PREFACE
CHAPTER 17 OF TDEC's DESIGN CRITERIA FOR SEWAGE WORKS
Design Guidelines for Wastewater Disposal Using Drip Dispersal
October 18 2023

Utilizing soil to treat domestic strength wastewater and return the treated water to the environment has been practiced for centuries, most commonly to accommodate wastewater flow from single family residences with the systems constructed on the property where the wastewater is being generated. Beginning in the mid to late 1990s TDEC began permitting soil-based treatment and dispersal systems in support of multi-home developments ranging from just a few homes per system to hundreds. Most of these systems utilize drip irrigation technology to apply the effluent to an identified area of soil. TDEC's State Operating Permit structure has been utilized to permit these non-discharging systems which are commonly referred to as decentralized land application systems. Use of this approach to wastewater management flourished in TN during the 2000s and continues. Chapter 17 of TDEC's Design Criteria for Review of Sewage Works Construction Plans and Documents, "Design Guidelines for Wastewater Disposal Using Drip Irrigation" is the Division of Water Resources' (Division) guidance document pertaining to land application of wastewater effluent through drip irrigation and has been relatively unchanged since 2007.

Wastewater systems relying on soil as a method of treatment and a medium through which the treated effluent is returned to the environment will become noncompliant if the volume of wastewater added to the soil profile exceeds the profile's ability to receive, treat, and transmit the effluent away from the point of application. Noncompliance can be in multiple forms but is frequently associated with saturation of the soil profile leading to ponding of wastewater effluent and surface flow of effluent away from the land application area. Obtaining additional land application area and constructing additional drip irrigation infrastructure or extending public sewer to the area are typically the only long-term remedies that can address these conditions of noncompliance.

Estimating the capacity of a land application area to consistently manage the applied wastewater effluent in compliance with non-discharging permit conditions is challenging. It is the Division's position that the most successful systems, in terms of compliance, are those that are designed with conservative estimates of the land application area capacity. Additionally, utilities that set aside additional area for land application on the front end can more effectively resolve matters of land application area noncompliance. Utilities that max out their available area on the front end may suffer from chronic noncompliance and expensive remedies.

Public and private utilities that own and operate these systems are responsible for maintaining compliance with permit conditions and are in the best position to ensure the systems are conservatively designed. **Submittal of plans to and approval by the Division should not be construed as creating a presumption of correct operation nor as warranting by the commissioner that the approved facilities will reach the designated goals.** The Division recommends that any entity (public or private) that intends to utilize drip irrigation as a method of wastewater management develop their own standards for system design. There are multiple examples of utilities and local governments in TN that have developed standards for system design, both early on as the methodology was being established, and later as experience was gained. There are also many academic, industry, and regulatory publications available for consideration. The Division is currently funding research through the University of Tennessee Extension Service that, once complete, will also provide a compendium of recommended practices specific to TN.

CHAPTER 17

Design Guidelines for Wastewater Dispersal Using Drip Irrigation

DRIP DISPERSAL TREATMENT

17.1 General

17.1.1 General

This chapter provides guidelines and criteria for the design of drip dispersal systems for domestic wastewater effluent treated to a level of secondary treatment. It is not applicable to spray irrigation, overland flow or rapid infiltration. The design engineer should use best professional judgment (BPJ) to produce a system that will be robust and sustainable for many years.

17.1.2 Applicability

Drip dispersal systems are designed and operated to allow the soil to provide final treatment of the wastewater prior to its introduction to groundwater. Dispersal and treatment occurs via physical, chemical and biological processes within the soil and through evapotranspiration and nutrient uptake by plant matter.

The ultimate goal is to create a treatment and dispersal system that will return the treated water to the environment while protecting ground water and surface waters from excessive pollution. Water does not disappear in the soil column, it evaporates into the atmosphere, is used by plants and/or organisms, or moves through the soils to ground water or into water courses. There are many factors to be considered when designing drip dispersal systems, such as the quality of treated effluent being applied, depth of soils, and retention time in the soils before water returns to either ground water or surface water. The development of these guidelines utilized general assumptions, best professional judgment (BPJ) and empirical data.

The infiltrative capacity of soil is a critical factor to be considered when designing any type of subsurface sewage disposal system. However, equal consideration should be given to other factors that control the overall lateral movement of groundwater within the soil profile.

If the profile of a particular soil considered for drip dispersal extended to a significant depth without a restrictive horizon (most limiting layer), the ability to load that soil per unit area would be relatively high. On the other extreme, if a soil being considered for drip dispersal had a shallow restrictive horizon, the ability to load that soil would be lower relative to the deeper soil. Depth to restrictive horizon, soil permeability and slope of the restrictive horizon are factors that control the amount and rate at which ground water can exit an area. If the amount of treated effluent applied to an area, in combination with rainfall over the area and groundwater moving into the area, exceed the soil profile's ability to transmit the water away from the application area, mounding and runoff will occur.

Evaluation of a soil area's suitability for drip dispersal should take into consideration limiting aspects of the soil profile. Level sites with shallow restrictive horizons overlain by low permeability soils represent one of the more limited scenarios for drip dispersal and the application rate and/or application area should be suitably modified.

Also critical when designing systems in soils with shallow restrictive horizons are the presence and location of hydrologic boundaries such as drainage ways and waterways.

These hydrologic boundaries provide an outlet for ground water discharge. Not only is it critical to identify these features in consideration of appropriate setbacks/buffers, it is also critical to factor in their role in the overall hydrologic cycle of the landscape.

Horizons along which lateral flow would be expected include, but are not necessarily limited to: bedrock, fragipans, and zones with high clay percentage overlain by more permeable soil.

Drip dispersal design submittals should take into consideration all factors influencing the infiltrative capacity of the soil and the ability of the soil and site to transport ground water away from the application area. It should be noted that the use of historical information from existing systems installed and operated in similar soils, with documented loading rates, landscape positions and design conditions similar to the proposed system may be applicable. Therefore, soils that have been highly compacted and/or disturbed, such as old road beds, foundations, etc., must be excluded when evaluating suitable areas for drip dispersal systems.

17.1.3 Slopes and Buffers

Slopes - Slopes up to and including 50% slope with suitable soils may be considered for drip dispersal. Depending upon the overall shape of the slope (concave, convex or linear on the planar and profile view) the design engineer may have to make adjustments in the aspect ratio of the drip lines on the slope, the loading rate, or both to ensure that all applied effluent will move down gradient and/or into the underlying formations without surfacing. It is important to note that when the proposed drip field area slopes are greater than 30%, the design engineer may need to a obtain a geologic investigation conducted by a geologist or geotechnical engineer evaluating the slip potential of the slope under operating conditions. When slopes increase above 10 percent, wastewater flow down the slope (parallel to the slope) may control the hydraulic design of the system.

For land application areas with slopes between 10 percent and 50 percent and with a restrictive horizon less than 48 inches, the design engineer should calculate the percentage saturation of the soil column at the narrowest portion of the cross-sectional area of the dispersal area perpendicular to the direction of flow. This landscape loading rate analysis will determine the saturation depth at design load and flow of the most restrictive cross-section in the down gradient flow path within and beyond the drip field. The aspect of ratio of the drip field should be adjusted or the loading rate reduced as necessary to ensure that surfacing does not occur.

Buffers - Treatment and dispersal system components should be located so as to protect potable water supplies and distribution systems and surface waters. The design engineer is responsible to identify setbacks on construction drawings. Setbacks from water bodies, water courses, and sink holes will be a function of local subsurface geology and quality of the applied effluent. It is important to note that varying site conditions may require different distances of separation. The distances may increase or decrease as soil conditions so warrant as determined by a qualified professional (engineer, soil scientist, geologist, etc.).

If site buffers are different from Table 17-1, then the design engineer must provide rationale used for the recommended site buffers which must be approved by the Tennessee Department of Environment and Conservation.

TABLE 17-1

	Buffer Distance	
Site Feature	**Septic Tank and /or Dosing Chamber (Feet)**	**Dispersal Field (Feet)**
Wells and Springs	**50**	**50**
Dwellings and Buildings	**5**	**10**
Property Lines	**10**	**10**
Underground Utilities	**10**	**10**
Septic Tank	**NA**	**5**
Gullies, Ravines, Blue Line Streams, Drains Drainways, Cutbanks, and Sinkholes	**25**	**25**
Closed Depressions	*****	*****
Soil Improvement Practice	**25**	**25**

*To be determined by the design engineer and approved by the Division of Water Pollution Control.

17.1.4 Soils

In general, moderately permeable and well-drained soils are desirable. However, the use of any soil is acceptable if it meets the following four (4) criteria:

1. The applied effluent loading rate does not exceed the applicable hydraulic loading rate in **Table 17-2**. The applicable hydraulic loading rate is determined by a detailed site evaluation in which the site is mapped utilizing soil borings and pits to determine the physical properties of soil horizons and soil map units.
2. The applied effluent maximum loading rate does not exceed 10% of the minimum NRCS saturated vertical hydraulic conductivity (K_{SAT}) for the soil series or 0.25 GPD/SF whichever is least. Note: this may have to be lowered based upon the results of the nutrient loading rate calculation per Section 17.5.2.
3. The soil does not have a restrictive horizon within its top twenty (20) inches.
4. The soil is well drained, or capable of being drained.

TABLE 17-2

Hydraulic Loading Rates (GPD/SF) – For Drip Dispersal Systems

TEXTURE	**STRUCTURE**		**HYDRAULIC LOADING RATE* GPD / SF BOD ≤ 30 mg/L**
	SHAPE	**GRADE**	
Coarse Sand, Loamy Coarse Sand	**NA**	**NA**	**NA**
Sand	**NA**	**NA**	**NA**
Loamy Sand, Fine Sand, Loamy Fine Sand, Very Fine Sand, Loamy Very Fine Sand	**Single Grain**	**Structure less**	**1.00**
Coarse Sandy Loam, Sandy Loam	**Massive**	**Structure less**	**0.60**
	Platy	**Weak**	**0.50**
		Moderate, Strong	
	Blocky, Granular	**Weak**	**0.70**
		Moderate, Strong	**1.00**
Loam	**Massive**	**Structure less**	**0.50**
	Platy	**Weak, Moderate, Strong**	
	Angular, Blocky	**Weak**	**0.60**
	Granular, Sub angular	**Moderate, Strong**	**0.80**
Silt Loam	**Massive**	**Structure less**	**0.20**
	Platy	**Weak, Moderate, Strong**	
	Angular, Blocky, Granular, Sub angular	**Weak**	**0.60**
		Moderate, Strong	**0.80**
Sandy Clay Loam, Clay Loam, Silty Clay Loam	**Massive**	**Structure less**	
	Platy	**Weak, Moderate, Strong**	
	Angular, Blocky	**Weak**	**0.30**
	Granular, Sub angular	**Moderate, Strong**	**0.60**
Sandy Clay, Clay, Silty Clay	**Massive**	**Structure less**	
	Platy	**Weak, Moderate, Strong**	
	Angular, Blocky	**Weak**	
	Granular, Sub angular	**Moderate, Strong**	**0.30**

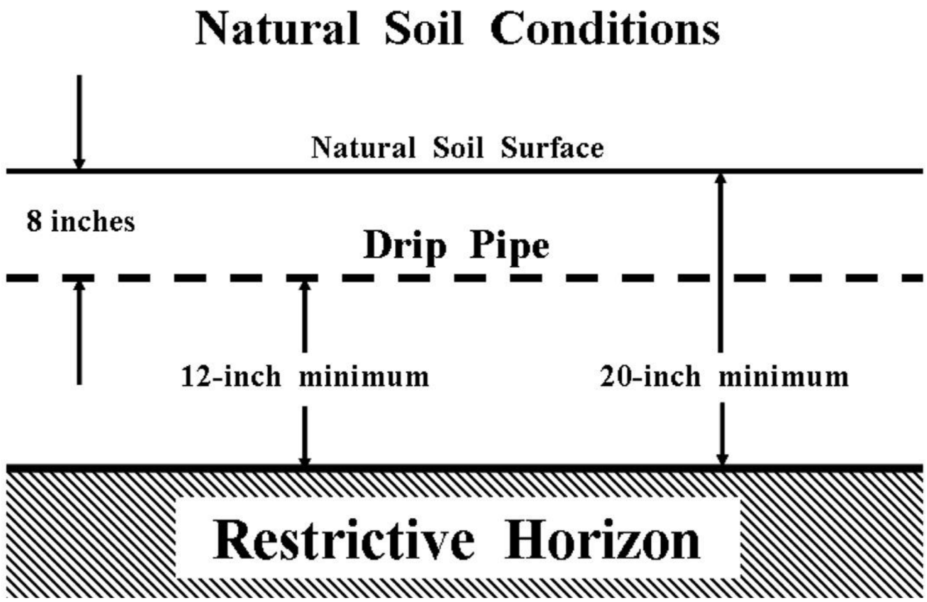
***Maximum allowable hydraulic loading rate is 0.25 GPD/SF; however, all hydraulic loading rates may be adjusted based upon special site specific evaluations approved by TDEC.**

These soils are considered unacceptable for drip dispersal.

Reference: EPA/R-00/08, February 2002, "*Onsite Wastewater Treatment Systems Manual*"

It is desirable to have a minimum depth of twenty (20) inches of undisturbed soil above a restrictive horizon which may need to be increased as slope increases. This is necessary to provide adequate installation depth and buffer below the drip line. (For example, see **Figure 17.1**).

FIGURE 17.1



Even if a soil meets the depth requirements it may not be suitable due to the texture and/or structure. If a soil shows signs of wetness within a depth of 20 inches of the soil surface, it will most likely require a soil improvement practice such as an interceptor or drawdown drain. The location and size of the drains and buffers must be factored into the total area required for the drip dispersal system.

17.1.5 Line Spacing

In an attempt to achieve even distribution of the wastewater and maximum utilization of the soil, it is recommended that the emitter line spacing and emitter spacing be at 2-foot spacing. Depending upon site conditions (soil type, slope and reserve area) the Department of Environment and Conservation may allow spacing to increase to ensure that each emitter supplies a minimum wetted area of not more than ten (10) square feet (i.e., 5-foot line spacing with 2-foot emitter spacing or 10-foot line spacing with 1-foot emitter spacing).

17.1.6 Line Depth

Drip dispersal lines should be placed at depths of six (6) to ten (10) inches below the surface. The drip lines should be laid level and should run with the contour.

17.2 Soil Investigations

17.2.1 General

Preliminary soil investigations should be done to identify areas best suited for subsurface wastewater drip dispersal. The proposed drip dispersal area must be mapped at sufficient accuracy to identify each soils series (or lowest possible level of soil classification) present and the boundary location between series. Once those areas are identified, the more detailed procedures outlined below will be employed. It is required that all soil investigations be performed by a soil scientist currently on the Ground Water Protection list of approved soil scientists/soil consultants.

17.2.2 Soil Mapping

The mapping procedure will usually begin with the property/land being generally evaluated to delineate or separate areas with suitable characteristics. This procedure will save time and money since some areas will be too shallow, too wet, too steep, etc.

Adequate ground control is mandatory for all sites. The ground control is necessary to reproduce the map if needed. All located coordinates (soil map boundaries and pit locations) must be shown on the final Water Pollution Control (WPC) Soils Map.

Soil data collection shall be based upon one, or combination of the following:

1. Grid staking at intervals sufficient to allow the soils scientist to attest to the accuracy of the map for the intended purpose;
2. Mapping of pits and critical auger locations using dual frequency survey grade Global Positioning System (GPS) units.
3. Other controls adequate to map the location of pits, physical features, and separations.
4. Grid stakes and GPS data points must be locatable to within two (2) feet of distance shown.
5. The ground control has to correlate to the exterior boundaries of the property so as to show the location of the soils areas within the bounds of the project and must be certified by a Registered Land Surveyor per TCA 62-18-102(3).

The soil scientists are responsible for conducting a sufficient number of borings that, in their professional opinion, will allow them to certify the soils series (or lowest possible level of soil classification) present, identify boundaries between series, and describe each soil horizon as to color, depth to restrictive horizon, and depth to rock. Any redoximorphic features observed are to be described. This delineation should be based upon the texture and structure of the soils to a depth of forty-eight (48) inches or restrictive horizon whichever is shallower.

After the mapped soils area is established and marked, soil borings to a minimum depth of forty-eight (48) inches or restrictive horizon, whichever is shallowest, shall be taken at sufficient intervals to identify and map the boundaries of the soils series (or lowest possible level of soil classification) present on the site. The exact number and location of borings will be determined by the soils scientist in consultation with the design engineer. Sufficient borings should be made to identify any dissimilar soils accounting for more than 10 percent of the total proposed drip dispersal area.

The soil scientist shall excavate an adequate number of pits to determine the typical profiles and soils characteristics that are expected for all soils mapped. It is recommended that a minimum of two (2) pits per acre in polygons of qualifying soils be excavated; however, the actual number and location of pits will be left to the best professional judgment of the soil scientist. If less than two (2) pits per acre are utilized, the soil scientist must include the rationale in notes on the WPC Soil Map. The pit description must be entered onto a pedon sheet and submitted with the soils map and engineering report. The "Soil Description" should include all of the information contained on form NRCS-Soils-232G (5-86), U.S. Department of Agriculture, Natural Resources Conservation Service (as shown in Appendix D).

In their description of the pit profiles, the soil scientists must describe the soil's structure, texture, color, and any redoximorphic features present. They should also describe root depth and presence of macropores, etc. The series name or lowest possible level of soil classification will be recorded. The depth to hard rock using an auger or a tile probe must be specified if the depth is less than forty-eight (48) inches and estimated if greater than forty-eight (48) inches. The auger borings and soil backhoe pits should be located, numbered and shown on the WPC Soils Map. The soil scientist will be required to prepare and sign a detailed certification statement for each site evaluated as follows:

Water Pollution Control Soils Map Completed by:

Signature Date

John/Jane Doe, Soils Consultant

The following statement should appear on the map:

"I, (Soils Consultant's Name) affirm that this Water Pollution Control Soils Map has been prepared in accordance with accepted standards of soil science practice and the standards and methodologies established in the NRCS Soil Survey Manual and USDA Soil Taxonomy. No other warranties are made or implied."

Soil profile information and pit excavation, as described in these design criteria, are additional requirements deemed necessary to properly assess an area's suitability for drip dispersal.

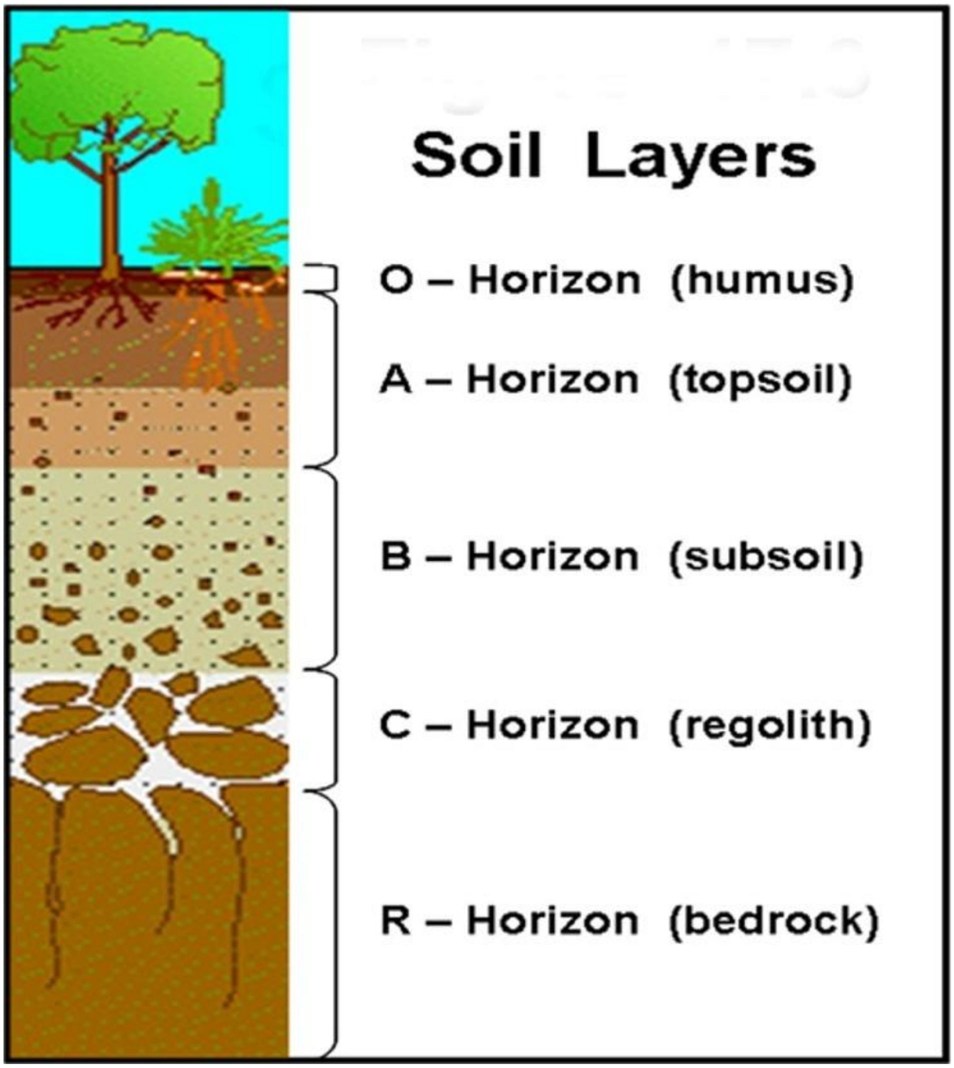
17.2.3 Definitions:

Soil Horizons (layers): Soil is made up of distinct horizontal layers; these layers are called horizons and display vertical zones. They range from rich, organic upper layers (humus and topsoil) to underlying rocky layers (subsoil, regolith and bedrock).

Soil horizons develop due to the nature of soil formation. Soil is the product of the weathering of parent material (i.e. bedrock), accompanied by the addition of organic matter. The method for naming the soil horizons is quite simple as the **Figure 17.2** shows.

In the simplest naming system, soils horizons are designated **O** (organic), **A** (topsoil), **B** (mineral soil), **C** (weathered parent material), and **R** is the un-weathered rock (bedrock) layer that is beneath all the other layers. The horizons of most importance to plant growth and forest health are the **O** and **A horizons**. The **litter layer** found covering the soil is also of interest because it provides most of the organic matter found in the O and A horizons.

FIGURE 17.2



The **Litter Layer** is the topmost layer on the forest floor. It consists of leaves, needles and other non-decomposed material on the forest floor. While this is not considered part of the soil, it is interesting to measure the depth of the litter layer when sampling the soil. The depth of the litter layer can vary greatly even within a particular site. Because of this, several measurements are required to attempt to characterize litter layer depth. The litter layer can be considered part of the overall soils depth.

The **O-Horizon** primarily consists of decomposed organic matter and has a dark rich color, increased porosity, and increased aggregate structure (larger soil "clumps"). The depth of the O horizon is measured from the surface of the soil (after the litter layer has been cleared away) to the point where the darker organic color changes to a slightly lighter colored soil that contains increased mineral particles in addition to organic matter. The transition from the O to the A horizon can also be recognized by a significant increase in the mineral soil particles. In many urban soils, the O horizon may very thin if it exists at all. The O horizon can also be considered part of the overall soils depth.

The **A-Horizon** is the **mineral** "topsoil" and consists of highly weathered **parent material** (rocks), which is somewhat lighter in color than the O horizon due to a decrease in **organic matter**. The particles in the A horizon are more granular and "crumb-like". Seeds germinate and plant roots grow in this layer. It is made up of humus (decomposed organic matter) mixed with mineral particles. The depth of the A horizon is measured from the region of color changes from the dark O horizon to the transition to the B horizon. The transition to the B horizon can be identified by increased clay content (see below) and the absence of organic material: no root hairs, small pieces of needle, etc.

The most thorough soil study involves analysis on separate O and A horizon samples. This requires separating and storing O and A horizon samples. It also involves completing the entire soil analysis on both the O and A samples. If this is not possible, the O and A samples can be combined (or composited) and the analysis can be completed on the O and A sample together.

The **B-Horizon** is also called the **subsoil** - this layer is beneath the A horizon and above the C horizon. It contains clay and mineral deposits (like iron, aluminum oxides, and calcium carbonate) that it receives when soil solution containing dissolved minerals drips from the soil above.

The B horizon is identified by increased clay content that makes the soil hold together when moist. A simple test for clay content is to moisten a small handful of soil and attempt to smear a small portion up the forefinger. Soils high in clay will hold together and form a "ribbon", soils with more sand and silt will be granular and fall apart. It is lighter in color and often may be reddish due to the iron content.

The **C Horizon** (layer beneath the B Horizon) consists of porous rock (broken-up bedrock, bedrock with holes). It is also called regolith or **saprolyte** which means "rotten rock." Plant roots do not penetrate into this layer; very little organic material is found in this layer.

The **R-Horizon** is the un-weathered rock (bedrock) layer that is beneath all the other layers. For the purposes of drip dispersal designs, the R horizon is considered an impermeable layer.

Water Pollution Control (WPC) Soils Map. A first order survey as defined in the Soil Survey Manual, United States Department of Agriculture, October 1993. These surveys are made for various land use that requires detailed soils information. Map scale should be one (1) inch equals one hundred (100) feet or a scale that will allow the map to fill a 24" x 36" plan sheet. These maps should have adequate cartographic detail to satisfy the requirements of project. The WPC Soils Map is essentially a special map that shows a very high degree of soil and landscape detail. Baseline mapping standards for these WPC Soils Maps prepared in support of drip dispersal should be a first order survey in accordance with the current edition of the Soil Survey Manual, United States Department of Agricultural; October 1993. Soil profile information and pit excavation, as described in these design criteria are additional requirements deemed necessary to properly assess an area's suitability for drip dispersal. These maps should be clearly marked or labeled as "Water Pollution Control Soils Map".

Soil map unit. A unique collection of areas that have common soil characteristics and/or miscellaneous physical and chemical features.

Soil scientist. A person having the experience and education necessary to measure soil properties and classify soils per *Soil Taxonomy*, synonymous with the term "soil consultant".

Soil series. A group of soils that have similar properties; the lowest level of soil classification.

Most limiting horizon. A horizon in the soil (bedrock or fragipan) that either provides the greatest impediment to or completely stops the downward movement of liquids through the soil.

17.2.4 Special Soil/Geologic Considerations

For sites with slopes between 30% and 50%, TDEC may request, a special investigation (performed by a qualified professional, such as a geologist, geo-tech engineer, engineering geologist, etc.) to be conducted to evaluate those sites. To adequately complete these determinations the following information should be provided.

- Strike and dip angle of underlying bedrock
- Depth to either hard rock and partly weathered rock
- Type of rock (limestone, shale, etc.)
- Soil particle-size class designation to a depth of six (6) feet or to hard rock whichever is less
- Slippage potential of slope
- Certification statement signed by a qualified professional that addresses all of the above characteristics.

For sites with slopes between 30% and 50%, in addition to meeting all other soil suitability requirements, the site should also meet the following requirements:

- Have a vertical depth of at least twenty (20) inches of soil above the rock layer.
- Not have a predominant particle size class of fragmental or sandy-skeletal.

17.3 Determination of Design Application Rates

17.3.1 General

One of the key steps in the design of a drip dispersal system is to develop a "design application rate" in gallons per day per square foot (GPD/SF). This value is derived from either the hydraulic (water) loading rate (Lwh) based upon the most restrictive of (1) the NRCS hydraulic conductivity data and the texture and structure (per Table 17-2), or (2) the nutrient (nitrogen) loading rate (Lwn) calculations to determine design wastewater loading(s) and, thus, drip field area requirements.

17.3.2 Design Values

The most limiting horizon, of <u>each</u> soil series (or lowest possible level of soil classification) shall be identified. Any surface condition that limits the vertical or lateral drainage of the soil profile shall also be identified. Examples of such conditions are shallow bedrock, a high water table, aquitards, and extremely anisotropic soil permeability. Design considerations relative to the soils per Section 17.1.4 must be used.

Sites with seasonal high groundwater less than twenty-four (24) inches deep may require drainage improvements before they can be utilized for slow rate land treatment. The design hydraulic conductivity at such sites is a function of the design of the drainage system.

17.4 Determination of Design Wastewater Loading

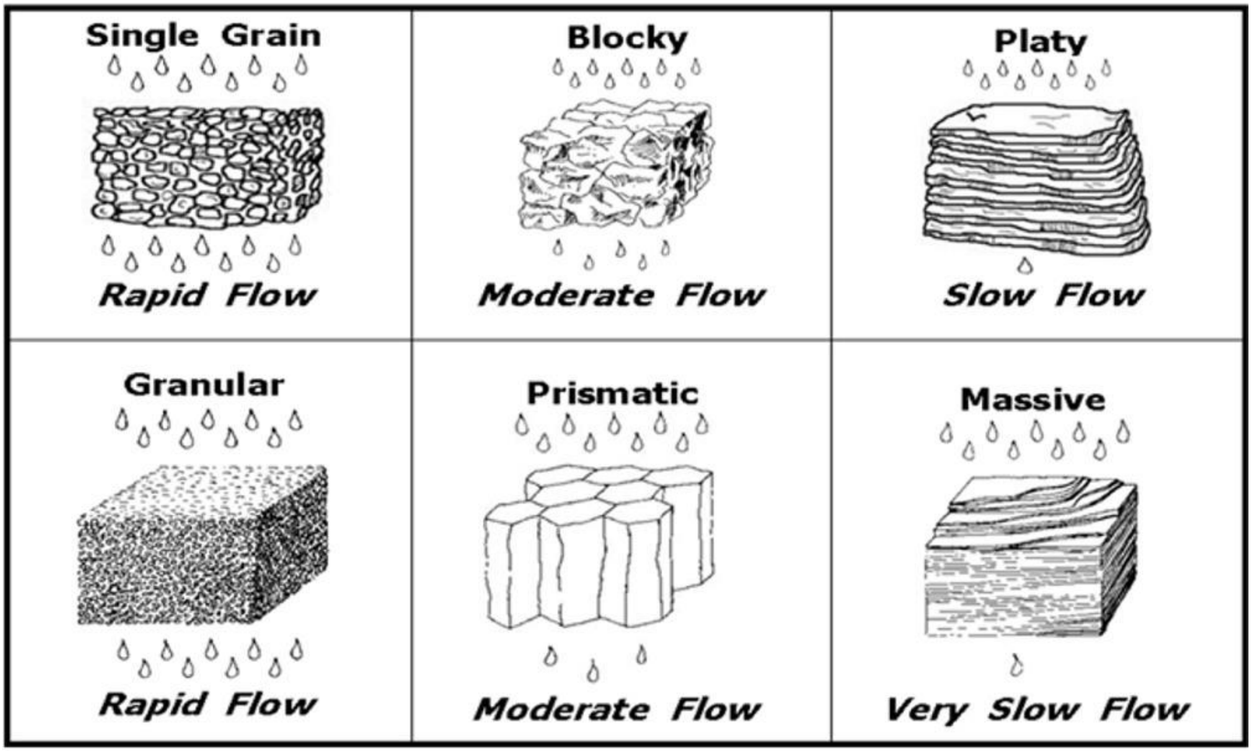
17.4.1 General

The design wastewater loading is a function of:

a. Precipitation.
b. Evapotranspiration.
c. Design hydraulic conductivity rate.
d. Nitrogen loading limitations.
e. Other constituent loading limitations.
f. Groundwater and drainage conditions.
g. Average and peak design wastewater flows.
h. Soil denitrification rates
i. Rate of nitrogen uptake in site vegetation

Therefore, developing the design wastewater loading is an iterative process. The Lwh value is determined by a detailed site evaluation and will be dependent upon the soil characteristics as shown in Table 17-2 and pictorially represented in **Figure 17.3**. This loading is then compared to the Lwn loading limitations (reference Section 17.5). If the initial Lwh value exceeds the Lwn value, the design wastewater loading resulting from the nitrogen reduction evaluation described in Section 17.5 becomes the design loading rate.

FIGURE 17.3



17.5 Nitrogen Loading and Crop Selection and Management

17.5.1 General

Nitrate concentration in percolate from wastewater irrigation systems will be limited via a State Operation Permit (SOP) to not exceed 10 mg/L nitrate-nitrogen at the site property line. Percolate nitrate concentration is a function of nitrogen loading, cover crop, and management of vegetation and hydraulic loading. The design wastewater loading determined from using the criteria stipulated in 17.1.4 for hydraulic conductivity must be checked against nitrogen loading limitations.

17.5.2 Nitrogen Loading

In some instances, the amount of wastewater that can be applied to a site may be limited by the amount of nitrogen in the wastewater. A particular site may be limited by the nitrogen content of the wastewater during certain months of the year and limited by the infiltration rate during the remainder of the year.

Equation **17-2** is used to calculate, on a monthly basis, the allowable hydraulic loading rate based on nitrogen limits:

$$\mathbf{Lwn} = \frac{Cp\,(Pr - PET) + N(4.413)}{(1 - f)(Cn) - Cp} \qquad \textbf{(Equation 17-2)}$$

Where:

Lwn = allowable monthly hydraulic loading rate based on nitrogen limits, inches/month

Cp = nitrogen concentration in the percolating wastewater, mg/L. This will usually be 10mg/L Nitrate-Nitrogen

Pr = Five-year return monthly precipitation, inches/month

PET = potential evapotranspiration, inches/month

U = nitrogen uptake by cover, lbs./acre/year

N = nitrogen uptake by cover, lbs./acre/month

Cn = Nitrate-Nitrogen concentration in applied wastewater, mg/L (after losses in pre-application treatment)

f = fraction of applied nitrogen removed by denitrification and volatilization.

The values of Lwh and Lwn are compared for each month.

The lesser of the two values will be used to determine the amount of acreage needed.

NOTES:

- A "**Cn**" value of less than 23 mg/L will become a permit condition.
- The allowable (default value) vegetative uptake "**U**" of nitrogen on the drip area will be an uptake rate of 100 pounds per acre per year unless trees or other vegetation are acceptable to, and permitted by WPC.
- The "**f**" values for denitrification have been estimated based upon data supplied by the University of Tennessee and Oak Ridge National Laboratory. Denitrification rates (f) ranging from 25% in January and February to 35% in July and August are very conservative, but are defendable based upon the literature. Denitrification rates are assumed to vary linearly with the temperature and the actual rates are likely to be higher than the default values shown in Table 17-2.
- Conversion Factor - **4.413**mg-acre-inch/liter-lb. The equation and factor are from the TDHE Design Criteria for Sewage Works (April 1989). The factor comes from assuming that one pound of contaminant of concern is diluted within a volume of water equal to one acre-inch. For the derivation of this factor see Appendix 17-C.

Table **17-3** shows the default values for Lwn calculations. Other values may be used provided adequate rationale and documentation is presented to, and approved by the Department of Environment and Conservation.

TABLE 17-3

MONTH	Pr[1] Inches / Month	PET[2] Inches / Month	N Uptake[3] Percent / Month	f Denitrification[4] Percent / Month
JAN	7.62	0.10	1%	25%
FEB	6.72	0.27	2%	25%
MAR	8.85	0.97	4%	27%
APR	6.59	2.30	8%	29%
MAY	6.13	3.59	12%	31%
JUN	5.52	4.90	15%	33%
JUL	6.85	5.44	17%	35%
AUG	4.73	5.00	15%	35%
SEP	5.54	3.79	12%	34%
OCT	4.47	1.98	8%	32%
NOV	6.11	0.82	4%	29%
DEC	7.55	0.27	2%	26%

(1) Based upon Table A-3 of Chapter 16 – 5-year return monthly precipitation

(2) Based upon Table A-2 of Chapter 16 – Potential Evapotranspiration

(3) Based upon Table A-5 of Chapter 16 – Monthly Nitrogen Uptake by Vegetation

(4) Applied Nitrogen Fraction Removed by Denitrification / Volatilization

Note: Appendix 17-B shows Equation 17-2, using the default values.

17.6 Plan of Operation and Management

Each decentralized wastewater treatment system utilizing drip effluent dispersal should be covered by a Plan of Operation and Management (POM). For public utility systems, a General POM applicable to all of the utility's facilities and covering the items discussed below will suffice. The POM is written by the owner or the owner's engineer and once accepted by the Division of Water Pollution Control, the POM becomes the operating and monitoring manual for the facility. This manual should be kept on file by the facility owner and should be available for inspection by personnel from the Tennessee Department of Environment and Conservation.

This Plan should include, but not be limited to, the following information unless previously submitted via the permit application process:

17.6.1 Introduction

a. System Description:

1. A narrative description and process design summary for the land treatment facility including the design wastewater flow, design wastewater characteristics, pre-application treatment system and drip fields.

2. A map of the land treatment facility showing the pre-application treatment system, drip fields, buffer zones, roads, streams, drainage system discharges, monitoring wells, etc.

3. A map of the collection system including gravity lines, force mains and pump stations tributary to the land treatment facility. Indicate their size and capacity.

4. A schematic and plan of the pre-application treatment system identifying all pumps, valves and process control points.

5. A schematic and plan of the irrigation distribution system identifying all pumps, valves, gauges, etc.

b. Discuss the design life of the facility and factors that may shorten its useful life.

Include procedures or precautions that will compensate for these limitations.

17.6.2 Management and Staffing

a. Discuss management's responsibilities and duties.

b. Discuss staffing requirements and duties:

1. Describe the various job titles, number of positions, qualifications, experience, training, etc.

2. Define the work hours, duties and responsibilities of each staff member.

3. Describe the location of operational and maintenance personnel relative to the location of the treatment system.

17.6.3 Facility Operation and Management

a. Pre-application Treatment System:

1. Describe how the system is to be operated.

2. Discuss process control.

3. Discuss maintenance schedules and procedures.

4. Discuss the use of telemetry

b. Drip Dispersal System Management:

1. Wastewater Application. Discuss how the following will be monitored and controlled. Include rate and loading limits.

(a) Wastewater loading rate

(gallons per day per square foot or inches/week)

(b) Drip dispersal field application cycles

2. Discuss how the system is to be operated and maintained.

(a) Storage pond(s), where utilized.

(b) Irrigation pump station(s)

(c) Drip dispersal field force main(s) and laterals

3. Discuss start-up and shut-down procedures.

4. Discuss system maintenance.

(a) Equipment inspection schedules

(b) Equipment maintenance schedules

5. Discuss operating procedures for adverse conditions.

(a) Electrical and mechanical malfunctions

6. Provide troubleshooting procedures for common or expected problems.

7. Discuss the operation and maintenance of back-up, stand-by and support equipment.

c. Drainage System (if applicable):

1. Discuss operation and maintenance of surface drainage and run off control structures.

2. Discuss operation and maintenance of subsurface drainage systems.

17.6.4 Monitoring Program

a. Discuss sampling procedures, frequency, location and parameters for:

1. Pre-application treatment system.

2. Drip Dispersal System:

(a) Storage pond(s), where utilized

(b) Groundwater monitoring wells

(c) Drainage system discharges (if applicable)

(d) Surface water (if applicable)

b. Discuss soil sampling and testing:

c. Discuss ambient conditions monitoring:

1. Rainfall
2. Soil moisture

d. Discuss the interpretation of monitoring results and facility operation:

1. Pre-application treatment system.
2. Drip dispersal fields.
3. Soils.

17.6.5 Records and Reports

a. Discuss maintenance records:

1. Preventive.
2. Corrective.

b. Monitoring reports and/or records should include:

1. Pre-application treatment system and storage pond(s).
   - (a) Influent flow
   - (b) Influent and effluent wastewater characteristics
2. Drip Dispersal System.
   - (a) Wastewater volume applied to drip dispersal fields.
   - (b) Loading rates.
3. Groundwater Depth.
4. Drainage system discharge parameters (if applicable).
5. Soils data.
6. Rainfall and climatic data.

APPENDIX 17 – A

APPENDIX 17-B

Hydraulic Values and Conversion Factors

0.2 gallons per day per square foot (GPD/SF) = 2.25 inches per week (in/wk.)

0.18 GPD/SF = 2.00 in/wk.

0.13 GPD/SF = 1.5 in/wk.

0.11 GPD/SF = 1.25 in/wk.

0.10 GPD/SF = 1.12 in/wk.

Moderately Slowly Permeable @ 0.2 in/hr. x 10% = 3.4 in/wk.

Slowly Permeable @ 0.06 in/hr. x 10% = 1 in/wk.

0.25 GPD/SF = 2.81 in/wk. = 0.4 in/day = 10,899 gallons per acre per day (gal/ac/day)

1 in/wk. = 0.089 GPD/SF = 3,880 gal/ac/day

0.1 GPD/SF = 4.7 x 10^{-6} cm/sec

APPENDIX 17 – C

EXAMPLE (Hydraulic & Nutrient Loading Calculations)

Lwn = [Cp (Pr - PET) + N(4.413)] / [(1 - f)(Cn) – Cp]

Lwn =		Calculated Allowable Nitrate Loading Rate
Pr =		Table A-3 of Chapter 16 - 5-year return monthly precipitation (in/month)
PET =		Table A-2 of Chapter 16 - Potential Evapotranspiration (in/month)
N =	**Uptake**	Table A-5 of Chapter 16 - Monthly Nitrogen Uptake Rate by Vegetation (lbs./acre/month)
F =		Applied Nitrogen Fraction Removed by Denitrification / Volatilization (%)
Cp =	10	Maximum Nitrate Concentration in Leachate (mg/L)
Cn =	23	Nitrogen Concentration in Applied Wastewater (mg/L)
	4.413	Conversion Factor
U =	100	Annual Nitrogen Uptake Rate for Crop, Variable (lbs./acre/yr.)

MONTH	**Pr in/mo**	**PET in/mo**	**N Uptake %/mo**	**N Uptake lb/ac/mo**	**f (Denitrif) %/mo**	**Lwn in/mo**	**Lwn in/wk**	**Lwn in/day**	**Lwn GPD/SF**	**Lwh GPD/SF**
JAN	7.62	0.10	1%	1	25%	10.98	2.48	0.35	0.221	
FEB	6.72	0.27	2%	2	25%	10.12	2.53	0.36	0.225	
MAR	8.85	0.97	4%	4	27%	14.21	3.21	0.46	0.286	
APR	6.59	2.30	8%	8	29%	12.37	2.89	0.41	0.257	
MAY	6.13	3.59	12%	12	31%	13.37	3.02	0.43	0.269	
JUN	5.52	4.90	15%	15	33%	13.41	3.13	0.45	0.279	
JUL	6.85	5.44	17%	17	35%	18.04	4.07	0.58	0.363	
AUG	4.73	5.00	15%	15	35%	12.86	2.90	0.41	0.258	
SEP	5.54	3.79	12%	12	34%	13.63	3.18	0.45	0.283	
OCT	4.47	1.98	8%	8	32%	10.69	2.41	0.34	0.215	
NOV	6.11	0.82	4%	4	29%	11.15	2.60	0.37	0.232	
DEC	7.55	0.27	2%	2	26%	11.63	2.63	0.38	0.234	
TOTALS	**76.68**	**29.43**	**100%**	**100**		**152.47**				

APPENDIX 17 – D

Derivation of Conversion Factor for Equation 17-2.

(Provided by Harry J. Alexander, P.E.)

1 acre-inch: (1 acre) (1 inch) (43,560 SF/acre) (1 foot/12 inches) = 3,630 CF

(3,630 CF) (7.481 gal/CF) (3.785 liters/gal) = 102,785 liter, or 102,790 to the correct number of significant figures which is 5 in this case since the resultant product began with a "1" but none of the other figures (which each were taken to have 4 significant figures) began with a "1"

1 lb. = 453, 590 mg (here again we have 5 significant figures)

(453,590 mg/lb.) (102,790 liters/acre-inch) = 4.41278mg-acre-inch/liter-lb.

or 4.4128 mg-acre-inch/liter-lb. to the correct number of significant figures. But it would probably be best to state it to only four significant figures.

or 4.413 mg-acre-inch/liter-lb. This would be preferred given that it is likely nothing else in Equation **16-5** would be known to be more than four significant figures.

The foregoing explains where the conversation factor and its units (mg-acre-inch/liter-lb.) come from.

The number **4.413** is a better number than the previously used number of 4.424.

APPENDIX 17 – E

U.S. DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

NRCS-Soils-232G
5-86

SOIL DESCRIPTION

Soil type   File No.

Area	Date	Stop No.

Classification

Location

N. veg. (or crop) — Climate

Parent material

Physiography

Relief	Drainage	Salt or alkali
Elevation	Gr. water	Stoniness
Slope	Moisture	
Aspect	Root distrib.	% Clay *
Erosion	% Coarse fragments *	% Coarser than V.F.S. *

Permeability

Additional notes

* Control section average

Hori-zon	Depth	Color		Texture	Structure	Consistence			Reac-tion	Bound-ary			
		Dry	Moist			Dry	Moist	Wet					