curves represents a general relationship, not a specific emitter).

For both the turbulent and the pressure compensating emitters on sloping sites, the lower emitters will discharge more effluent following the dose cycle as the upper lines will drain down to the lower lines. Methods are available to minimize the movement of effluent between upper and lower emitters and will be discussed later.

Table 2.1: Turbulent emitter flow rates for various pressures for a given non-pressure compensated emitter (Geoflow, 1999)

Pressure (psi)	Flow (gph)
10	0.93
15	1.13
20	1.32
25	1.49

Special Design Considerations

Drainage during Depressurized Flow

When the pump shuts off, the remaining effluent in the drip lateral and manifolds will drain out through the emitters. On sloping sites and to some extent on level sites, it will flow via the tube and manifolds to the lowest point where it will flow out the emitters. This may cause severe overloading and breakout on the ground surface especially in larger systems and on slowly permeable soils. Things that can be done to minimize this from happening are:

- Keep each zone as small as is reasonable.

- Use a small compressed horizontal manifold with small diameter pipes extending to the drip laterals. This compressed manifold isolates drip laterals from one another as it is normally placed on the up slope side of the zone. The isolated lines supplying effluent from the manifold to the drip laterals prevents drainage of the manifold to the lower drip laterals.

- Isolate each lateral by having the PVC feeder tubing for each lateral pass over an elevated berm between the manifold and beginning of the tubing to reduce gravity flow out of the lateral. In looped systems, elevating the loop will keep the effluent in its respective run.

- Use a sufficient dose volume so that the percentage of effluent which drains by gravity is small compared to the amount delivered while the laterals are fully pressurized.

- Use a bottom-loading supply manifold with check valves installed before each lateral to prevent residual water from flowing down the slope. The return manifold should also have check valves to prevent water flowing down the slope during drainage.

- The supply and return manifolds can also be drained from the bottom of the field back to the pump tank. This prevents effluent from draining into the drip laterals and returns it back to the tank to be dosed again during the next event.

Saturated Soils

Under saturated soil conditions, groundwater may flow back into drip lateral through emitters. If the pump chamber is at a lower elevation than the drip lateral and the dispersal field is subject to periodic saturation, installation of a check valve is required to prevent drainage back into the pump chamber. If soil saturation occurs during pumping, lower dose volumes may correct this problem. If it occurs during heavy rains, there is not much that can be done other than to install a check valve in the supply line. Placement of the drip laterals as high in the soil profile as possible will minimize the problem. On very wet sites, it may be appropriate to place the system in several inches of sand above the soil surface and then place soil over the top of the drip laterals if local regulation allows. In this case the system is placed above the native soil.

Chapter 3: Drip Emitters and the Soil

Soil is the final treatment and dispersal component of a drip dispersal system. The soil must be capable of accepting and treating the wastewater. Drip emitters provide uniform distribution of wastewater which includes both the water and contaminants. Understanding the water movement and the effect of wastewater constituents on the soil assists the designer in developing a system capable of long-term management of the wastewater.

Loading Rates

SOIL HYDRAULIC LOADING RATE

Wastewater loading rates used for determining the footprint of a drip dispersal systems can be the infiltrative loading rates (R_a) used for sizing other final treatment and dispersal onsite wastewater treatment systems. Designers should check local regulations to determine the appropriate loading rate. The soil texture is plotted on the USDA textural triangle (Figure 3.1) and the soil classification is determined. The USDA textural triangle is divided into four soil classifications represented by Class Ib, II, III, and IV. Figure 3.1 represents the four textural classes used in Texas. Other states also divide the textural triangle into four textural classes. However, the soil types may not be in the same textural classes as in Texas.

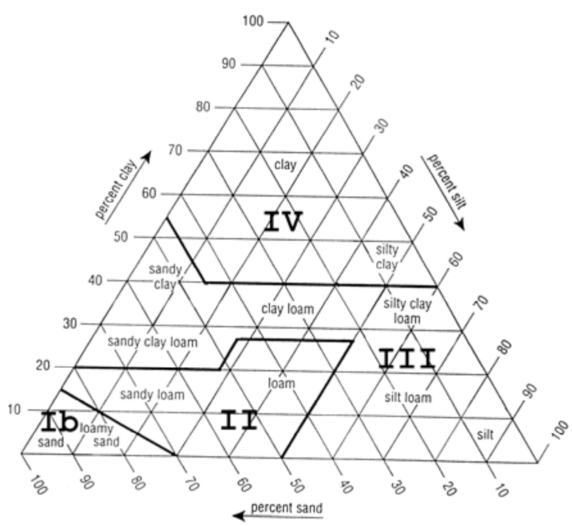

Figure 3.1: Soil Textural Triangle Classification with the four textural classes used in Texas.

The required absorptive area should be calculated by the following formula:

ABSORPTIVE AREA = Q/R_a, Where Q is the wastewater flow rate in gallons per day and R_a is the areal loading rate or system footprint loading rate.

Soil Organic Loading Rate
The organic loading is determined by the oxygen demand that microorganisms need to degrade the organics. Therefore, it isn't the soil that is doing the treatment and creating the demand. What the soil must do is be able to replenish the oxygen the microbes use. The ability of the soil to supply the oxygen depends on the depth at which the demand exists (shallower is better), the moisture content of the soil (lower moisture tensions mean more of the soil pores are filled with water and unavailable for reaeration), soil structure (more important than texture because of the larger, continuous pores that good structure provides), and texture.

Water Movement in Soil
Water moves under three main flow conditions in the soil: saturated flow, unsaturated flow and preferential flow. Saturated flow is when the pores are filled with water and the majority of the flow is through the larger, continuous pores in the soil. Saturated flow can be represented by laminar flow water movement through pore spaces. Unsaturated flow moves along the surfaces of the pores or soil particles. The large pores have air filling the void space thus providing good aeration. Preferential flow can be described as bypass flow because the majority of the water moves around the mass pore spaces and flows through breaks between soil peds, root channels, worm channels and shear planes. Page: 23
Preferential flow occurs under both saturated and unsaturated conditions. Preferential flow is determined by the pore size distribution in the soil. Under unsaturated conditions, the flow avoids the larger pores. Under saturated conditions, the majority of flow is through the large, continuous pores. But flow occurs in all pores. Preferential flow allows the wastewater to bypass the majority of the treatment mechanisms and move rapidly through the soil profile.

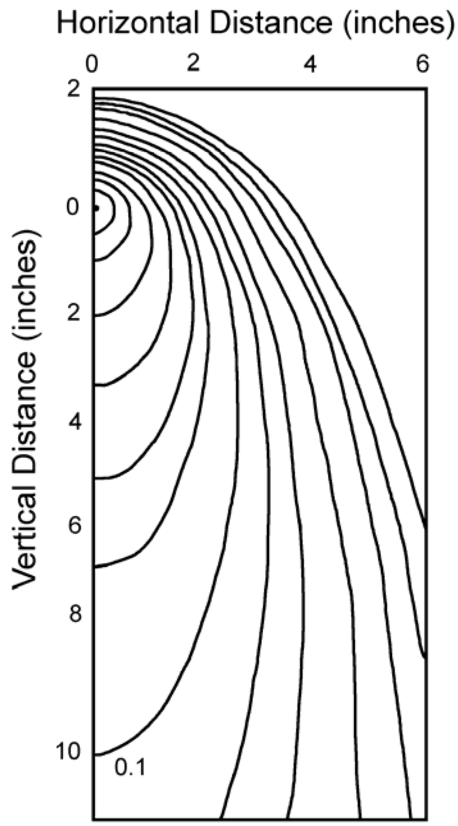

Figure 3.2: A modeled cross-sectional view of water movement patterns around a drip emitter.

Water Movement in a Drip Field

Water moving through a subsurface drip field travels via several different flow regimes.

The first flow regime is saturated flow conditions around the emitter as the water moves from the emitter out into the soil. Generally, the water exits the emitter at a faster rate than it can move away from it, thus resulting in saturated flow. It is important to set a dose volume that will only saturate a small bulb around the emitter and not force saturated flow to the ground surface.

The second flow regime is unsaturated flow during water dispersal into the soil treatment area. It is important to have a sufficient rest period between doses to allow the water to move away from the emitter and allow aeration around the emitter. The water moves up, down and sideways from the emitter as shown in Figure 3.2. Gravity will play a role in moving the water downward away from the emitter.

The third flow regime is saturated flow away from the soil treatment area. When the water encounters a change in soil texture or shallow ground water, ponding and saturation will occur. Once these conditions are encountered, the water will then move laterally from the soil treatment area under saturated flow conditions as a result of increased head. Placing a relatively long and narrow field along the contour of the site distributes the water across a greater amount of the slope face.

Chapter 4: System Design

Tracking wastewater movement is a key point to successfully designing a subsurface drip dispersal system. Understanding how the water is distributed, where it goes during pressurized and depressurized flow and how the water flows in the soil are all factors that affect the performance of a drip system. Asking the right question pertaining to the location and movement of the water during each phase results in effective system design.

Design Principles

Subsurface irrigation designs for agricultural purposes are based primarily on estimated evapotranspiration, rainfall and plant water requirements with less emphasis on soil type and characteristics (NRAES, 1985). However, when the primary concern is effluent dispersal and not meeting plant requirements, the design is usually based on the hydraulic conductivity and how much water the soil will accept. If it were based only on plant needs, then wastewater storage during wet periods would be considered in the design and provisions would be made to provide supplemental water during dry periods.

Since soil dispersal without storage is the primary emphasis for effluent drip dispersal especially with home size systems and small community systems, the design procedures will be similar to those used for other treatment/dispersal units such as in-ground trenches, at-grades and mounds.

Effluent Quality and Loading Rates

As with all soil based treatment/dispersal units, both the quantity and quality of the effluent applied must be assessed when sizing the system. Both organic loading rates and hydraulic loading rates must be considered. Unfortunately, there is very little information available on organic loading rates that affect the oxygen demand. For all soil treatment/dispersal units, if the oxygen demand (BOD, nitrogen) is not met, then a clogging mat will develop over time regardless of the method of application (gravity, pressure or drip). The potential for clogging mat development is greatly reduced when applying septic tank effluent via drip dispersal because 1) the effluent is applied in the upper horizon, where oxygen is more readily available and 2) the effluent is applied more uniformly and more frequently. Since the oxygen demand is essentially met with aerobic treatment (low BOD and ammonia nitrogen converted to nitrate), the hydraulic loading rate for aerobically treated effluent can be higher than for septic tank effluent based on organic strength, and degree of nitrification. Therefore system sizing is dependent upon the extent of pretreatment (septic tank only or septic tank plus aerobic pretreatment) and the soil conditions.

Types of Loading Rates

When applying effluent to soils, there are two design concepts that need to be considered. They are 1) estimating the infiltration rate into the soil and 2) estimating the ability of the soil to move the effluent away from the system. As a result several loading rates must be considered when designing drip dispersal. They are:

Areal Loading (footprint)
The areal loading rate (gpd/ft^2) is the amount of effluent applied over the entire area dedicated to treatment/ dispersal. If drip lines are spaced 2’ on center with 24" emitter spacing along the drip line, then each emitter serves 4 ft^2 of footprint. If laterals are spaced one foot on center and the emitters are spaced 12" along the drip line, then each emitter serves 1 ft^2 of footprint. For the same areal loading rate, the emitter serving the 1 ft^2 area would discharge 1/4 the effluent/day than the emitter serving the 4 ft^2 application area. This approach may be appropriate when dealing with high oxygen demanding wastewater as it gives 4 times the number of treatment points and more access to oxygen. However, system hydraulic requirements of the piping network will be affected with 4 times the emitters and 2 times the tubing length.

Tables 4-1 and 4-2 give the long-term loading rates for soils. Table 4-1 gives the estimated areal loading for aerobically treated effluent with low BOD and Table 4-2 gives the estimated areal loading for mechanically filtered effluent (septic drip). Although the various soil types do not exactly match, comparison of the tables shows that the loading rates suggested for aerobically treated effluent (Table 4.1) are considerably higher than for the filtered septic tank effluent (Table 4-2). The difference is primarily due to differences in organic loading and oxygen demand. These tables are provided as examples available to designers. The designers should select a loading rate appropriate for their location through evaluation of local codes and an understanding of their systems relationship between actual and design flow.

Table 4.1: Recommended soil loading rate for various soil textures receiving aerobically treated effluent using 24" spacing between lines and emitters (Geoflow, 1999).[1]

Soil Texture	Loading Rate (gpd/ft^2)
Coarse Sand	2.0
Fine Sand	1.6
Sandy Loam	1.3
Loam	0.9
Clay Loam	0.6
Silt-Clay Loam	0.4
Clay Non-Swell	0.2
Clay-Swell	0.1
Poor Clay	0.075

[1] These values are guidelines and state codes should be used where appropriate. Consult Geoflow (1999) for additional information relative to loading rates.

Table 4.2: Loading rates for mechanically filtered effluent (aerobically treated and septic drip) based on hydraulic loading, organic loading and fats/oils and greases (American Manufacturing, 1999)

SEPTIC DRIP HYDRAULIC LOADING RATES							
Texture Group	Estimated Perc Rate (MPS)	Soils Group	USDA Texture Class	Hydraulic Load High (gpd/sq ft)	Hydraulic Load Low (gpd/sq ft)	Hydraulic Load High (gpd/lf)	Hydraulic Load Low (gpd/lf)
I	0-15	Sands	S,L S	0.40	0.30	0.8	0.6
IIA	16-25	Coarse Loams	SL,L	0.30	0.23	0.60	0.46
IIB	26-45	Med Loams	SL,L.SCL	0.23	0.20	0.46	0.40
IIIA	46-70	Silt Loams	SiL,CL	0.20	0.15	0.40	0.30
IIIB	71-90	Clay Loams	CL,SiCL	0.150	0.125	0.30	0.25
IVA	91-120	Clays	SC,SiC,C	0.125	0.075	0.25	0.15
IVB	Above 120	Fine Clays	C	0.075	Under .075	0.15	0
SEPTIC DRIP ORGANIC AND GREASE LOADING RATES							
Texture Group	Estimated Perc Rate (MPI)	Soils Group	USDA Texture Class	BOD High (lbs/d/lf)	BOD Low (lbs/d/lf)	FOG High (lbs/d/lf)	FOG Low (lbs/d/lf)
I	0-15	Sands	S,L S	0.002000	0.001500	0.000160	0.000120
IIA	16-25	Coarse Loams	SL,L	0.001500	0.001150	0.000120	0.000092
IIB	26-45	Med. Loams	SL,L,SCL	0.001150	0.001000	0.000092	0.000080
IIIA	46-70	Silt Loams	SiL,CL	0.001000	0.000750	0.000080	0.000060
IIIB	71-90	Clay Loams	CL,SiCL	0.000750	0.000625	0.000060	0.000050
IVA	91-120	Clays	SC,SiC,C	0.000625	0.000375	0.000050	0.000030
IVB	Above 120	Fine Clays	C	0.000375	0	0.000030	0

Contaminant Concentrations are based on: (BOD_5 300 mg/L, 0.25lbs/Day/100 gal) (FATS, OILS and GREASE (FOG) 25 mg/L, 0.02lbs/Day/100 gal)

Infiltrative Surface Loading Rate

The infiltrative surface in drip dispersal is different than it is for trenches where the bottom area/sidewall area is used. In many cases in drip dispersal the effluent moves along the outside of the drip line thus increasing the infiltrative area. Assuming that the effluent moves along the length of the drip line, every 5 linear feet of drip line has 1 ft^2 of infiltrative area. If each emitter serves a 2 by 2 ft area, then the calculated infiltrative rate is approximately 10 times the areal loading rate. If each emitter serves 1 by 1 ft area, then the calculated infiltrative area is approximately 2.5 times the areal loading rate. Thus, the actual infiltration rate for drip is considerably greater than that used for in-ground trenches, at-grades and mounds. However, since the effluent is applied very slowly several times a day (assuming time dosing of effluent), the soil will accept it at a higher rate. The ratio of infiltrative rate to areal rate is dependent upon the configuration as noted above.

Linear Loading Rate

The linear loading rate (LLR) is defined as the amount of effluent applied along the length of a single drip line in gpd/lf of drip line. This concept relates to the soil's ability to move the effluent away from the drip line. Table 4.2 gives values for various soil textures on the basis of gpd/lf. However, other factors such as depth to limiting condition and soil permeability beneath the system which are not taken into account in Table 4.2 must be considered in the design process. These numbers were generated based on the areal loading rate and 2 ft spacing. (As noted they are exactly twice the areal loading rate). Converse, (1998) discusses linear loading rate and how it is estimated.

Landscape Linear Loading Rate

The landscape linear loading rate (LLLR) is defined as the amount of effluent applied along the length of the drip system or zone in gpd/lf of system along the contour. For example, if there were 10 drip lines in a system along the contour, the LLLR would be 10 times the LLR for a given drip line. It relates to how much effluent can be applied per linear foot of system along the contour so that the effluent (moving vertically, horizontally or a combination of both) can get away from the system. Converse (1998) discusses LLLRs.

Instantaneous Loading Rate

Instantaneous loading rate relates to how much can be applied per dose (gph/dose) so that the soil will accept it. If more is applied than can "instantaneously" move away from the emitter through gravity and matric potential, then the soil around the emitter becomes saturated. As the emitter continues to discharge effluent, wastewater will take the path of least resistance and move under saturated flow conditions away from the emitter. If the soil above the drip line is loose due to recent construction and is less compacted, the effluent may create a channel to the ground surface (chimney effect). This channel provides the least resistance to flow and the saturated flow around the emitter will move upward through the channel during future doses. If this happens, it probably means that the dose volume per emitter (gallons/dose) is too large. To remove the chimney effect, it may require physically breaking up the channel. Time-doses of short duration instead of demand dosing will minimize potential for developing the chimney effect.

There is also an interrelationship between lateral spacing and length, emitter spacing, instantaneous and daily infiltrative surface and areal loading rates. The instantaneous loading rate for the emitters should determine the dose volume. Ideally, each emitter will be dosed for short periods spread throughout the day to reduce the instantaneous loading rate. But no effluent is uniformly distributed throughout the field until all tubes are filled and pressurized and what remains drains by gravity when the dosing cycle ends. Generally, a longer dosing time is used to minimize the volume of effluent distributed during non-pressurized conditions compared to volume distributed during pressurized conditions, but this increases the instantaneous loading rate. A smaller zone size can reduce the time to reach pressurized conditions and potentially reduce the water volume stored in the manifolds, thus potentially reducing the volume distributed during non-pressurized conditions. Increasing the emitter density by adding laterals lowers the infiltrative surface loading rate if the areal (footprint) loading is held constant. A preferred alternative may be to keep the same lateral length (e.g., lines on 2-foot centers), but increase the number of emitters only (e.g. emitters on 1-foot centers), to reduce the loading rate from each emitter without increasing the minimum required dose volume. This would not affect infiltrative surface loading rate.

The designer may need to do a better job of matching the emitter discharge rate to the soil type and its ability to move effluent away from the emitter. An emitter that discharges at 1.0 gph may be appropriate for some soil conditions but not for others. An emitter that discharges 1.0 gph for 30 minutes discharges the same amount of effluent as a 0.5 gph emitter discharges in 60 minutes but the lower discharge rate may allow the soil to assimilate the effluent better than the higher discharge rate. Unfortunately, we do not have tables matching emitter discharge rate and time of dose to various soil conditions.

Additional Design Considerations

Vertical Separation Distances

Separation distances from the drip line to seasonal saturation and other unsuitable soil conditions should be at least 12" to promote unsaturated flow for final polishing of the effluent and to minimize surface breakout during extremely wet periods. Converse and Tyler (1998a and b) found that soil receiving aerobically treated effluent had no fecal coliform detected (based on median values) below 12" if loaded under typical loading rates and if the effluent had low fecal coliform counts. Aerobically treated effluent with higher fecal counts may require a greater separation distance. Also, for mechanically filtered septic effluent, increased separation distance may be needed since data show that there is very little fecal coliform reduction as the effluent passes through the filter. Short frequent doses result in greater contact time and allow better treatment of effluent in the soil. Thus, the separation distance for septic tank effluent dispersed near the soil surface may not need to be as great as is typical for other dispersal systems such as in-ground trenches. Further study needs to be done to delineate separation distance for both aerobically treated and mechanically filtered effluent. Site-specific analysis is necessary for larger systems serving multi-family homes or commercial facilities to assure that water table mounding and lateral flow is moving the effluent away from the field. This analysis should confirm that minimum depths to unsaturated conditions can be maintained.

Climate

Freezing is of concern in cold climates. However, in wooded areas where forest debris is left in place and snow accumulates, experience has shown that drip units continue to function very well if buried 6" beneath the ground surface. Installation in well-manicured lawns still remains a concern in cold climates. It is recommended to cover the system the first winter if a good vegetative cover has not yet been established. The temperature of the effluent entering the drip system is also an important design consideration. Aerobically treated effluent (especially when pretreated via a recirculating filter) is at a lower temperature than septic tank effluent entering the drip line. This configuration may require deeper installation of drip lines in northern climates.

Application Schedule

As indicated elsewhere, it is recommended that effluent be applied in short pulses many times per day to allow better movement of effluent away from emitters and minimize the possibility of surface breakout. Applying the daily load all at once may cause breakouts in slowly permeable soils and reduce the treatment capacity of more permeable soils such as sand. However, the reality of maintaining a dose volume equivalent to several times the piping volume may limit the ability to dose water frequently through out the day. Additionally, small doses may result is localized overloading due to redistribution during depressurizing flow. Certainly, timed-dosing has obvious advantages over demand dosing from this standpoint.

System Configuration

On slowly permeable soils where vertical movement of effluent away from the system may be minimal, sites with shallow groundwater, and on flat sites, the landscape linear loading rate should be considered (Converse, 1998; Converse and Tyler, 1990; Converse, et al, 1990). Surface breakout may be a problem if the landscape linear loading rate is too great especially during wet periods when the soil system is stressed. Thus, longer and narrower systems are as appropriate for drip dispersal systems in slowly permeable soils with restrictive horizons as they are for mounds or at-grade systems. During dry periods when ET is the greatest, this concern is minimized as much of the effluent is removed vertically through ET with less reliance on moving the water away laterally from point of entry.

It may be appropriate to place drip lines at 12" spacing instead of 24" spacing to assist in getting the water away from the emitters. This will reduce the linear loading rate on the drip lines but will not change the landscape linear loading rate. Also, it will not reduce the footprint area required but will give 4 times as many emitters and reduce the instantaneous loading rate. If emitter spacing is reduced after the design is completed, (increasing number of emitters), recalculation will have to be made to make sure the pump delivers the required pressure and flow rate for both dosing and forward flushing the zones.

Chapter 5: Installation Considerations

Drip dispersal systems are applicable for installation on most sites. Using drip systems on sites with a limited ability to accept and treat effluent makes proper design, installation, operation and maintenance critical because of the limited margin for error. If we do not use this technology correctly, it will gain a reputation as a system that does not function well and we will lose it as a viable option. Since there is not another good option for working in sites with limited surface area and high groundwater conditions, the implications of not having this option available are clear.

System Installation

System installation is critical to long-term success of the drip field. Some guidelines and hints to consider follow.

- Site selection is critical to the operation of the system. Choose a site with good natural drainage for location of the system. If natural drainage is not available, implement your site preparation before installation of the system. Installation prior to site grading can cause the field to be destroyed during final landscaping. Soil needs to be prepared through addition of moisture if it is too dry. Also, prepare the site to prevent excessive rainfall infiltration. Placing a crown on the site will promote drainage away from the drip fields. Developing a diversion berm around the site will divert rainfall runoff around and limit runoff accumulation over the soil treatment area. However, care must be taken to not compact the in-situ soil or destroy the soil structure. Grading the site for uniform slope, filling depressions and cutting high spots may cause more damage to the soil than good if improperly implemented.

- Drip line installation can be accomplished with a trencher, static plow or vibratory plow. A trencher is slower and opens a trench for hand placement of the tubing. The trencher also develops a small trench of higher permeability soil around and above the drip tubing. Care must be taken during placement of the tubing in the trench to make sure the tubing is in contact with the bottom of the trench and does not have many high and low points in the line. A trencher may be the best method when installing in clay soils under moist conditions to limit potential for smearing. A static plow is towed behind the tractor and the tubing is pulled into the trench with the plow shank. The operator of the plow should watch the tubing roll to make sure it continues to unroll and not snag and stretch the tubing. A coulter placed in front of the plow shank will cut the turf and allow a cleaner installation. A gage wheel will assist in installing the tubing to grade on level sites. A vibratory plow provides for minimal site disturbance and may be the best approach to cutting through roots in the soil. Watch the tubing roll during installation to make sure it continues to unroll. If the roll stops moving, the roll may have grabbed the tubing may be stretched as a result. If good site preparation was performed, a plow type installation method will provide a uniform depth of installation and minimize the occurrence of high and low points in the tubing.

- Try to ensure that the tubing, drip lateral, and connection to each supply and return manifold is of approximately uniform length to allow for proper flushing of the system.

- Use specifically manufactured fittings for connecting drip line to PVC manifolds and for making connections between separate tube segments. Line ends must be carefully sealed when not completed during installation to prevent entry of debris.

- Supply lines, supply manifolds, return manifolds, and return lines should be bedded in the trench to prevent settlement and possible crimping of lines. Check their installation depth in relation to the tubing in the field. Always ask the question of how the air will move into the tubing as the system drains and minimize the occurrence of high and low points for trapping water in the drip laterals.

- Pre-assemble as many of the components as possible to decrease the field time. This practice maintains uniformity in component construction and also allows repair or replacement components to be standardized.

- Use proper procedures for installation of PVC pipe. Make clean cuts on the pipe. Remove burrs from the edge of the cut and loose material from inside the pipe. Primer should be used to prepare the pipe for gluing. Select the proper cement for your conditions.

- Use a flexible PVC pipe for connecting the individual drip lines together. This minimizes the potential occurrence of crimped end lines and allows some movement of the tubing from shrinking and swelling. Some manufacturers recommend the use of their tubing to make turns to prevent the accumulation of biological slime in the flexible PVC at the ends of the field.

- Check elevations of the tubing, supply line, supply manifold, return manifold, return lines and air relief valves to insure proper water movement and air relief.

- Make sure the air relief valves are not buried. They must have air exchange with the atmosphere to ensure proper venting during pressurization and proper air inflow during depressurization.

- In areas with freezing soil conditions, make sure the system will drain to prevent ice build-up in the lines. Check the air relief/vacuum breaker valve installation to make sure ice will not form in the valve and cause the valve to stick in an open or closed position. The valve box may need insulation to prevent freezing of the air relief/vacuum breaker. Note: evaluation of some systems operated in cold climates indicate that the air entering through the vacuum release valve can lower the soil temperatures. Further investigation of cold weather applications for drip dispersal systems will provide additional guidance in the future.

Chapter 6: Start-up Considerations

System start-up is a critical time period for the long-term success of the drip dispersal field. A couple of key points to consider include the following items.

- Flush the lines to remove PVC burrs and other debris from internal components of the system. This may be accomplished by systematically attaching the components together as the components are flushed. For example the connection between the supply line and supply manifold could be left open until after the supply line is flushed. This connection could then be completed. The supply manifold could be flushed before connecting the drip laterals. The drip laterals could then be attached and flushed. The return manifold could be connected to the drip laterals for flushing of the return manifold. And finally, the return line could be flushed. If flushing is accomplished by the normal operating approach of opening the return/flush line to the treatment device the debris is not removed from the system but allowed to circulate through the system. Even worse this debris must pass through the drip tubing and past the emitters to get to the return line. Emitters may be plugged during the installation process rather than during operation. An alternative method to sequential flushing is removal of the vacuum release valves and flushing most of the debris through that opening.

- Check all connections before establishing final vegetative cover over the fields to make sure the connectors do not leak. Fix leaking connections to prevent hydraulic overloading of the field area.

- The operating pressure for the system needs to be set and verified. If a return flow valve is used for adjusting system pressure, set the return flow rate to adjust the operating pressure. If a pressure regulating valve is used, confirm it is providing for the design operating pressure in the drip fields.

- Check the filters to make sure they are operating and the flushing/backwashing mechanisms are functioning. You may wish to open the filters following start-up to make sure they are clean and ready to operate.

- Record the flow rates and operating pressures at the pump and at the ends of the drip fields during normal operation and flushing cycles. This provides a reference point to determine if the emitters are plugging and thus reducing water flow rate through the field and pump, thus increasing the operating pressure of the system. If the tubing starts to clog, the pressure drop across the field during flushing will increase, even if the emitter flow rate is unchanged. This is important to monitor, because it will result in reduced flushing efficiency and eventually to hydraulic failure of the system. Pressure gauges or Schrader valves can be placed in the piping for measuring the operating pressure.

- During the installation process, the pump tank may be filled with water. This water must be dosed into the drip fields to get the system operating. Check the tank to make sure it is free of construction debris that damage the system. Initiate dosing to the field using a normal operating procedure. Each zone should be dosed with a normal dose volume. All zones should be walked to check for wet spots. If any are found, they should be flagged and evaluated. These wet spots on the surface may be indicators of faulty emitters, connections, or broken lines and must be repaired before placing the system in service. An additional reason for a wet spot can be a high instantaneous loading rate. The remaining water in the tank should be dosed to the field through small doses of the same volume and frequency as normal operating procedure. Sending a large volume of water to the field in a relatively short period of time may cause the development of preferential flow paths from the emitter to the soil surface and jeopardize the long-term usage of the drip field.

- If the depressurized flow is returned to the pump tank (such as in areas with potentially freezing conditions) check the return flow when the pump turns off to make sure the lines are free draining. Please remember the drip field will function as a subsurface drainage system during periods of saturation and this approach is not advisable under those conditions.

- Check the air relief valves to make sure they have closed and do not emit excess water.

Chapter 7: Operation and Maintenance

All on-site wastewater systems require maintenance to keep them operational. Conventional systems may only require septic tank pumping every two to five years while proprietary systems and advanced dispersal systems such as spray and subsurface drip require on-going maintenance contracts. Proper maintenance can provide owners with long-term success and satisfaction with their on-site system with minimal cost when compared with replacement.

At maintenance checks of drip systems, there are a few procedures that will aid in preserving the performance of the drip dispersal system. The following items are provided as points of review. Ultimately, follow manufacturer's guidelines when maintaining a unit.

- **Pretreatment System:** Check the pretreatment unit to make sure it is operating properly.
- **Pump Tank:** Check the pump tank for accumulation of solids. If solids have carried over from the pretreatment unit, make sure the settled material is sufficiently below the pump intake zone to prevent solids from being passed into the filtration system. Periodic pumping of the tank is essential.
- **Pump Screens:** If the pump has an intake screen or a pump vault with a filter, these need to be checked and cleaned. Solids accumulated on the screens and filter can reduce water flow into the pump and reduce the operating pressure.
- **Sensors:** Check the water level sensors to make sure they are operating properly. Activate the sensors to verify activation of the corresponding alarms and operating units.
- **System Override Operation:** If the system has override controls, activate them to verify proper operation.
- **Operating Pressure:** Pressure gauges or air pressure valves installed at the pump discharge and return line will allow the maintenance provider to set the system operating pressure at the design specifications and monitor any changes in pressure over time. An increase in pressure could be due to a decrease in emitter flow rates, clogging filter surfaces or slime accumulation in the drip tubing. A decrease in pressure or no pressure on the return line could signal a leak within the system, a change in the pump performance, and/or broken or inoperable valves.
- **Visual Inspection of Drip Field:** The maintenance provider should walk around the soil treatment area while the system is applying wastewater. A leak in the line would be very obvious because of surfacing water. The maintenance provider can check to make sure there is no ponding or surfacing of water from excessive use and/or improper design and/or installation.
- **Air Relief Valves:** The air relief valve must be checked on every visit to the site. Occasionally, valves can wear down or have material caught in the seat causing them to improperly seal during system operation. This will cause water to leak and a wet area to develop near the air relief valve. In addition, if the valve does not allow air to flow back into the system after the pump shuts off, there is potential for sucking mud into the emitters while the system is depressurizing. This may affect uniform dispersal within the field. Unlike organic buildup and carbonaceous material that

may buildup in the line and be treated with doses of chlorine and acid, soil in the emitter poses a problem without a good solution. The best way to alleviate this concern is to properly provide good air relief at the highest point in the field.

- **Water Usage:** Flow meters are another good tool to use when evaluating a drip system. These can be installed permanently or used when excessive wetting in the field is experienced. In some applications, the actual water usage rate may be considerably higher than the design rate. A flow meter would be able to tell you the approximate gallons per day that is being applied. If flows are excessive, The owner should be informed and educated about the consequences of exceeding the design flow.
- **Field Flow Rate:** A flow meter can also help you monitor the flow rate in the system. This flow rate (along with changes in pressure) can help you determine whether flow is increasing or decreasing in the system. Decreased flow rates may indicate emitter plugging is occurring within the system. Increased flow rates may indicate malfunctioning check valves, vacuum release valves, broken drip tubing, and breaks in piping.
- **Field Flushing:** All drip systems need to be flushed by passing water through the drip line. Check the manufacturers recommendations for the appropriate flushing velocity. In most systems, the return line can be opened to perform this procedure. Installation of the system with line lengths less than the maximum length of run helps assure that adequate field flushing pressure can be maintained in the system. Systems with automatic controllers may automatically flush the fields.
- **Repairing a Drip Line:** A drip line can be easily repaired with a coupling. The tubing can be cut and reconnected with a coupling, according to the manufacturer’s specifications. Make sure you do not stretch the tubing during the repair. The tubing may return to normal length thus pulling the coupling apart. Field flushing is also important after repairing any leaks to assure that any soil particles that were in the line are removed immediately through the line instead of through the emitters.
- **Filters:** Clean the filters in the filtration unit. The filters should be dismantled and inspected for particles attached to the filter material. Some maintenance providers keep an extra set of filters in their supplies for the purpose of exchanging the filters at the site. Exchanging the filters allows placement of the used filter into a disinfecting solution before cleaning at a later time. The filter can be cleaned when back at the shop rather than in the field, reducing time exposed to the elements. If the filter is impregnated with an herbicide, the filter should be checked, cleaned if necessary, and returned to operation.
- **Monitors:** If the system has dosing counters or elapsed time meters, these can be checked to verify a reasonable value for the period between maintenance visits.
- **Pests:** Check for fire ants entering the electrical components. Fire ants are attracted to electrical contacts. If they are entering the components, they may interrupt the operation of the system. Rodents can also chew on the system components. Typically, they are controlled with odoriferous additives.
- **Field Control Valves:** Check valves are used on many systems at the point where the return

manifold is connected to a common return line. These valves can fail and thus allow back flow into zones. This will result in a high flow reading for all of the zones except for the zone with the failing valve. If a valve is failing, it must be replaced

- **Lightning issues:** Lightning can cause problems with controllers or field solenoid valves. These items need to have proper grounding to prevent problems.
- **Larger system concerns:** Drainback, electronic complexity, self monitoring, and more sophisticated alarm capabilities can be enhanced when working with larger systems.

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