DEPARTMENT OF ENVIRONMENTAL PROTECTION
Bureau of Clean Water

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TITLE: Manual for Land Treatment of Wastewater

EFFECTIVE DATE: Upon final publication in the *Pennsylvania Bulletin*

AUTHORITY: The Clean Streams Law of Pennsylvania

POLICY: This document provides guidance regarding the land treatment of wastewater.

PURPOSE: This document is intended to provide general guidance on the existing methods and types of wastewater land treatment systems and their relative effectiveness and limitations; it is not to be construed as an endorsement of any particular system. This manual presents factors which should be considered when determining whether land treatment is a feasible and environmentally sound alternative. This manual also contains information on the general design, installation, and maintenance of wastewater land treatment systems. The information presented in this document will need to be supplemented with additional detailed research once a land treatment method has been selected. The Department of Environmental Protection (DEP or Department) will evaluate each land treatment proposal relative to its adherence to all applicable guidelines, policies, regulations, and laws. The manual replaces in entirety DEP's *Manual for Land Application of Treated Sewage and Industrial Wastewater* (362-2000-009).

APPLICABILITY: This guidance document applies to consulting engineers, geologists, and soil scientists regarding site selection, system design, and permitting requirements for the land treatment of domestic and industrial wastewater.

DISCLAIMER: The policies and procedures outlined in this guidance are intended to supplement existing requirements. Nothing in the policies or procedures shall affect regulatory requirements.

The policies and procedures herein are not an adjudication or a regulation. There is no intent on the part of DEP to give the rules in these policies that weight or deference. This document establishes the framework within which DEP will exercise its administrative discretion in the future. DEP reserves the discretion to deviate from this policy statement if circumstances warrant.

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MANUAL FOR LAND TREATMENT OF WASTEWATER

A Guide to Site Selection, System Design,
and Permitting Requirements
385-2188-006

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

For more information, visit www.dep.pa.gov,
keyword: Wastewater.

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1. LEGISLATIVE AND REGULATORY AUTHORITY

The Department's statutory authority to regulate land treatment of wastes is contained in Pennsylvania's Clean Streams Law (Act of June 22, 1937, P.L. 1987, No. 394, as amended, 35 P.S. §§ 691.1 et seq.) and the Pennsylvania Sewage Facilities Act (Act of January 24, 1965, P.L. 1535, No. 537, as amended, 35 P.S. §§ 750.1 et seq.) (Act 537).

DEP's regulatory authority to permit land treatment of wastewater is codified at 25 Pa. Code Chapter 91.

The sewage planning requirements under Act 537 are codified at 25 Pa. Code Chapter 71.

Wastewaters which are treated by seasonal land treatment with surface discharges of wastewaters for part of the year are also regulated through the National Pollutant Discharge Elimination System (NPDES) permit process, which is codified at 25 Pa. Code Chapter 92a.

2. INTRODUCTION AND SCOPE

2.1. Definitions

The following words and terms, when used in this manual, have the following meanings, unless the context clearly indicates otherwise:

5-day Biochemical Oxygen Demand (BOD_5)—The dissolved oxygen used by microorganisms in the biochemical oxidation of organic matter in a period of 5 days, expressed in mg/L.

Absorption area—A component of an individual or community sewage system where liquid from a treatment tank seeps into the soil; it consists of an aggregate-filled area containing piping for the distribution of liquid and the soil or sand/soil combination located beneath the aggregate. (25 Pa. Code § 73.1). It is the area of land within the project site used for the actual infiltration of effluent for final renovation through natural physical, chemical, and biological processes within the soil matrix.

Agricultural Waste—includes manure and residual material generated in the production and marketing of agricultural commodities. Residual materials generated during production, harvesting, and marketing of agronomic, aquacultural, horticultural, and silvicultural crops are included as long as they are not hazardous. Examples include livestock manure, fishery manure, soil residue dislodged from harvested crops, waste animal feed, plant parts, and livestock washwater.

At-grade—A system that is designed and installed such that all or part of the absorption area is located at or above original ground elevation.

Distribution system—A network of pumps, pump and flow controls, piping, and aggregate that transport and disperse effluent through a sewage system.

Community sewage system—A sewage facility, whether publicly or privately owned, for the collection of sewage from two or more lots, or two or more equivalent dwelling units and the treatment or disposal, or both, of the sewage on one or more of the lots or at another site. (25 Pa. Code § 73.1)

Community onlot sewage system—A community sewage system which uses a system of piping, tanks or other facilities for collecting, treating and disposing of sewage into a soil absorption area or retaining tank. (25 Pa. Code § 73.1)

Community sewerage system—A publicly or privately owned community sewage system which uses a method of sewage collection, conveyance, treatment and disposal other than renovation in a soil absorption area, or retention in a retaining tank. (25 Pa. Code § 73.1)

Domestic wastewater—A substance that contains any of the waste products or excrement or other discharge from the bodies of human beings. Note that this term is synonymous with the definition of **Sewage** below.

Drip Irrigation—A fluid handling system in which a small volume of wastewater is dosed at predetermined time intervals throughout the day to the soil through a flexible pressurized piping network that comes close to achieving uniform distribution over the footprint of the absorption area.

Effluent is domestic or industrial wastewater usually pretreated, to be applied to a soil absorption area for final renovation as part of a land treatment system.

Evaporation—Water that is converted from a liquid phase to a vapor phase without passing through a plant or other organism.

Evapotranspiration (ET)—Water converted from a liquid phase to a vapor phase through the processes of both evaporation and plant transpiration.

Floodplain—The lands adjoining a river or stream that have been or may be expected to be inundated by flood waters in a 100-year frequency flood. (25 Pa. Code § 105.1)

Floodway—The channel of the watercourse and portions of the adjoining floodplains which are reasonably required to carry and discharge the 100-year frequency flood. Unless otherwise specified, the boundary of the floodway is as indicated on maps and flood insurance studies provided by FEMA. In an area where no FEMA maps or studies have defined the boundary of the 100-year frequency floodway, it is assumed, absent evidence to the contrary, that the floodway extends from the stream to 50 feet from the top of the bank of the stream. (25 Pa. Code § 105.1)

Food Processing Residual Waste—An incidental organic material generated by processing agricultural commodities for human or animal consumption. The term includes food residuals, food coproducts, food processing wastes, food processing sludges, or any other incidental material whose characteristics are derived from processing agricultural products. Examples include: process wastewater from cleaning slaughter areas, rinsing carcasses, or conveying food materials; process wastewater treatment sludges; blood; bone; fruit and vegetable peels; seeds; shells; pits; cheese whey; off-specification food products; hide; hair; and feathers. (from DEP's *Food Processing Residual Management Manual* (254-5400-100))

Groundwater mounding—A situation that occurs when the localized groundwater surface rises below an area of concentrated recharge. Mounding can occur in areas where infiltrating water intersects a groundwater table and the rate of water entering the subsurface is greater than the rate at which water is conveyed away from the infiltration system.

Hydraulic Linear Loading Rate—The maximum volume of effluent that a soil surrounding an effluent infiltration system can transmit far enough away from the infiltration surface such that it no longer influences the infiltration of additional wastewater, expressed in gallons per day per foot (gpd/ft).

Infiltration Loading Rate—The peak daily flow of effluent applied per unit area of undisturbed soil, expressed in gallons per day per square foot (gpd/ft^2). It may also be referred to as the basal loading rate or the soil infiltration loading rate.

Industrial wastewater—
(i) A liquid, gaseous, radioactive, solid or other substance, which is not sewage, resulting from manufacturing or industry, or from an establishment, and mine drainage, refuse, silt, coal mine solids, rock, debris, dirt and clay from coal mines, coal collieries, breakers or other coal processing operations.
(ii) The term includes all of these substances whether or not generally characterized as waste. (25 Pa. Code § 73.1)

Infiltration rate—The rate at which water enters the soil surface, measured in millimeters per hour (mm/hr) or inches per hour (in/hr). Infiltration rates are related to the extent of large, interconnected pore spaces in the soil.

Land treatment—The controlled application of wastewater onto the land to achieve a designed degree of treatment through natural physical, chemical, and biological processes within the plant-soil-water matrix. Methods of land treatment described in this manual include:

a. Spray irrigation;
b. Drip irrigation; and
c. Large volume onlot sewage systems (including at-grade beds)

Large volume onlot sewage system—An individual or community onlot sewage system with a peak design capacity to discharge subsurface sewage flows which are in excess of 10,000 gpd. (25 Pa. Code § 71.1). In this manual, this term also specifically refers to systems that are primarily designed using the criteria outlined in 25 Pa. Code Chapter 73, such as seepage beds, sand mounds, at-grade beds, or subsurface sand filters.

Lateral flow—The horizontal movement of percolating water under gravitational and/or capillary forces. This may occur in soil, bedrock, or both.

Limiting zone—A soil horizon or condition that limits either movement or renovation of the effluent. The limitation applies wholly to siting onlot systems of any size and may apply in whole or part in the siting of other land treatment systems.

Official Plan—A comprehensive plan for the provision of adequate sewage systems, adopted by the municipality or municipalities possessing authority or jurisdiction over the provision of the systems, and submitted to, and approved by, the Department as provided by Act 537. Planning for land treatment systems may be contained in Official Plans or may be amendments to the plan. (25 Pa. Code § 73.1)

Percolation Rate—A measure of the soil's ability to transmit water as derived by the percolation test described in 25 Pa. Code Chapter 73, reported in minutes per inch of drop. The percolation rate is related to the infiltration rate and the saturated hydraulic conductivities (both vertical and horizontal) of the soil, but it is not a direct measure of any of these values.

Professional Soil Scientist—A person who meets the following standards for education and experience:

a. A full 4-year course of study in an accredited college or university leading to a bachelor's or higher degree with major study in soil science plus five (5) years of professional experience (as defined below) beyond the baccalaureate degree in soil mapping, soil classification, and/or soil interpretations. This includes at least 30 semester hours of courses in biological, physical, and earth sciences, and at least 15 semester hours in soils in such subjects as soil genesis and pedology, soil physics, soil chemistry, soil biology, soil fertility, soil and water management and conservation, forest soils, soil and plant analysis for nutrient management, soil mineralogy, wetland soils, and soil and environmental quality as defined by the current divisions in the Soil Science Society of America;

b. A full 4-year course of study in an accredited college or university leading to a bachelor's or higher degree with major study in a related biological, physical, or earth science field plus six (6) years of post-academic professional experience (as defined below). This includes at least 30 semester hours of courses in biological, physical, and earth sciences and 15 semester hours in soils in such subjects as soil genesis and pedology, soil physics, soil chemistry, soil biology, soil fertility, soil and water management and conservation, forest soils, soil and plant analysis for nutrient management, soil mineralogy, wetland soils, and soil and environmental quality as defined by the current divisions in the Soil Science Society of America;

c. Soil Science Society of America (SSSA) certification as a Certified Professional Soil Scientist (CPSS) or Certified Professional Soil Classifier (CPSC); or

d. Office of Personnel Management (OPM) "Soil Scientist GS-5" rating and five (5) years of professional experience.

Professional experience is defined as post-academic experience devoted to soil classification, mapping, or interpretations using the procedures of the National Cooperative Soil Survey, or equivalent procedures, after satisfying the other provisions of this section.

Each advanced soil science-related degree (M.S. and Ph.D.) may substitute for a maximum of two (2) years' experience.

Saturated Hydraulic Conductivity (K_s)—A quantitative measure of a saturated soil or geologic formation's ability to transmit water when subjected to a hydraulic gradient. It can be thought of as the ease with which pores of a saturated media permit water movement. Note that in anisotropic soils and geologic formations, the vertical K_s and the horizontal K_s will be different.

Sewage—A substance that contains any of the waste products or excrement or other discharge from the bodies of human beings. (25 Pa Code §73.1). Note that this term is synonymous with the definition of **Domestic wastewater** above.

Sewage facilities—A system of sewage collection, conveyance, treatment and disposal which will prevent the discharge of untreated or inadequately treated sewage or other waste into waters of this Commonwealth or otherwise provide for the safe and sanitary treatment and disposal of sewage or other waste. (25 Pa. Code § 73.1)

Spray Irrigation System—A form of slow rate application which applies wastewater effluent evenly over the surface of the ground through aerial application to a vegetated land surface where a portion of the flow is used by the on-site vegetation. The wastewater is typically applied through a sprinkler distribution system and the portion that does not escape to the atmosphere through ET percolates to groundwater.

Storage Unit—Any tank, storage impoundment, lagoon, or other containment component of a land treatment system used for the temporary storage of treated or untreated wastewater.

Test Pit—A machine-excavated trench for visual observation and physical evaluation of the soil horizons and overall soil conditions, both horizontally and vertically, at a location. Soil test pits are also referred to as **Soil Probes** elsewhere.

Test Well—A well that is used during planning to measure aquifer characteristics beneath the proposed land treatment area. The aquifer characteristics will be used to screen for the growth of an adverse groundwater mound and determine the direction of groundwater flow. A test well may also supply background water samples. This differs from a monitoring well which, once operations have started, will allow sampling of the groundwater to ensure that treatment is being achieved and pollutants are not leaving the treatment site.

Transpiration—The process of water movement through a plant and its release as water vapor from aerial parts, such as leaves, stems and flowers. This volume can be significant during the growing season.

2.2. Introduction

Land treatment of wastewater offers many environmental benefits, such as groundwater aquifer recharge, improving watershed management, and decreased nutrient load to surface waters. As wastewater infiltrates the soil, pathogens, bacteria, nitrogen, phosphorus, organic material, and many other compounds are removed from the wastewater as it returns to recharge the aquifer. This recharge effectively adds additional water to the watershed while also adding nutrients to the soil.

The importance of providing acceptable methods of land treatment has intensified due to the increasingly stringent requirements associated with the discharge of wastewater to surface waters and the need for wastewater treatment where streams are not readily accessible. When done properly, land treatment of wastewater can play a role in the protection of water resources and aquatic organisms from potential impacts of treated sewage, minimizing rising costs of water supply treatment, and meeting demands for water-based recreation.

When determining whether land treatment is a feasible and environmentally sound wastewater treatment alternative, there are several important factors to consider. Non-discharge alternatives should be considered in watersheds with designated or existing uses of high quality (HQ) or exceptional value (EV) in Pennsylvania's water quality standards at 25 Pa. Code Chapter 93 or in DEP's Statewide Existing Use Classifications. For additional information on protection of special protection uses, see DEP's *Water Quality Antidegradation Implementation Guidance* (391-0300-002).[1] Land treatment options should be evaluated during the alternatives evaluation process and are required when proposing the use of the land for treatment and disposal of sewage. Requirements for the sewage disposal alternatives analysis are contained in Subchapter D of 25 Pa. Code Chapter 71.

The following list includes the design considerations for the land treatment of wastewater:

a. **Pretreatment** – The degree of pretreatment prior to land treatment is based on the characteristics of the wastewater and the end use of the effluent.

b. **Hydraulic Engineering Design** – The engineering design provides for collection and conveyance of the wastewater to the pretreatment facility as well as method of conveyance from the pretreatment facility to the land treatment area.

c. **Storage** – The design storage capacity will depend on the type of land treatment proposed and the climatic conditions at the site.

d. **Infiltration** – The effluent is applied to the surface of the soil before it travels through the soil matrix.

[1] DEP documents referenced in this manual can be accessed on DEP's eLibrary website, where documents can be browsed by document type, or searched based on document name or document number.

e. **Effluent retention and movement** – The soil provides significant treatment for many wastewaters. The effluent needs sufficient time within the soil matrix so that soil microbes and other treatment mechanisms in the soil can renovate the wastewater. The soil needs to have adequate thickness and hydraulic conductivity to provide aerobic renovation and movement of the effluent.

f. **Wastewater impact on groundwater** – After movement through the soil, effluent will enter a local or regional groundwater aquifer. Groundwater may be in bedrock or soil; it may be perched above the bedrock aquifer by dense soil horizons such as fragipans, plow pans, or dense basal till. The impact of nitrate-nitrogen in the infiltrating wastewater should be evaluated in order to protect groundwater quality.

g. **Groundwater mounding** – The soil/bedrock needs sufficient vertical and horizontal hydraulic conductivity to allow infiltration and lateral movement of effluent away from the site. This prevents backup of effluent and infiltrating precipitation into the aerobic treatment zone of the soil inhibiting full treatment and further infiltration. The mound may rise such that it creates a discharge running across the ground surface. Groundwater mounding is prevented by correctly characterizing the site soils and hydrogeology and applying the effluent at rates that do not exceed the soil infiltration capacity, and the aquifer's ability to transmit groundwater laterally away from beneath the site.

The applicant or their consultants should be prepared to utilize professional soil scientists, licensed geologists and engineers, and other professionals as appropriate, as part of the project team for developing a land treatment system. Interaction with the Department is encouraged throughout the process. Applicants should contact Clean Water Program staff in their DEP Regional Office as early as possible during the planning stage of a project.

Seasonal discharges to surface waters from land treatment systems may be permissible when conditions preclude year-round land treatment. Operators of wastewater land treatment systems must obtain an NPDES permit for the seasonal surface water discharge. The NPDES permit application packages can be found on DEP's NPDES Permitting Program webpage. Before considering development and submission of an application for an NPDES discharge, one should contact the DEP Regional Office that covers the geographic region where the facility would be located.

2.3. Scope

This manual contains guidance for project applicants and their consultants in the planning, siting, design, installation, operation, and maintenance of wastewater land treatment systems. These systems are based either solely or in part on the use of soil for effluent renovation. This manual incorporates DEP's experience with land treatment systems and generally accepted practices.

The guidance in this manual is intended for proposals of domestic and/or industrial wastewater treatment that utilize the natural soil as the final treatment that are not permitted by a Sewage Enforcement Officer.

Topics covered in this manual include:

a. Spray irrigation systems, except for Individual Residential Spray Irrigation Systems (IRSIS);
b. Drip irrigation systems; and
c. Large volume onlot sewage systems, including at-grade beds.

This manual also describes procedures regarding planning and permit applications for wastewater treatment systems based either solely or in part on the use of soils as the final treatment method. Reasonable safety factors have been built into the design criteria considering the uncertainty of estimated long-term wastewater acceptance rates. Proposals that do not meet the typical criteria provided in this manual will be reviewed on a case-by-case basis.

The guidance does not include detailed information on the design of pretreatment facilities which are likely to be necessary. Guidance regarding design of pretreatment facilities for domestic wastewater is contained in DEP's *Domestic Wastewater Facilities Manual* (362-0300-001). Standards for conventional onlot systems, including septic tanks and IRSIS, are set forth in 25 Pa. Code Chapter 73.

This guidance document is not intended to address agricultural uses of wastewater generated from agricultural activities. Descriptions of procedures for design, operation, and management of these activities can be found in DEP's guidance documents *Manure Management for Environmental Protection* (361-0300-001) and *Land Application of Manure* (361-0300-002). Additional sources of technical assistance include county agricultural extension agents and the local offices of the United States Department of Agriculture (USDA) Natural Resource Conservation Service and the local County Conservation District.

For residual waste, captive processing facilities (a facility that processes residual waste that is generated solely by the operator) may be deemed to have a residual waste permit by rule, if the facility has, and complies with, a Water Quality Management (WQM) permit, and also complies with the other requirements of 25 Pa. Code § 287.102(b). For residual waste, non-captive processing facilities not discharging into a water of the Commonwealth under an NPDES permit, or to a publicly owned treatment works, are not deemed to have a permit by rule under 25 Pa. Code § 287.102(c) and must obtain a residual waste processing permit from DEP's Bureau of Waste Management.

The requirements for land treatment and storage of residual waste are contained in DEP's waste management regulations at 25 Pa. Code Chapters 287 – 299.

This manual does not cover land treatment of wastewater that is defined as hazardous under 25 Pa. Code Chapters 260a – 270a.

Any questions concerning land treatment of hazardous wastewater, or residual waste and wastewater, should be directed to DEP's Bureau of Waste Management. Coordination with other Department programs, such as residual waste management, may be necessary to determine whether some industrial and agricultural wastes are covered under this manual or another Department guidance document. As noted previously, it is important for applicants to engage DEP early in project development so that DEP can provide guidance on the proposal. Preapplication meetings should be coordinated with the DEP Regional Office that covers the geographic area where the proposal will be located.

3. WASTEWATER CHARACTERIZATION

3.1. Wastewater Flows

3.1.1. General

This manual contains design standards for three types of land treatment systems: spray irrigation systems, drip irrigation systems, and conventional large volume onlot systems.

Of these systems, conventional large volume onlot systems and at-grade beds utilize absorption areas as defined in 25 Pa. Code § 73.1 and, for the purposes of this manual, are classified as community onlot sewage systems. Spray irrigation systems and drip irrigation systems do not utilize absorption areas as defined by DEP's regulations, so they are classified as community sewerage systems.

3.1.2. Determination of sewage flows for community onlot sewage systems

a. Sewage flows from single-family dwellings served by a community onlot sewage system, or from apartments, rooming houses, hotels and motels served by a community sewage system, shall be peak daily flows determined from the table in 25 Pa. Code § 73.17(a).

b. Sewage flows, excluding industrial waste, for nonresidential establishments served by a community sewage system shall be determined from the table in 25 Pa. Code § 73.17(b).

c. Actual water meter or sewer meter flow data indicating peak daily flows different than those shown in this section over a 1-year period for a similar nonresidential establishment may be accepted for use in sizing the onlot disposal system. If average daily flows are used, the peak daily flow shall be calculated by multiplying the average daily flow by at least two.

d. Under 25 Pa. Code § 73.17(d), establishments with food preparation facilities are required to install adequately designed pretreatment units and traps to reduce greases and biological oxygen demand (BOD) prior to discharge to a community sewage system.

3.1.3. Determination of sewage flows for community sewerage systems

The procedures in DEP's *Domestic Wastewater Facilities Manual* (362-0300-001) should be used to calculate the sewage flows for a community sewerage system.

The design by analogy method, as described in Section 43.511 of DEP's *Domestic Wastewater Facilities Manual* should not be used; this methodology was intended for systems discharging to receiving streams. There is a fundamental difference between discharging to a receiving stream, and relying on the soil for infiltration and renovation of wastewater. Land treatment systems do not afford the designer the ability to use average daily flow, and it is important to design for peak daily flow unless flow equalization is employed in the design.

The volume of equalization employed will determine the appropriate design flow. For example, in systems with equalization storage of less than 3 days, the most appropriate design flow for the land treatment system is the peak daily flow. For systems with equalization storage of 3 – 5 days, it may be more appropriate to design the land treatment system on a maximum weekly flow. For lagoon systems capable of holding multiple months of flow, it may be appropriate to use an annual average flow. Consult with the appropriate regional office to determine the appropriate design flow.

Industrial wastewater flows vary widely depending on the application and operation. Peak daily wastewater flows should be estimated from application-specific data. When available, wastewater flow meter data, either influent or post-treatment, should be utilized.

3.2. Wastewater Quality

Prior to land treatment, all wastewaters should undergo pretreatment. The degree of pretreatment provided determines the reliance on the soil's renovative capacity. A greater reliance on the soil's renovative capacity requires a greater factor of safety used in sizing the soil dispersal area. Higher degrees of treatment or lower hydraulic loading may be requested for high-strength wastes. Industrial wastes should be adequately characterized to determine whether they are suitable for land treatment. Wastes that are non-biodegradable, toxic to vegetative cover, cause soil dispersion, contain greases, waxes, or other soil pore clogging substances, or that are persistently toxic in the environment should not be applied to the soil.

In addition to the effluent chemistry, the pretreatment needs are based on site characteristics, the type of application system proposed, and the site-specific objectives of the system. Methods for assessing the characteristics of the proposed site are addressed in the soils and hydrogeologic reports and are incorporated into the design specifications for the system being proposed.

Pretreatment for industrial wastewaters is dependent on the characteristics of the wastewater and the soils available for land treatment. Refer to Chapter 6 of this manual for information on evaluating the degree of pretreatment for industrial wastewater.

In order to prevent fecal contamination and nuisance conditions associated with odors, domestic wastewater effluent for land treatment should be treated to a minimum of secondary treatment standards prior to land treatment, unless otherwise specified in the technology-specific provisions in this manual's subsequent chapters. Secondary effluent should meet the following minimum standards:

Parameter	Treatment Standard	
	Monthly Average	Average Weekly
BOD_5	< 30 mg/L	< 45 mg/L
TSS	< 30 mg/L	< 45 mg/L
Fecal Coliform*	< 200 /100 mL	< 800 / 100 mL

* May not be required for subsurface distribution systems.

In cases where secondary treatment may not be sufficient to protect human health and the environment, more advanced levels of effluent pretreatment may be necessary; this should be addressed in the soils report and hydrogeologic reports. In these cases, advanced secondary effluent is often necessary to ensure that the wastewater is adequately treated through the land treatment process.

Advanced secondary effluent should meet the following minimum standards:

Parameter	Treatment Standard	
	Monthly Average	Average Weekly
BOD_5	< 10 mg/L	< 20 mg/L
TSS	< 10 mg/L	< 15 mg/L
Fecal Coliform*	< 200 /100 mL	< 800 / 100 mL

* May not be required for subsurface distribution systems.

4. SEWAGE FACILITIES PLANNING

4.1. General

Under the Pennsylvania Sewage Facilities Act (also commonly known as Act 537), municipalities are required to develop and implement a comprehensive sewage management plan, known as the Official Plan or Act 537 plan. Municipalities are required to keep the Official Plan up to date through the completion of plan revisions, updates, and special studies.

All domestic sewage projects that will result in the construction of a land treatment system as described in this manual will require some form of Act 537 sewage facilities planning. When new land development is proposed, the revision to the Act 537 plan normally takes the form of a "planning module" that is specific to an individual subdivision or land development as described in Subchapter C of 25 Pa. Code Chapter 71. When the proposed treatment system will serve existing sewage flow, the planning could take the form of a "base plan update/revision," the content of which is described in Subchapter B of 25 Pa. Code Chapter 71. However, a Component 3 planning module could be considered as well.

Sewage planning generally should be discussed with DEP after the Waste Characterization process discussed in Chapter 3 of this manual and the initial desktop site evaluation discussed in Chapter 5, f this manual, as that minimum information related to wastewater volume, wastewater characteristics, and expected site characteristics will be necessary to guide the early stages of the process. The rest of this chapter will summarize the planning process and requirements. At the conclusion of the planning process, specific technology and siting will be established for the land treatment system, including requirements for operation and maintenance.

There is no prerequisite to obtain Act 537 planning approval for industrial wastewater projects prior to submitting a WQM Part II permit application. However, it is necessary to follow the pre-permitting process described in DEP's *Industrial Wastewater Management: A Guide to Requirements and Procedures for Obtaining Permits and Other Approvals and for the Planning and Design of Industrial Wastewater Management Systems* (362-0300-004). Prior to conducting a site evaluation, the DEP regional office should be contacted for a pre-application meeting to determine additional specific project requirements for an industrial wastewater project.

Appendix A of this manual contains a flow diagram showing the process for planning, designing, and implementing land treatment applications.

4.2. Planning

The formal planning process for domestic wastewater projects starts with contacting the appropriate DEP Regional Clean Water Program Sewage Planning Section staff for a pre-planning meeting, followed by submission of a sewage facilities planning module application mailer or plan of study task/activity report to the DEP Regional Office.

Once submitted, DEP typically provides a checklist letter or email to the applicant that explains planning requirements and provides contact information for DEP staff assigned to the project. A cooperative site evaluation can then be conducted. Typically, DEP staff also meet with the project's consultants to discuss the project and the site exploration goals. Initial site evaluation and field investigation are detailed in Chapters5, Chapter 6, and Chapter 7 of this ual.

The remainder of this manual may be used to develop alternatives for various land treatment options. When preparing an Act 537 plan update, DEP's *Sewage Facilities Planning: A Guide for Preparing Act 537 Update Revisions* (362-0300-003) should be followed. When preparing a planning module, the appropriate planning module instructions should be followed. The complete planning documents should be able to delineate the amount of area needed for the selected land treatment alternative through the soil and geologic investigations presented in this manual. The planning documents should identify the selected administrative alternatives for ownership, operation, and maintenance. The planning documents should also show that the proposal is compliant with local codes, ordinances, and zoning.

The final step in the planning process is submission of complete planning documents to the municipality for concurrence and thereafter to DEP. Planning approval is a prerequisite to the submission of a WQM permit application, which is required to construct, operate, and monitor a land treatment system. The documentation of planning approval is then submitted with the *WQM Permit Application* (3850-PM-BCW0400b), available in the *WQM Permit Application Package* (3850-PM-BCW0400), which is also available from DEP's regional offices.

As described in 25 Pa. Code Chapter 71, DEP's review of the planning will consider the plan's ability to be implemented, municipal responses to comments received during the public comment period, and the planned operation and maintenance of the system. Therefore, planning documents will need to describe every aspect of the land treatment system in sufficient detail for these items to be evaluated by the municipality and DEP. Site and field investigation are covered in detail in in Chapter 5, Chapter 6, and Chapter 7 of this guidance document.

4.3. Summary of Act 537 Sewage Planning Submission

Complete sewage planning documents, in addition to the requirements of 25 Pa. Code Chapter 71, should include the following items as described in this manual:

a. Proposed wastewater effluent flows, average and peak;

b. Effluent storage size and location;

c. Soil Scientist report, with the results of all testing;

d. Proposed soil loading rates based upon both hydraulic and nutrient uptake characteristics with supporting documentation;

e. Proposed loading rates based upon the Hydrogeologic Report;

f. Proposed land treatment absorption area location with corresponding square footage or acreage:

    1. Additional area provided for distribution design or,

    2. Preliminary distribution engineering layout;

g. Isolation Distances;

h. Fence protection of proposed absorption area; and

i. Site Vegetation Report.

5. INITIAL SITE SCREENING

5.1. Background

A great deal of evaluation goes into choosing land treatment as a method of wastewater treatment and reuse. The type of evaluations and designs vary between domestic wastewaters and industrial wastewaters. For example, under Act 537, an evaluation of alternatives is required as part of the sewage facilities planning pursuant to Subchapter C of 25 Pa. Code Chapter 71.

Prior to any planning effort, a potential applicant should contact the DEP regional office to discuss the project. The regional office will provide guidance on the anticipated site exploration items. Actual site conditions will dictate the degree of exploration and the specific exploration items necessary to determine if a site is suitable.

Initially, sites are mapped and screened through a preliminary evaluation process to eliminate sites which are unsuitable for land treatment based on slopes, isolation distances, inadequate soils, potential direction of groundwater flow, and slow permeability. The preliminary site evaluation processes for soils and geology are described below. The sites which pass the screening are identified and then prioritized for field study.

5.2. General Site Plan Elements

The general site plan consists of plan views, elevations, and supplementary views which provide information for understanding the proposed treatment facilities. The general site plan also includes dimensions and relative elevations of structures, treatment units, and ground surface. The plan should be clear and legible and drawn to a scale which will permit all necessary information to be plainly shown. The maximum plan size should be 30 inches by 42 inches.

a. The general site plans and maps should include the following:

    1. Datum used;

    2. Locations and logs of test borings, when evaluated;

    3. Property boundary;

    4. Existing streams (perennial, intermittent, and ephemeral), stream classifications and designations, man-made swales, other water bodies, wetlands, and, floodplains.

        i. Streams can be identified by accessing eMapPA and/or doing a site reconnaissance.

ii. To identify wetlands listed on the United States Fish and Wildlife Service (USFWS), National Wetlands Inventory, use USFWS's Wetlands Mapper tool.

5. Site geomorphology (topography, slope, landform, and drainage patterns);

6. Existing land uses;

7. Other natural or man-made features or conditions that may impact design, such as existing nearby structures (such as buildings, roads, utilities, and walls);

8. The location of water supply sources (wells, reservoirs, cisterns, drinking water intakes, regulatory well head protection areas);

9. The location of environmentally sensitive areas such as critical habitats of endangered, threatened, or species of special concern.

   i. This is done by performing a Pennsylvania Natural Diversity Inventory (PNDI) search.

   ii. The PNDI search can be initiated from the Conservation Explorer tool found on the Pennsylvania Natural Heritage Program's web site.

10. Utility location and associated rights-of-way;

11. The location of proposed development as it relates to the land treatment area (such as buildings, treatment units, roads, utilities, and walls);

12. Proximity to recreation facilities (parks, playgrounds, athletic fields);

13. A map of the project area in relation to surrounding land uses;

14. Soil types and boundaries;

15. Geologic formations and contacts;

16. Stormwater management areas;

17. Floodways (no land treatment area should be located in a floodways);

18. Minimum horizontal isolation distances identified below, as measured from the feature to the edge of the land treatment system. Exceptions may be available as noted:

	Minimum Horizontal Isolation Distances (feet)		
Features	Spray Irrigation[*]	Drip Irrigation[*]	Large Volume Onlot[*]
Public water supply well	400/100[†]	400/100[†]	400/100[†]
Private water supply well	100	100	100
Surface water	50	50	50
Property line	50	10	10
Public road or driveway	25	25	25
Residence or occupied structure	100	10	10
Sinkhole or closed depression	100	100	100
Rock outcrops	25	10	10
Stormwater drainageways	25	10	10
Slope >25%	N/A	10	10

[*] Where geological or other conditions warrant, greater horizontal isolation distances may be required.

[†] May be allowed if justified by a detailed hydrogeologic study.

19. Stormwater BMPs and proposed land treatment areas – Stormwater best management practices may influence site hydrology. An evaluation to determine the appropriate isolation distance should be provided and the isolation distance should be shown on the plan.

b. Available land treatment areas – Once features associated with the proposed site have been identified, the available area should be adjusted to exclude those areas within the horizontal isolation distances.

5.3. Initial Soils Screening

5.3.1. General

It is important that a professional soil scientist be involved in the assessment of soils at potential land treatment sites since land treatment is reliant on the soil as a medium to provide final treatment of effluent before it enters the groundwater. Selecting a site with soil characteristics conducive to wastewater treatment and dispersal is crucial.

It is critical to identify the limiting factors present in site soil for the proper design of a land treatment system. Having a professional soil scientist evaluate the site soil morphology and interpret the complex interrelationships between the various soil characteristics will produce the information necessary to conduct a land limiting constituent analysis. A thorough soils evaluation will aid in the design of a long-term functioning land treatment system that will be protective of water quality, human health, and the environment.

Land treatment of wastewater should only be considered for undisturbed soils. Undisturbed soil is a natural filter that provides effluent renovation using physical, chemical, and biological processes. The natural conditions of soil, such as its structure, texture, density, and permeability, are lost when the soil is translocated or physically altered. Prior to planning for land treatment on a fill site or a disturbed site, the applicant should contact Clean Water Program staff in the DEP regional office that covers the geographic region where the facility would be located.

Every attempt should be made to eliminate or minimize any physical modifications to the site soil during the planning phase. Modifications to the soil profile include grading, smoothing, leveling, cutting, and filling. Physical modifications to the soil profile should be discussed with the DEP soil scientist before site investigations.

A limiting soil condition may include situations where wastewater infiltration is either too fast or too slow to effectively renovate wastewater constituents prior to infiltration to groundwater. Each of the following should be considered a limiting soil condition and be evaluated by a professional soil scientist:

a. Insufficient soil depth to a limiting zone;

b. Depth to water table;

c. Restrictive layers;

d. Depth to bedrock;

e. Rock fragments with insufficient fines;

f. High shrink-swell clays;

g. Convergent topography;

h. Disturbed soil; and

i. Soil contamination.

Soils play a central role in the successful land treatment of wastewater and require a thorough investigation. Applicants and their consultants should consider the heterogeneity and anisotropic properties of soil both spatially across a proposed site and vertically in order to design a system that will function properly and safely.

5.3.2. Desktop Soils Investigation

The purpose of performing a desktop survey of the available soils data is to get a general idea of the suitability of site soil for land treatment before investing time and money on a field study.

Soil data is best obtained via the National Resource Conservation Service (NRCS) Web Soil Survey (WSS) tool. The WSS is updated and maintained online as the single authoritative source of soil survey information. The WSS website offers a vast array of tools to collect and analyze soil data for your selected area and provides a means to print a custom document with all selected information including maps and tables.

Soils data are compiled for proposed sites and used by the professional soil scientist to make an initial determination of the site suitability for land treatment of wastewater. Data that should be compiled and evaluated for each proposed site include:

a. A soils map of the site using WSS to determine the location, number, and extent of different soil series at the site. The soil scientist should characterize all soil series and phases (predominantly slope classes) present on each site being evaluated. By selecting the Official Soil Series Description (OSD) feature and viewing each soil series, the soil scientist can evaluate soils data before going to the field, including information such as:

    1. Narrative summarizing the conditions and physiographic setting the soils form under;

    2. Taxonomic Class;

    3. Typical soil profile description, including:

        i. Number and type of horizons;

        ii. Horizon depth and thickness;

        iii. Color (Munsell color system);

        iv. Texture (USDA classification);

        v. Structure (grade, size, and type);

        vi. Consistence (workability or plasticity);

        vii. Redoximorphic features (formerly called mottling);

        viii. Abundance of coarse fragments;

        ix. Abundance of roots; and

x. Any other non-typical, but potentially significant feature within the horizon.

4. Range of characteristics;

5. Competing series;

6. Geographic setting;

7. Geographically associated soils;

8. Drainage and permeability of each horizon in the soil profile;

9. Use and vegetation;

10. Distribution and extent;

11. Hydric soil rating; and

12. Hydrologic soil group rating.

b. When evaluating the soils data for the site, attention should be given to the slope class for each soil series polygon on the site soils map.

c. Slope analysis can be visually aided by accessing the Pennsylvania Spatial Data Access (PASDA) website and using the Pennsylvania Imagery Navigator tool to view the site through the Statewide Lidar Hillshade data layer.

5.3.3. Consultants Site Suitability Evaluation

Using the information listed in above in Section 5.3.2, the soil scientist should screen sites as to their eventual viability for land treatment. Sites showing promise will need to undergo site-specific soils testing for attributes indicating that the subsurface materials will efficiently treat the applied effluent and that the land treatment system will not cause a water quality problem. A site-specific subsurface investigation program as described in Chapter 6 is necessary for all land treatment sites.

5.4. Initial Hydrogeological Screening

5.4.1. Background

Although soils are often the primary controlling factor impacting land treatment of wastewater, geology can play a significant role in determining site suitability. An adequate understanding of the hydrogeology serves as a basis for:

a. Providing baseline groundwater level and compositional information;

b. Evaluating the potential for groundwater mounding in situations where application rate could lead to mounding (hydraulic conductivity too low); and

c. Monitoring the site.

5.4.2. Desktop Screening

A desktop review of existing information should include, where available:

a. Regional and site-specific geological maps and reports;

b. Logs from any nearby public or private water wells;

c. Logs from buildings or quarries;

d. Groundwater records;

e. Groundwater source protection plan documents; and

f. Pennsylvania Groundwater Information System (PaGWIS), aerial photos over time (e.g., Google Earth).

Since land treatment may add contaminants, including nitrates, to the groundwater, it is necessary to determine background groundwater concentration of contaminants of interest at the proposed site. Depending upon background concentrations, a number of different options may be necessary, including contaminant-specific treatment for the wastewater prior to land treatment.

The desktop study may find characteristics that could limit the suitability of the site. There should be no land treatment of effluent to sinkholes and undrained depressions. A licensed professional geologist should evaluate features such as:

a. Surface bedrock exposure;

b. Karst Terrane features;

c. Limestone or dolostone bedrock aquifers – this includes sinkholes (both open and active) as well as sinkholes manifested as closed topographic depressions;

d. Sites where surface water elevations indicate high groundwater tables beneath the area of interest;

e. Sites adjacent to or within a wetland where the wetland is caused by high regional and high seasonal water table;

f. Sites where isolation distances to geologic features and water supplies may impinge upon available land treatment areas; and

g. Aquifers with low permeability and hydraulic conductivity as it relates to well yield. Aquifers showing low well yields may result in the growth of an adverse groundwater mound.

5.4.3. Consultants Site Suitability Evaluation

Using the information listed above in Section 5.4.2, the hydrogeologist should screen sites as to their eventual viability for land treatment. Sites showing promise will need to undergo site-specific aquifer testing for physical attributes indicating the subsurface materials will efficiently transmit the applied effluent away and that the land treatment system will not cause a water quality problem. A site-specific subsurface investigation as described in Chapter 7 is necessary for all land treatment sites.

6. SOILS FIELD EVALUATION

6.1. General

It is important that a field evaluation of the site soils be conducted by the applicant's professional soil scientist and be coordinated with the DEP regional soil scientist. The purpose of this field evaluation is to determine actual soil conditions in areas of the site that have been selected during the initial site screening as potential land treatment absorption areas. A cursory soil investigation can be conducted by evaluating hand auger samples to refine the areas of the site to be fully characterized by excavating test pits. Test pits will need to be evaluated for final verification that suitable soils exist. The number and location of test pits will depend on the type of system proposed, anticipated sewage flows, and characteristics of the site. A scope of work should be discussed with the DEP soil scientist prior to conducting any field work. Conservative estimated loading rates should be used as a guide to determine the land area to be evaluated. Soil test pit descriptions, documenting the morphological characteristics of the soil profiles, should be completed for all soil test pits. Field notes should be taken to record site conditions during the site visit. Field notes should include, but are not limited to:

a. The date, time of day, and weather conditions;

b. The name of the describer (soil scientist);

c. The name(s) of DEP soil scientist and any other observer(s);

d. The Test Pit ID or other sample location identification;

e. The geographic location of the site including the physical address;

f. Observed landscape position, landform, and slope characteristics;

g. The plant cover or land use of the site;

h. Test pit and/or soil boring observations;

i. Parent material composition, source, and mode of deposition;

j. Inferred soil drainage class; and

k. Correlation of mapped soil series to field observations.

The location and direction of photographs used in the soils report (which is discussed further in Section 6.6 below) should be marked on a map and annotated in a photo log. The location and direction in which each photograph was taken can be indicated on the map with a symbol (e.g., < or ^) and numbered to correlate with the photo log in the soils report.

The locations of all soil test pits and any other observations should be marked in the field and included on the plot plan with a unique identifier. It is highly recommended that locations in the field are surveyed shortly after completing the field investigation. This survey documents information obtained in planning and design phases of the project. All test pits conducted on the site, regardless of suitability, need to be shown on the plot plans.

6.2. Test Pits

Hand auger borings and other less intrusive field screening methods are useful in developing a plan to determine the most appropriate locations for additional soil tests. Soil evaluations should be conducted by a professional soil scientist. A test pit (excavated trench) allows visual observation and physical evaluation of the soil horizons and overall soil conditions, both horizontally and vertically, in a given portion of the site. **No person should enter a test pit under unsafe conditions, which include but are not limited to: wet soil conditions; unconsolidated material; boulders; sinkholes; improperly benched, sloped or supported; and cracking or sluffing sidewalls. In addition, excavated material and the excavation machinery should be a safe distance from the sides of the excavation. Occupational Safety and Health Administration (OSHA) regulations should be followed.** The soil scientist should adhere to the following principals when excavating test pits:

a. A test pit should be a machine-excavated trench, 2.5 to 3.0 feet wide, excavated to a depth sufficient to describe the full soil profile or to a maximum depth of 84 inches.

b. The test pit should be benched at appropriate depths for access and as required for safe entry.

c. Additional benching may be done to facilitate hydraulic conductivity testing.

d. Low-impact machinery should be used for excavating test pits to prevent compaction of the soil and should avoid tracking across potential absorption areas.

e. Efforts should be made to separate the topsoil from the subsoil during excavation in preparation for backfilling.

f. Any organic material or organic horizon on top of the mineral soil should be noted but not included in the depth measurements.

g. Depth measurements should be described in inches below the ground surface. **The ground surface is defined as the top of the mineral soil.**

h. Limiting zone horizons should be measured from the ground surface to the shallowest depth of that horizon within the pit.

i. All other soil descriptions should follow the methods and nomenclature listed in the *Field Book for Describing and Sampling Soil*, published by NRCS's National Soil Survey Center.

j. At each test pit, the following conditions should be noted and described, if able to be observed:

1. For each soil horizon, describe in detail;

    i. Master and sub horizon designations;

    ii. Depth to upper and lower boundary;

    iii. Horizon boundary distinctness and topography;

    iv. Soil color (matrix and mottles);

    v. Soil texture;

    vi. Coarse fragments (type, size and percent);

    vii. Soil structure (grade, size and type);

    viii. Soil consistence (resistance to rupture); and

    ix. Redoximorphic features (type, abundance, size, and contrast).

2. Depth to seasonal high water table;

3. Depth to regional groundwater table;

4. Depth to bedrock and/or excessive coarse fragments with insufficient fines;

5. Observance of pores or roots (size, abundance, and depth);

6. Hydraulic conductivity limiting conditions (i.e., most restrictive horizon);

7. Slope and slope direction; and

8. Additional relevant comments or observations, such as seeps and manganese staining.

k. While evaluating the test pit, the professional soil scientist should note the depth to the horizon with the most restrictive hydraulic conductivity based on soil morphology. This information may be useful if the location is going to be used for additional testing.

l. Any other limiting zone conditions should be specified on the soil profile description.

m. The Soil Profile Description in Appendix B of this manual should be used for documentation of each test pit. Test pit data can be documented on any appropriate field soil profile description form provided it includes all the information on the attached form.

n. The soil profile description should document all observations made from an individual test pit location and its associated soil profile information, be numbered, and identified on a map.

o. It is important that the test pits provide detailed information related to soil conditions throughout the soil profile and at the proposed application depth within the land treatment absorption area.

p. At the soil scientist's discretion, soil samples may be collected from various horizons for additional analysis.

q. After completing the soil morphological descriptions, collecting soil samples, and performing any testing, the test pits should be backfilled.

    1. Backfill with the original soil, beginning with the subsoil, and completed with the original topsoil.

    2. If test pits are left open for further review or future testing, they should be secured with fencing or other means to prevent unauthorized or accidental entrance.

    3. Protect proposed absorption areas from equipment traffic during and after test pit evaluations. Consider using a physical barrier or some other visual markings around the absorption area.

    4. It is recommended that lightweight tracked equipment be utilized.

r. The field soil evaluation should confirm areas where soil conditions are suitable for renovation of the effluent as well as identify areas with unfavorable soil or site conditions. Locations that are not preferred for testing and land treatment include swales, the toe of slopes for most sites, convergent topography, and karst topography.

s. Throughout site evaluation and system construction, the designers, investigators, and contractors should pre-plan activities in a manner that minimizes site disturbance and avoids soil compaction so that a greater opportunity exists for testing and siting land treatment absorption areas. Disturbed areas may not be approved for absorption areas.

t. The test pits should be conducted immediately outside the perimeter of the proposed area identified in the preliminary assessment.

u. Use a sufficient number of test pits to confirm that suitable conditions exist for the selected effluent dispersal method. In cases where extremely large absorption areas are needed, it may be appropriate to substitute hand auger borings for confirmation within the proposed absorption area between test pit locations.

6.3. Hydraulic Conductivity Test

Hydraulic conductivity testing of soil in the proposed land treatment absorption area is necessary to determine site suitability. Hydraulic conductivity occurs as three-dimensional flow, but a measurement of the vertical flow is needed for system design. The vertical hydraulic conductivity rate is measured as hydraulic conductivity (K) in inches per hour (in/hr). It is important that the rate at which the effluent passes through the soil be fast enough to accept a reasonable application rate without causing anaerobic conditions, but slow enough for effluent renovation to take place. Although the rate at which water (and, thus, effluent) moves through unsaturated soil is faster than under saturated conditions, it is important that the design account for the rate of movement when the water reaches the saturated portion of the soil (or rock) interacting with the groundwater. The movement under saturated conditions is known as saturated hydraulic conductivity (K_{sat}). The thickness of the soil profile free of any limiting zone along with K_{sat} are the key components used to determine site suitability and for land treatment system design. The following items should be considered when evaluating the hydraulic conductivity:

a. The soil horizon most restrictive to hydraulic conductivity, as identified by the professional soil scientist, should be used for determining K_{sat}.

b. A sufficient number of tests should be conducted to characterize site conditions within the proposed absorption area and should occur within the most restrictive horizon.

c. The number of test(s) required will depend on the size of the absorption area and the variability of the soil.

d. The proposed plan of work (including the methodology for collecting the data and the test number/location/depth and data assessment) should be reviewed with the DEP soil scientist prior to conducting the testing.

e. Loading rates based on 10% of the geometric mean of K_{sat} results should be used to confirm the proposed loading rate.

f. Hydraulic conductivity tests should be conducted in the field; results from bench-top testing do not adequately represent field conditions.

g. Tests should not be conducted in the rain or within 24 hours of significant rainfall events (>0.5 inches), or when the temperature is below freezing.

h. Additional testing may be warranted if the results of the K_{sat} tests are substantially different.

i. Other testing methodologies and standards that are available but not discussed in detail in this manual include (but are not limited to):

   1. Constant head double-ring infiltrometer;

   2. ASTM 2003 Volume 4.08, Soil and Rock (I): Designation D 3385-03, Standard Test Method for Infiltration Rate of Soils in Field Using a Double-Ring Infiltrometer;

   3. ASTM 2002 Volume 4.09, Soil and Rock (II): Designation D 5093-90, Standard Test Method for Field Measurement of Infiltration Rate Using a Double-Ring Infiltrometer with a Sealed-Inner Ring;

   4. Guelph Permeameter;

   5. Constant Head Permeameter (Amoozemeter); and

   6. Falling Head Cased Borehole.

6.3.1. Methodology for Double-Ring Infiltrometer Field Test

A double-ring infiltrometer consists of two concentric metal rings. The outer ring helps to prevent divergent flow. The rings are driven into the ground and filled with water. The drop in water level in the inner ring is used to calculate a hydraulic conductivity rate. The hydraulic conductivity rate is determined as the amount of water per surface area and time unit that penetrates the soils.

6.3.2. Equipment for Double-Ring Infiltrometer Test

a. Two concentric cylindrical rings 6-inches or greater in height.

   1. The inner ring diameter should be 50% to 70% of the outer ring diameter, with a minimum inner ring diameter of 4 inches, preferably much larger. (Bouwer, 1986).

2. The use of a 12-inch diameter inner ring and 24-inch diameter outer ring is recommended.

3. Double-ring infiltrometer testing equipment that is designed specifically for that purpose should be used.

b. Water supply.

c. Stopwatch or timer.

d. Ruler or metal measuring tape.

e. Flat wooden board for driving cylinders uniformly into soil.

f. Mallet.

g. Log sheets for recording data.

6.3.3. Procedure for Double-Ring Infiltrometer Test

a. Prepare level testing area.

b. Install rings as follows:

1. Place outer ring in place.

2. Place flat board on outer ring.

3. Drive outer ring into soil to a minimum depth of two inches.

4. Place inner ring in center of outer ring.

5. Place flat board on inner ring.

6. Drive inner ring into soil a minimum of two inches.

7. The bottom rim of both rings should be at the same level.

c. Presoak the test area immediately prior to testing.

1. Fill both rings with water to the water level indicator mark or the rim at 30-minute intervals for 1 hour.

2. The minimum water depth should be 4 inches.

3. The drop in the water level during the last 30 minutes of the pre-soaking period should be applied to the following standard to determine the time interval between readings:

   i. If water level drop is 2 inches or more, use 10-minute measurement intervals.

   ii. If water level drop is less than 2 inches, use 30-minute measurement intervals.

d. Obtain a reading of the drop in water level in the inner ring at appropriate time intervals.

e. After each reading, refill both rings to water level indicator mark or rim.

f. Measurement of the water level in the center ring should be made from a fixed reference point and should continue at the appropriate time interval until a minimum of eight readings are completed or until a stabilized rate of drop is obtained, whichever occurs first. A stabilized rate of drop means a difference of 0.25 inches or less of drop between the highest and lowest readings of four consecutive readings.

g. The drop that occurs in the center ring during the final period or the average stabilized rate, expressed as inches per hour, represents the hydraulic conductivity rate for that test location.

h. The hydraulic conductivity rate should be used to calculate the field saturated hydraulic conductivity using the equation specified in SSSA's *Methods of Soil Analysis: Part 4, Physical Methods* (2002).

6.4. Percoloation Testing

Soil percolation testing within the proposed land treatment absorption area is required for projects proposing a large volume onlot system design with in-ground seepage bed or trench systems, subsurface sand filters, elevated sand mounds, and at-grade beds. Percolation tests shall be conducted in accordance with procedures described in 25 Pa. Code § 73.15, except as noted below. The number of test holes is determined by the DEP regional soil scientist. A pre-percolation test plot plan should be submitted to DEP for review prior to conducting the test. The DEP regional soil scientist will make determinations on percolation tests with one-third or more dry holes at the end of a 10-minute testing interval (25 Pa. Code § 73.15(7)(iv)). Scheduling multiple days for testing may be necessary due to the increased number of percolation testing holes or to test multiple absorption areas. Tests should be scheduled to allow for DEP observation of all test measurements, including the final pre-soak. Field data for percolation tests should include the following:

a. A map of the testing site showing the location of each numbered test hole, the slope direction, and a north arrow;

b. Depth of each test hole (25 Pa. Code §§ 73.15(1)(i-iii));

c. Start time of final pre-soak for each test hole;

d. Measurement time interval assigned to each test hole (25 Pa. Code §§ 73.15(6)(i-ii)); and

e. All timed measurements of drop in water for each test hole (25 Pa. Code §§ 73.15(7)(i-iv)).

Percolation test data should be recorded using the relevant sections of DEP's form *Site Investigation and Percolation Test Report for Onlot Disposal of Sewage* (3850-FM-BCW0290A).

The drop that occurs in each hole during the final interval of the percolation test, expressed as minutes per inch, is used to calculate the arithmetic average percolation rate. The square footage required for the absorption area design is based on project flows and the average percolation rate from the test holes located within the proposed absorption area and is calculated by the method codified at 25 Pa. Code § 73.16, Table A. For projects proposing multiple beds or trenches, applicants should consider and discuss with DEP how the test hole data should be used to calculate the percolation rate prior to submission of the design. Large volume onlot systems should utilize pressure dosing to maximize even distribution of effluent on the absorption area. One-third absorption area size reductions should be discussed with DEP prior to submission of a permit application.

Soil hydraulic conductivity tests should also be conducted within the proposed large volume onlot system absorption area. Hydraulic conductivity testing is discussed in Section 6.3 of this manual. Ultimately, the soil loading rate and absorption area size used for a large volume onlot system design should be based on the most conservative value derived from the percolation tests and the hydraulic conductivity tests.

6.5. Laboratory Analyses

Chemical and biological characteristics of the soil are important factors controlling the level of effluent treatment. However, some effluents may contain one or more chemicals that are significantly elevated in concentration relative to the other chemicals.

It is important that the effect of this potential chemical imbalance be evaluated with respect to the selected pretreatment options, the chemical affinities of the proposed vegetation, the total land area available, and the ability of the soil to renovate or remove the parameters of concern.

The soil chemical characteristics that may need to be considered include:

a. Soil pH/buffering capacity;

b. Cation exchange capacity (CEC);

c. Presence or absence of organic matter, and the soil carbon to nitrogen ratio;

d. Base saturation; and

e. Background metal concentrations in the soil.

Using these soil factors and the characteristics of the effluent to be applied, the soil scientist can assess whether a proposed land treatment system will function properly on a specific site.

For sites where established vegetation is critical to effluent renovation, nutrient uptake, and/or site stabilization, standard agronomic/soil fertility testing should be conducted as part of the site evaluation. Deficiencies identified should be corrected prior to use.

6.6. Analysis of Results/Soils Report

The professional soil scientist should prepare a report of the sites investigated, detailing all the observations and interpretations of data. The soil chemistry test results, such as the sodium adsorption ratio, should be used in conjunction with the wastewater characteristics, such as salinity, metals and fats/oils/grease concentrations, BOD, and pH, to determine whether the land treatment of the wastewater would cause adverse conditions at the site (e.g., soil clogging, leaching of soil constituents to the groundwater, groundwater mounding, plant toxicity). Based on the site and soil evaluations, a land treatment system should be proposed and explained. The report should provide an explanation of the proposed wastewater pretreatment, resulting effluent characteristics, application rates, and application method in relation to the absorption area's ability to perform final renovation and hydrologic acceptance of the effluent. Calculations used to determine application rates using measured K_{sat}, soil morphology, percolation test results, nutrient loading, organic loading, and loading of any other constituent of concern, should be included and considered in the system design. Final design should be based on the most limiting application rate. The report should include decisions supporting vegetative cover selection, a vegetation management plan, and site monitoring and maintenance plan. The report should also include maps of the sites at a scale sufficiently large to allow for 1-foot contours and include the soil series as mapped by the NRCS.

7. HYDROGEOLOGIC FIELD INVESTIGATION

7.1. General

The goal of the hydrogeologic investigation is to assess the impact of the land treatment system's infiltrate upon the underlying groundwater. Impacts will be physical in the form of a groundwater mound. Impacts may be chemical or biological and may manifest as a plume. Prior to embarking upon the hydrogeologic investigation, the consulting professional should contact the appropriate DEP Regional Office to discuss what is necessary for the hydrogeologic investigation. Pennsylvania has geology which varies widely in composition and structure, resulting in a highly varied hydrogeologic framework, which may require different approaches to accurately assess.

All land treatment systems will create a groundwater mound. This results from the addition of treated effluent to the groundwater in addition to the normal infiltration from rainfall within the bounds of the project. The amount of mounding will depend upon the receiving aquifer's physical characteristics such as its saturated horizontal hydraulic conductivity and its transmissivity. In no circumstance should a groundwater mound rise to within four feet of the original ground surface anywhere under the site. Depending upon the aquifer's material, a capillary fringe above the water table of a groundwater mound may interfere with soil treatment of effluent and continued infiltration. The hydrogeologic investigation may indicate the risk of a groundwater mound with can limit the application rate at the site.

Depending upon the wastewater type, and despite soil treatment, many land treatment sites will produce a contaminant plume. The hydrogeologic investigation will estimate the degree of contamination as well as predict the movement of the contaminant plume. The hydrogeologic investigation is used to prevent the contamination of any existing or potential groundwater supply wells.

The hydrogeologic investigation should determine the following factors:

a. Depth to all perched and regional water tables;

b. Fluctuations of the depth to groundwater under the absorption area;

c. Groundwater flow direction and gradient;

d. Aquifer thickness;

e. Aquifer hydraulic conductivity (K_{sat});

f. Aquifer transmissivity (T); and

g. Specific yield (Y_s).

Planning documents should include a water table or piezometric surface elevation map of the aquifer which will eventually receive the infiltrate from the land treatment site. In some situations, a number of aquifers of differing compositions may require assessment. In addition to characterizing the aquifer, results from the fieldwork should yield data sufficient to draft groundwater contour maps illustrating depth to groundwater across the site, flow direction, and gradient. Care should be taken to analyze the shallowest water table. Wells screened in confined aquifers may skew the data used to represent the piezometric surface of the water table.

Attempts should be made to devise a water budget combining weather data with the field test data. Inputs from precipitation events can cause significant changes in the level of the groundwater below the surface of the proposed absorption area under certain conditions. Using computer modeling to simulate groundwater mounding in and around the absorption area will be critical in the overall evaluation of the site suitability for land treatment systems.

Aquifer characteristics should be determined by a pump test with one or more observation test wells. The test should be of sufficient duration to obtain a transmissivity and hydraulic conductivity. In lieu of a pump test, slug tests done in a statistically sufficient number of wells may be done in order to obtain the hydraulic conductivity of the aquifer.

The licensed geologist should discuss the project with DEP's hydrogeologist to determine what work and level of exploration will be necessary for completion of the study.

7.2. Aquifer Testing

7.2.1. Test Well Construction

Properly installed and functional test wells and observation wells are necessary for a successful aquifer test and for obtaining appropriate water quality samples of the groundwater beneath the proposed land treatment site. Detailed well logs should be developed and should describe the materials bored, the location and estimated yields of water bearing zones, and well construction details. The logs should be recorded by professionals directly overseeing the installation of the test and observation wells. Both test and observation wells should be developed to provide sediment free samples and optimum well bore efficiency. Well development methodologies are outlined in Chapter 2 of DEP's *Groundwater Monitoring Guidance Manual* (383-3000-001).

7.2.2. Pump Test

A pump test of suitable duration of at least 8 hours will provide the hydraulic conductivity, transmissivity, and storage coefficient of the aquifer. These factors are used by the hydrogeologist to determine how far upward the groundwater will mound under the land treatment system. The DEP hydrogeologist may allow a shorter test.

7.3. Analysis of Results

7.3.1. Groundwater Mounding

Once the land treatment area is estimated from application rates determined by the soil hydraulic and crop nutrient information, the hydrogeologist should complete a groundwater mounding analysis. The mounding analysis should examine the potential future height of the mound after 10 years of continual use. This assessment is necessary to make sure that the groundwater aquifer can transmit the effluent/groundwater mix laterally from beneath the application site without backing up to within 4 feet of the original soil surface. A groundwater mound that rises closer than 4 feet of the original ground surface can alone, or with its associated capillary fringe, interfere with any natural treatment processes in the soil horizons. It may also interfere with the soil's ability to accept the discharged effluent. If the groundwater mound is projected to rise to within 4 feet of the surface, a larger application area may be needed. Also, a site with a different length-to-width orientation may permit application of wastewater. If the mound remains at least 4 feet below the original ground surface, groundwater mounding is not an adverse factor.

Groundwater modeling methods include both numerical and analytical methods. Prior to embarking upon the assessment, the hydrogeologist should thoroughly document the analysis method they will use. Consultation with the DEP hydrogeologist is useful.

The applicant also should address the interference of groundwater mounds from multiple absorption fields. In addition, groundwater mounding assessment areas often assume a completely flat water table. The consultant should address how the existing groundwater gradient may interplay with the growth of the real groundwater mound. These problems are most acute where the application area is large or the topography is converging and/or variable.

The applicant will need to address these issues in the hydrogeologic report submitted to support the system design. This is best accomplished using a site plan that provides 1- or 2-foot topographic contours, groundwater contours, and elevation measurements, and predicted groundwater elevations after full mound development. To insure proper system operation, the groundwater mound cannot rise to within 4 feet of the required depth of unsaturated soil needed to renovate the effluent.

7.3.2. Dispersion Plume

The licensed professional geologist should conduct a dispersion plume analysis for any chemical parameters that are not adequately removed by pretreatment, crop uptake, or the soil. For example, because nitrate-nitrogen (NO_3N) from domestic wastewater is not removed by a large volume onlot system, the applicant should estimate its concentration at the property line. Spray irrigation systems that are designed to deliver nitrate-nitrogen to the groundwater at or below 10 mg/L make a dispersion plume analysis unnecessary.

System design and analysis should ensure all wastewater contaminants with a maximum contaminant level (MCL) under Pennsylvania's safe drinking water regulations at 25 Pa. Code Chapter 109 are at concentrations less than the MCL when they leave the property.

A dispersion plume analysis may not be necessary for systems that meet 10 mg/L total nitrogen through pretreatment.

The licensed professional geologist should estimate the extent and shape of the dispersion plume above any drinking water MCL. This should be estimated for both normal precipitation and drought years. The proposal should demonstrate that acceptable normal precipitation and drought year data was used for the analysis.

The following information is needed to complete the dispersion plume analysis:

a. Direction of groundwater flow;

b. Location of potential groundwater divides;

c. Site-specific background groundwater quality data for parameters of concern;

d. Area within the project site boundaries;

e. Locations of existing or potential water supplies on the project site, surrounding properties, and within the projected dispersion plume; and

f. Recharge rate.

In estimating the plume, only the recharge infiltrating the area of the land treatment absorption area and the plume itself should be used to estimate recharge. Vertical mixing within the aquifer cannot be considered in the dispersion plume analysis, since such mixing is slow within the aquifer. Another issue with the use of upgradient recharge is that a facility or permittee has no direct control over the land uses or activities on up gradient areas. Constituents of industrial wastewater may need to be modeled differently depending upon wastewater characteristics and soil treatment efficiencies.

To obtain approval for a land treatment system, an applicant should be able to demonstrate that the contaminant plume will not adversely impact groundwater or compromise the existing and/or designated uses of receiving surface waters. Where a hydrogeologic investigation has shown that a contaminant plume will exit the site or adversely impact existing or potential groundwater supplies, the applicant should either provide for mitigation that may include pretreatment and/or lower hydraulic loading rates, or the applicant should obtain control of groundwater use inside the area of the plume through a groundwater easement.

If additional pretreatment is proposed to remove nitrogen from the effluent, the applicant should indicate what technology is expected to be used, document it as an accepted nitrogen removal technology, and provide an operation, maintenance, and monitoring plan. Experimental systems will need to have a non-experimental backup system.

7.4. Hydrogeologic Report

The professional geologist should prepare a signed and sealed report of the site(s) investigated. It should also include the methodology and results of the aquifer test(s).

The geochemistry test results should be used in conjunction with the wastewater characteristics to determine whether the land treatment of the wastewater would cause contamination of the groundwater. The degree of contamination should also be addressed. The potential of contaminants migrating off the site and site property should be addressed.

The report should include surface contour maps, groundwater elevation contour maps, a groundwater mound elevation contour map indicating the post-application groundwater mound elevation, and a map of the anticipated dispersion plume of any contaminants.

The report should make recommendations as to the allowable land treatment rate for each site.

Refer to Appendix D of this manual for the contents of a hydrogeologic report.

8. OWNERSHIP, OPERATION AND MAINTENANCE

8.1. Ownership

Ownership should be addressed during sewage facilities planning for domestic sewage projects as described in Chapter 4 of this manual. A new land treatment system should not be installed without an approved site evaluation and a determination made of whether there are any easements or deed restrictions that prohibit the complete and continual land treatment of effluent on the property. In most cases, the land on which the treatment system and storage facilities are located is owned by the permittee. In these cases, there should be a covenant in the deed providing for land treatment in perpetuity, as long as the land is needed for treatment. In those situations where the treatment area and storage cells are on property not owned by the permittee, the permittee should either secure a long-term lease or acquire long-term development rights and perpetual rights for the amount of land required. Changes in ownership/operation may require the transfer of the WQM permit.

8.2. Operation and Maintenance

8.2.1. General

This chapter provides general operation and maintenance guidelines that are applicable to all systems. Additional system-specific operation and maintenance guidelines are addressed in chapters related to the specific system. Many of these items will be included in WQM permits as special conditions.

Operation and maintenance, and municipal oversight thereof, must be addressed during sewage facilities planning for domestic sewage projects as described in Chapter 4 of this manual. The standards that must be met for municipal oversight are described in the sewage planning regulations at 25 Pa. Code § 71.72. Note that § 71.72 gives the responsibility for selection of oversight alternatives to the municipality. Additionally, some municipalities may have local ordinances governing operation and maintenance of DEP-permitted systems. It is important to work with the local officials on developing an operation and maintenance plan that conforms with local requirements.

Surface water should be diverted away from the land treatment area. Upslope surface water diversion structures should be inspected and maintained on a monthly basis. The structures should be maintained to prevent surface water run-on during the design storm. Routine inspections should also be made of the absorption area. The owner should check for evidence of soil erosion, wet areas and signs of an improperly functioning system (e.g., leaks, line breaks, exposed drip tubes, clogged or broken sprinkler heads).

Repairs or replacement of any malfunctioning equipment or component of the treatment system should be made as soon as practical following discovery.

Documentation of inspections and repairs completed should be recorded on daily logs maintained at the facility.

8.2.2. Pretreatment

In order to maintain desired effluent quality, the pretreatment system should be operated in accordance with the procedures contained in the operation and maintenance manual and permit requirements.

8.2.3. Storage structures and storage capacity management

Storage structures should be inspected monthly for structural integrity. Any storage structure found to be leaking should be immediately removed from use. Storage volume calculations should be made daily, including volumes of inflow and outflow, and should be compared with actual water surface levels to ensure adequate storage capacity is available during peak storage months. Storage volumes should be projected for a 12-month period to ensure that the storage volume required does not exceed the capacity of the storage structure.

8.2.4. Pumps

Pumps require periodic maintenance for wear and lubrication. Procedures and frequencies contained in the manufacturer's operation and maintenance manual should be followed. Motors should be monitored for power draw. Increasing power draws may indicate excessive wear or damage and should be investigated.

8.2.5. Flow Meters

All land treatment systems should have both influent and effluent flow meters. Influent flow meters should be located at the head of the treatment works. Pump station flows to the treatment facility or water use records should not be used as substitutes for influent flow meters. Effluent flow meters should provide information on the quantity of wastewater sent to each land treatment zone per dose and per day. This information should be readily accessible to the operator and recorded each day land treatment occurs. Flow meters should be calibrated in accordance with the manufacturer's recommendations. Sewage facilities with flows exceeding 100,000 gallons per day should have flow meters calibrated at least annually. Systems required to submit annual wasteload management reports under 25 Pa. Code Chapter 94 should submit the calibration certificate(s) with the *Wasteload Management Annual Report* (3800-FM-BPNPSM0507). Systems not required to submit annual wasteload management reports under Chapter 94 should submit calibration certificates as required in the permit. Flow meters should be replaced when they can no longer be successfully calibrated or are otherwise malfunctioning.

8.2.6. Vegetation Management

All land treatment systems should have vegetative cover. No roads, structures, or stockpiling of materials should be located over the land treatment area.

Vegetation management is dependent on the type of land treatment being used. Specific information is included in the design sections of this manual for each type of system. Recommendations in those sections should be followed.

Plans should be reviewed annually and updated as needed. Written approval from DEP should be obtained as a permit condition for any land use and/or vegetation changes.

9. PROCESS DESIGN – PUMPING AND CONVEYANCE

9.1. General

A pressurized distribution system consisting of a pump(s), delivery line(s), and a system of manifolds and laterals should be used to convey treated wastewater (effluent) from the treatment or storage facility to the land treatment area. Specific dosing pump design requirements for each type of land treatment system are provided in related chapters of this manual. Distribution pumping of effluent can involve either a "standalone" structure or structure built into a treatment/storage unit. Pumps used to convey treated wastewater from the treatment facility to storage facilities are referred to as effluent pumps and associated effluent return lines. The design basis for these is case-specific.

9.2. Dosing Pumps and Pumping Stations

Except as noted below, the design of pumping stations should be consistent with Chapter 30 of DEP's *Domestic Wastewater Facilities Manual* (362-0300-001). The pumps should have a capacity equal to the maximum daily flow divided by the number of hours of operation per day. Pumping capacity should be maintained with at least one pump out of service. Pumps should be selected with head-capacity characteristics that correspond as nearly as possible to the flow and head requirements of the overall system. Minimum head requirements at the terminal end of the land treatment system also need to be taken into consideration to ensure proper functioning. Flow metering is necessary to document both the actual treatment flow rates and actual application rates to ensure compliance with permitted application rates. The basis of the pump design is the total dynamic head (static plus friction) and the peak flow requirements. Flow requirements are determined based on the hours of operation per day or per week and the system capacity (see chapters on system-specific design).

9.3. Delivery Lines

Except as noted below, design of effluent delivery force mains to the land treatment system should be in accordance with Chapter 38 of DEP's *Domestic Wastewater Facilities Manual* (362-0300-001). The considerations in effluent delivery force main design are velocity and friction loss. Velocities should be in the range of 3 to 5 feet per second (ft/s) to keep any solids in suspension without developing excessive friction losses.

10. PROCESS DESIGN – SPRAY IRRIGATION

10.1. General

The information presented in this section is based on the United States Environmental Protection Agency's (EPA) *Process Design Manual – Land Treatment of Municipal Wastewater* (EPA/625/R-06/016) and historical experience with the design, permitting, and operation of these systems within Pennsylvania.

The spray irrigation system is a slow rate application system that involves dispersal of pretreated sewage or industrial wastewater to the land surface at seasonal peak rates up to 2.5 inches per acre per week for percolation and renovation within the soil mantle.

Spray irrigation systems with lagoon storage have been successfully utilized in Pennsylvania for several decades. These systems are a viable option for well-drained soils or a mix of well-drained and moderately well-drained soils. However, these systems are not well suited for use in colder climates or on poorly drained soils due to the expense of increased land and storage area requirements. Recent variations in climate have presented challenges to spray irrigation water budgets and lagoon levels. At the time of this manual's publication, insufficient long-term information exists to evaluate climate trends. Therefore, DEP advises that designers of these systems consider including additional land treatment spray irrigation areas, increasing storage capacity, or including a contingency option for disposing of effluent during a critical storage lagoon level.

The spray irrigation plan should indicate how these systems should be operated. For example, effluent meters and programmable logic controllers (PLCs) are recommended since permits require monthly reporting of quantities sent to each spray irrigation zone. Using pump rate and pump run time to determine the quantity of effluent out to a treatment zone is not sufficiently accurate. Also, DEP permits provide weekly application rates per irrigation zone. Therefore, the weekly rates proposed, considering the irrigation zone operating capacity in gallons per minute, should allow adequate time between irrigation cycles for soil re-aeration and should also consider rain days. For example, irrigation rates that require 40 hours to apply the weekly volume are not realistic.

Slopes in the range of 0 – 25% may be considered for spray irrigation systems (see Table 10-1). Spray fields with isolated areas exceeding 25% slope may be allowed based on site-specific conditions and should be discussed with DEP on a case-by-case basis. However, surface runoff of applied wastewater is not permitted. Vegetation is a critical component of any spray irrigation system for managing nutrients, hydraulics, slope stability, and erosion potential.

Table 10-1. Potential for surface application (adapted from EPA/625/R-06/016).

Percent Slope	Hay or Permanent Grass	Forest Land
0 – 12%	HIGH	HIGH
12 – 20%	MODERATE	HIGH
20 – 25%	LOW	MODERATE

In the development of spray irrigation loading rates, it may be necessary to calculate a Total Oxygen Demand (TOD) to ensure adequate time is allowed between application cycles for soil reaeration. See EPA's *Process Design Manual – Land Treatment of Municipal Wastewater Effluents (*EPA/625/R-06/016) for additional information.

10.2. Pretreatment

Spray irrigation systems generally utilize lagoons for pretreatment and/or storage. Designers of lagoons should review EPA's *Principles of Design and Operations of Wastewater Treatment Pond Systems for Plant Operators, Engineers, and Managers* (EPA/600/R-11/088).

The design engineer's report should include information on the anticipated influent and effluent characteristics and should include all design calculations. The report should include design information to obtain a treatment that is equal to at least secondary treatment for domestic wastewater, unless deemed inadequate to ensure protection of groundwater quality. The secondary treatment standard for domestic wastewater is:

Parameter	Unit	Minimum	Monthly Average	Weekly Average	Instantaneous Maximum
5-day CBOD*	mg/L	---	25[1]	40	50
TSS	mg/L	---	30[1]	45	60
Fecal coliform	No/100 mL	---	200[2]	---	1,000
pH	S.U.	6.0			9.0

[1] based on 30-day average concentration
[2] based on 30-day geometric mean concentration, to be met at the spray head

Best available treatment of industrial wastewaters will produce an effluent acceptable for spray irrigation, if the concentration of toxic pollutants is below the relevant human health criteria in 25 Pa. Code Chapter 93 or drinking water MCLs in 25 Pa. Code Chapter 109, or if their attenuation or degradation through the soil will result in acceptable concentrations in the groundwater.

10.3. Calculation of Design Loading Rates

10.3.1. General

a. A limiting design parameter (LDP) analysis will determine the most limiting factor for developing irrigation loading rates.

1. Typically, for domestic wastewater, soil hydraulic conductivity or nitrogen loading will be the LDP. However, creation of an excessive groundwater mound may limit application rates.

2. For industrial wastewater, additional parameters may need to be included in the LDP analysis. These include but are not limited to BOD, fats, oils, and grease, metals, and total dissolved solids (TDS).

3. The parameter requiring the largest treatment area is used to design the system.

b. Although these calculations are done on a monthly basis, spray irrigation rates expressed on a weekly basis are the most effective in the operation of these systems.

1. Weekly rates should be proposed based on the most limiting of the design parameter calculations.

2. DEP regional offices may offer standard weekly hydraulic loading rates that can be used for domestic wastewater facility projects. The loading rates presented in this manual are based on DEP's extensive experience with these types of facilities in DEP's southeastern region and are provided as an example. Applicants may follow the standard loading rate approach or EPA procedures. Both options are presented concurrently in the following sections of this manual.

c. Calculations for design loading rates are also included in the planning documents (for sewage) and/or permitting documents (for industrial waste) submitted to DEP for spray irrigation systems.

10.3.2. Calculation of Design Hydraulic Loading Rate Based on Hydraulic Conductivity

a. In regions where data exist, regional DEP standard hydraulic loading rates may be utilized in lieu of the calculation of design hydraulic loading rates steps presented in this section. Standard rates are to be compared to the overall saturated vertical hydraulic conductivity (K_{sat}) as determined by any tests conducted using the soil evaluation method recommended in Section 6.3 of this manual. The comparison's most conservative loading rate for each month should be used. Examples of DEP's southeastern region standard loading rates for two soil drainage classes are provided in Appendix G of this manual. These example rates are specific to that region and do not apply across Pennsylvania.

b. Hydraulic loading rates are based on a water balance that includes precipitation, evapotranspiration, and soil hydraulic conductivity.

c. The total monthly loading should be distributed uniformly, taking into consideration planting, harvesting, drying, and other periods of time where no application is occurring.

d. The following procedure should be used to determine hydraulic loading rates:

1. Determine the design precipitation for each month based on a 10-year return frequency analysis for monthly precipitation.

2. Estimate the evapotranspiration rates (E_t) of the selected crop for each month.

3. Determine the overall saturated vertical hydraulic conductivity (K_{sat}) of the site for tests conducted using the soil evaluation in Section 6.3 of this manual.

4. Establish a maximum daily design application (W_p) using a percentage of the minimum saturated vertical hydraulic conductivity from Section 6.3 of this manual (usually 10% unless advanced treatment is provided).

5. Calculate the monthly hydraulic loading rate using the following equation:

$$L_w = E_t - P + W_p$$

where:
L_w = wastewater hydraulic loading rate, inches per month
P = design precipitation, inches per month
E_t = crop evapotranspiration rate, inches per month
W_p = percolating water, inches per month

6. Calculate the loading rates for each month with adjustments for those months having periods of reduced or no application. Periods of reduced or no application may be due to wet weather, cold weather, or frozen soil.

10.3.3. Calculation of Design Hydraulic Loading Rate Based on Nitrogen

The following procedure should be used in all projects to determine wastewater loading rates when nitrogen concentration in the groundwater is a concern:

a. Calculate the allowable hydraulic loading rate based on nitrogen limits on a monthly basis and monthly design flow information using the following equation:

$$L_n = \frac{(C_p)(P_r - E_t) + (U)(4.413)}{[(1-f)(C_n) - C_p]}$$

where:

L_n = wastewater hydraulic loading rate, in/month
C_p = nitrogen concentration in percolating water, mg/L
P_r = precipitation rate, in/month
E_t = evapotranspiration rate, in/month
U = crop nitrogen uptake, lb/month
C_n = total nitrogen concentration in applied wastewater, mg/L
f = fraction of total applied nitrogen removed by denitrification and volatilization

It should be noted that the above equation is for sewage only. Nitrogen loading for industrial wastes should be determined for each specific proposal.

b. Sources should be cited for information used (e.g., Penn State Agronomy Guide for crop nitrogen uptake, effluent samples for nitrogen concentration in applied wastewater).

c. Design values for crop nitrogen uptake (U) will depend on actual crop yields and growing seasons. The Penn State Agronomy guide and/or Penn State AASL fertility recommendations should be referenced. No uptake is expected in the non-growing season.

d. Denitrification and volatilization are difficult to determine under field conditions, but general assumptions of 3% of the total applied nitrogen lost to volatilization and 15% loss to denitrification have been accepted for spray irrigation systems in Pennsylvania. Note that these ranges are applicable only for domestic-type wastewaters with a carbon-to-nitrogen ratio similar to effluent treated to a secondary treatment standard. Advanced treated effluent and industrial wastewaters may have different percentages for f in the hydraulic loading rate equation above.

e. The nitrogen concentration in percolating water factor (C_p) in the equation may be set to 10 mg/L, which corresponds to the drinking water standard for nitrate concentration.

10.3.4. Spray Irrigation Loading Rate Determination

a. Nitrogen wastewater loading rates from Section 10.3.3 of this manual should be compared to the hydraulic loading rates determined in Section 10.3.2 of this manual on a monthly basis.

b. The lowest estimate should be used to conduct a groundwater mounding assessment for the groundwater underlying site (see Chapter 7 of this manual).

   1. If the lowest estimate does not result in growth of an adverse groundwater mound, then:

      i. The lowest of the values should be used for that month as the design hydraulic loading rate.

      ii. The sum of the lowest monthly values can then be used as the annual design hydraulic loading rate (gallons per acre per year).

   2. If the lowest estimate does result in the creation of an adverse groundwater mound, application rates need further adjustment downward until the resulting groundwater mound is not adverse.

10.3.5. Spray Irrigation Minimum Area Determination

a. Design monthly hydraulic loading rates determined according to Section 10.3.4 of this manual should be used to establish the spray irrigation area required to dispose of project flows.

b. The project engineer's report should present all calculations and evaluations resulting in development of loading rates and area required.

c. Design weekly hydraulic loading rates for each month should be provided as inches per acre per week and gallons per acre per week. If accepted, DEP will use these weekly rates for permit issuance.

10.4. Storage Provisions

a. The following procedure should be used to determine the minimum storage for all land treatment systems that distribute effluent onto the ground surface.

b. Local climatic records, as well as nationally available climatic data (e.g., monthly precipitation and evaporation rates, and minimum monthly temperatures) should be evaluated and presented to determine minimum storage volume.

c. It is critical that all storage water balance calculations and storage capacity determinations include precipitation into the proposed storage structure.

d. Storage will vary for seasonal and year-round operations.

1. Seasonal operations that will not generate effluents during the cold season need to calculate the minimum storage volume that also accounts for wet weather and maintenance time.

2. In addition to considerations discussed in Section 10.4.c. above, year-round operations should determine needed storage based on freezing temperatures, precipitation, evaporation, and vegetation maintenance.

e. DEP regional standard loading rates provide values for the minimum days of storage required per month; see Appendix G of this manual.

f. EPA provides a two-step method of determining the storage volume that will be appropriate:

1. Step 1 – Initial Estimation of Storage Volume (Water Balance Calculations) – An initial estimate of the storage volume may be determined using a water balance calculation procedure, as described below:

i. Determine the design monthly hydraulic loading rate.

ii. Convert the actual volume of wastewater available each month to units of depth (in) using the following relationship:

$$W_a = \frac{Q_m}{A_w}\left(\frac{1\ ft^3}{7.48\ gal}\right)\left(\frac{1\ acre}{43{,}560\ ft^2}\right)\left(\frac{12\ in}{ft}\right) = \frac{Q_m}{27{,}152.4 \bullet A_w}$$

where:
W_a = depth of available wastewater, in
Q_m = volume of available wastewater for the month, gallons
A_w = field area, acres

iii. Formulate a water balance table listing the results for each month. In some instances, influent wastewater flow varies significantly with the time of year. The values used for Q_m should reflect monthly flow variation based on historical records.

iv. Compute the net change in storage each month by subtracting the monthly hydraulic loading from the available wastewater in the same month.

v. Compute the cumulative storage at the end of each month by adding the change in storage during one month to the accumulated quantity form the previous month. The computation should begin with the reservoir at a low water level at the end of the fall season.

vi. Compute the storage volume using the maximum cumulative storage and the spray field. An illustration of this process is provided in Appendix E of this manual.

2. Step 2 – Final Design of Storage Volume Calculations

i. The estimated storage volume obtained by the water balance calculation (Step 1) or computer programs is adjusted to account for net gain or loss in volume due to precipitation or evaporation.

ii. The storage volume should be determined by conducting a monthly water balance, which includes the inflow, amount land applied, precipitation, and evaporation. This method may require an iterative solution with some assumed initial conditions because the pond area is not known. It is usually convenient to assume a depth for the initial calculation.

iii. The overall storage volume is then increased to include a minimum freeboard at maximum water level, as follows:

Design Flow, gpd	Minimum Freeboard
≤ 50,000 gpd	2 ft
>50,000 gpd	3 ft

iv. Conditions:

a. Monthly evaporation (ET) and precipitation (P_r) data are necessary.

b. Seepage from a properly constructed pond is negligible.

c. Initial conditions and estimated storage volume from Example E-1 in Appendix E of this manual.

Calculations:

1. Using the initial estimated storage volume calculated in Step 1, and using an assumed storage pond depth compatible with local conditions and DEP's *Domestic Wastewater Facilities Manual*

(362-0300-001), calculate a required surface area for the storage pond:

$$A_s = \frac{V_s(est)}{d_s}$$

where:

A_s = area of storage pond, ft^2

$V_s(est)$ = estimated storage volume, ft^3

d_s = assumed pond depth, ft

2. Calculate the monthly net volume of water gained or lost from storage due to precipitation, evaporation, and seepage:

$$\Delta V_s = (P_r - E - S)(A_s)\left(\frac{1\,ft}{12\,in}\right)$$

where:

ΔV_s = net gain or loss of storage volume, ft^3

P_r = monthly precipitation, in

E = monthly evaporation, in

S = monthly seepage, in

A_s = storage pond area, ft^2

3. Estimated lake evaporation in the local area should be used for E, if available. Lake evaporation data is given in Appendix F of this manual. Potential ET values may be used if no other data are available. Tabulate monthly values and sum to determine the net annual ΔV_s. Results are tabulated in Column (3) of Table E-2 in Appendix E of this manual.

4. Tabulate the volume of wastewater available each month (Q_m), given in Example E-1 in Appendix E of this manual.

5. Calculate an adjusted field area to account for annual net gain/loss in storage volume.

$$A'_w = \frac{\sum \Delta V_s + \sum Q_m}{(L_w)\left(43{,}560\,\frac{ft^2}{acre}\right)}$$

where:

A'_w = adjusted field area, acres

$\Sigma\Delta V_s$ = annual net storage gain/loss, ft^3

ΣQ_m = annual available wastewater, ft^3

L_w = design annual hydraulic loading rate, in

Note: For this example, the final design calculation reduced the field area necessary for land treatment because potential ET was greater than annual P_r. For sites in Pennsylvania, annual P_r will exceed potential ET; therefore, a larger storage area and perhaps a larger application area will be needed.

6. Calculate the monthly volume of applied wastewater using the design monthly hydraulic loading rate and adjusted field area:

$$V_w = \frac{(L_w)}{12}(A_w)\left(43{,}560\,\frac{ft^2}{acre}\right)$$

where:

V_w = monthly volume of applied wastewater, ft^3
L_w = design annual hydraulic loading rate, in
A_w = adjusted field area, acres

7. Calculate the net change in storage each month by subtracting the monthly applied wastewater (V_w) from the sum of available wastewater (Q_m) and net storage gain/loss (ΔV_s) in the same month. Results are tabulated in Column (6) of Table F-2 in Appendix F of this manual.

8. Calculate the cumulative storage volume at the end of each month by adding the change in storage during one month to the accumulated total from the previous month. The maximum monthly cumulative volume is the storage volume used for design. Results are tabulated in column (7) of Table F-2 in Appendix F of this manual.

9. Adjust the assumed value of storage pond depth (d_s) to yield the design storage volume using this equation:

$$d_s = \frac{V_s}{A_s}$$

The design depth should be in accordance with DEP's *Domestic Wastewater Facilities Manual* (362-0300-001).

10. If the pond depth cannot be adjusted due to subsurface constraints, then the surface area is adjusted to obtain the design volume. However, if the surface area is changed, another iteration of the above procedure will be necessary because the value of net storage gain/loss (ΔV_s) will be different for a new pond area.

g. Freeboard level criteria

In order to effectively verify the adequacy of the design, it is critical that the final storage lagoon design calculations provide:

1. Elevations of the lagoon bottom, low water level, high water level, freeboard and top of berm.

2. The surface area of the lagoon.

3. The effective operating capacity of the lagoon. It is critical that the operating capacity meet the peak needs of the lagoon annual water budget calculations.

4. The volume of the lagoon in gallons per foot.

5. Sufficient freeboard. It is critical that the lagoon be designed to maintain a minimum freeboard of 2 feet at all times. A freeboard of 3 feet should be maintained for systems with design flows > 50,000 gpd.

h. Storage structures and storage capacity management

Storage structures should be inspected regularly for failure. Projected storage capacity calculations should be maintained to ensure adequate storage capacity is available during winter months.

10.5. Dosing Methods

a. Time dosing should be the method of application used for spray irrigation systems.

b. If the operator is not available at all times the system is in operation, alarms should be set up to notify the operator remotely if a problem should occur.

c. Timed dosing requires that the system (conveyance, treatment, and dispersal dose tanks) be sized to store peak flows until the effluent can be dispersed. Clear water infiltration, leaking plumbing fixtures, or excessive water use can be detected by the high water level alarm in the dosing tank.

d. The final design should include influent and effluent flow meters to measure application rates to each zone.

e. The design of the dosing system and dosing schedule should be included in the design engineer's report discussed in Chapter 13 of this manual.

10.6. Lateral Design

a. Lateral design consists of selecting sizes to deliver the total flow of the lateral with friction losses limited to a predetermined amount. A general practice is to limit all hydraulic losses in a lateral to 20% of the operating pressure of the sprinklers. This will result in sprinkler discharge variations of approximately 10% along the lateral.

b. Since flow is being discharged from a number of sprinklers, the effect of multiple outlets on friction loss in the lateral needs to be considered. A simplified approach is to multiply the friction loss in the entire lateral at full flow (discharge at the distal end) by a factor based on the number of outlets. The factors for selected numbers of outlets are presented in Table 10-2. For long lateral lines, capital costs may be reduced by using two or more lateral sizes that will satisfy the head loss conditions. Elevation losses or gains should be incorporated into the hydraulic loss calculations. Flexible flow-regulating sprinkler nozzles can be used in difficult terrain or design conditions.

Table 10-2. Pipe Friction Loss Factors to Obtain Actual Loss in Line with Multiple Outlets (from *EPA/625/R-06/016*).

Numbers of outlets	Value of F
1	1.000
2	0.634
3	0.528
4	0.480
5	0.451
6	0.433
7	0.419
8	0.410
9	0.402
10	0.369
15	0.379
20	0.370
25	0.365
30	0.362
40	0.357
50	0.355
100	0.350

c. Where possible, run the lateral lines on contour, perpendicular to slope, and provide equal lateral lengths on both sides of the mainline.

d. Avoid running laterals uphill where possible. If this cannot be avoided, the lateral length needs to be shortened to allow for the loss in static head.

e. Lateral lines may be run down slopes from a mainline on a ridge, provided the slope is relatively uniform and not too steep. With this arrangement, static head is gained with distance downhill, allowing longer or smaller lateral lines to be used compared to level ground systems.

f. Lateral lines should run as nearly as possible at right angles to the prevailing wind direction. This arrangement allows the sprinklers rather than laterals to be spaced more closely together to account for wind distortion and reduces the amount of pipe required.

g. Winter drain-down for each riser or lateral is necessary.

10.7. Sprinkler System Selection

a. Delivery systems such as set sprinklers and center pivot irrigation are typically suitable for distributing wastewater evenly over the permitted area.

b. Traveling water guns and truck mounted water cannons are generally not suitable due to their inability to distribute wastewater evenly. If proposed, the applicant will need to demonstrate even distribution.

c. The determination of a sprinkler system design involves the optimum rate of application, sprinkler selection, sprinkler spacing and performance characteristics, lateral design, and miscellaneous requirements. Detailed design provisions for specific systems may be obtained from equipment suppliers.

d. System automation selections, where used, should be based on a comparison of labor with the cost of controls at the desired level of operating flexibility. Common control devices include remote control valves energized electronically or pneumatically to start or stop flows in a lateral or main and weather stations for remote operation with automatic shut-offs for preventing spray in freezing and raining conditions.

10.8. Sprinkler Design – General

a. Sprinkler selection is dependent on the type of distribution system, pressure limitations, application rates, clogging potential, and effect of winds.

b. Sprinklers used for application of wastewater are usually of the rotating head type with one or two nozzles. Manufacturers should be consulted for specific sprinkler specifications.

c. For all sprinkler systems the design application rate should be less than the hydraulic loading rate of the surface soil to avoid surface runoff.

d. The maximum application rate for the sprinklers is 0.25 inches per hour (in/hr). Recommended reductions in application rate for sloping terrain are given in Table 10-3.

Table 10-3. Recommended Reductions in Application Rates Due to Grade (adapted from *EPA/625/R-06/016*).

Percent Grade	Maximum Application Rate (in/hr)
0 – 5%	0.25
6 – 8%	0.20
9 – 12%	0.15
13 – 20%	0.10
20 – 25%	0.0625

e. The optimum rate of application for a sprinkler system will provide uniform distribution under prevailing climatic conditions without exceeding the infiltration rate of the soil, as calculated in Chapter 6 and Chapter 7 of this manual.

f. Sprinkler spacing and performance characteristics are jointly analyzed to determine the most uniform distribution pattern at the optimum rate of application.

1. Since the amount of water applied by a sprinkler decreases with distance from the nozzle and the distribution pattern is circular, sprinklers and laterals are spaced to provide overlapping of the wetted diameter.

2. Choice of spacing between sprinklers is closely associated with both the application rate and the amount of pressure at the nozzle.

3. The primary factor that affects the choice of spacing is the vegetative cover (e.g., open field crops or forests). Spacing of 80 feet by 100 feet is preferred for open fields and spacing of 60 feet by 80 feet is recommended for wooded areas. Other spacing alternatives may be determined empirically or by using published guidelines.

g. Once the preliminary spacing has been determined, the nozzle discharge capacity to supply the optimum application rate is found by the following equation:

$$Q = \frac{SL \ x \ SM \ x \ I}{C}$$

where:

Q = flow rate from nozzle, gallons/minute (gpm)
SL = sprinkler spacing along lateral, feet
SM = sprinkler spacing along main, feet
I = optimum application rate, inches/hour
C = constant = 96.3

h. This establishes the basis for final sprinkler selection, which is a trial and adjustment procedure to match given conditions with performance characteristics of available sprinklers.

10.9. Fixed Solid Set Sprinkler Systems

a. General

1. Riser heights are determined by vegetation heights and spray angle.

2. Sprinklers should be spaced at prescribed equal intervals along each lateral pipe, usually 40 – 100 ft.

3. A diamond or triangular pattern for sprinkler head layout is recommended to improve application uniformity.

4. Adequate (typically 50%) overlapping patterns from adjacent sprinkler nozzles are essential regardless of sprinkler head layout.

b. Application Rate

1. The application rate is expressed as a function of the sprinkler discharge capacity, the spacing of the sprinklers along the lateral, and the spacing of the laterals along the main according to the following equation:

$$R = \frac{q_s C}{S_s S_l}$$

where:
R = application rate, in/hr
q_s = sprinkler discharge rate, gpm
C = constant (96.3)
S_s = sprinkler spacing along lateral, ft
S_l = lateral spacing along main, ft

c. Sprinkler Selection and Spacing Determination

1. Only the wetted perimeter of a sprinkler or group of overlapping sprinklers will be considered for the purpose of calculating the application area.

2. Sprinkler selection and spacing determination typically involves an iterative process. The usual procedure is to select a sprinkler and lateral spacing, then determine the sprinkler discharge capacity needed to provide the design application rate at the selected spacing. The sprinkler discharge capacity may be calculated using the application rate equation given above.

3. Manufacturers’ sprinkler performance data are then reviewed to determine the nozzle sizes, operating pressures, and wetted diameters of sprinklers operating at the desired discharge rate. The wetted diameters are then checked with the assumed spacings for conformance with spacing criteria. Recommended spacings are based on a percentage of the wetted diameter

and will vary with the wind conditions. Recommended spacing criteria are given in Table 10-4.

Table 10-4. Recommended Spacing of Sprinklers (from *EPA/625/R-06/016*).

Wind speed		Spacing
km/h	mph	% of wetted diameter
0 – 11	0 – 7	40 between sprinklers
		65 between laterals
11 – 16	7 – 10	40 between sprinklers
		60 between laterals
>16	>10	30 between sprinklers
		50 between laterals

4. The sprinkler and nozzle size should be selected to operate within the pressure range recommended by the manufacturer.

d. Forest Systems

1. Spacing of sprinkler heads will be closer and operating pressures lower in forests than other vegetation systems because of the interference from tree trunks and leaves and possible damage to bark. Spacing of 60 feet between sprinklers and 80 feet between laterals has proven to be an acceptable spacing for forested areas.

2. Operating pressures at the nozzle should not exceed 55 pounds-force per square inch (psi), although pressures up to 85 psi may be used with mature or thick-barked hardwood species.

3. The sprinkler risers should be high enough to raise the sprinkler above most of the understory vegetation, but generally not exceeding 5 feet.

4. Low-trajectory sprinklers should be used so that water is not thrown into the tree canopies, particularly in the winter when ice buildup on pines and other evergreen trees can cause the trees to be broken or uprooted.

5. General practice is to use low-trajectory, single-nozzle impact-type sprinklers, or low-trajectory, double-nozzle hydraulic-driven sprinklers.

6. Installation of a buried solid set irrigation system in existing forests should be done with care to avoid excessive damage to the trees or soil. Alternatively, solid set systems can be placed on the surface if adequate line drainage is provided.

7. For buried systems, sufficient vegetation may be removed during construction to ensure ease of installation while minimizing site disturbance so that site productivity is not decreased or erosion hazard increased. A 10-foot wide path cleared for each lateral meets these objectives.

8. Following construction, the disturbed area is mulched or seeded to restore infiltration and prevent erosion.

9. During operation of the land treatment system, a 5-foot radius should be kept clear around each sprinkler.

10.10. Site Vegetation

a. Land treatment systems are long-term dedicated wastewater application areas. Therefore, it is necessary that a detailed area vegetation report be prepared and included with either the planning submission for domestic wastewater projects, or the permit application for industrial wastewater projects. The report should include an evaluation of the area's existing vegetation, conversion to a different type of vegetation, if applicable, including proposed site preparation, seeding, and maintenance of the selected vegetation. Some examples of a vegetation report would be to remove trees for a drip irrigation system installation, convert an existing horticultural nursery into a grass drip irrigation field, or convert a corn field to spray irrigation hay field.

b. It is important that the final selected site vegetation for drip irrigation and spray irrigation be established in advance of system installation. This will prevent delays in the startup of systems since sufficient vegetative cover is required.

c. An established site cover will also reduce the likelihood of soil erosion and/or the need for site repair after installation. If the project is proposing a spray irrigation system, a crop management report should be submitted at the planning stage. Details for a vegetation management report are provided in the appropriate design sections of this manual.

d. Vegetation covering the spray field should be managed to achieve treatment system goals, prevent erosion and soil compaction, and comply with the following guidelines:

    1. A plan to manage vegetation in the spray field should be submitted to DEP for approval. The plan should include a discussion of the intended use, establishment, and maintenance procedures for the selected vegetation.

    2. Actions should be taken to ensure the vegetation does not interfere with or impair the proper operation of the spray systems.

3. A plan to minimize compaction and tire rutting and address measures to correct any conditions that increase the potential for soil erosion or runoff.

e. The treatment system area should not be used for any activity that may damage the spray field. It is important to match the type of vegetative cover to the selected land treatment system. Choose vegetation that is able to thrive under the application conditions, prevent soil erosion, tolerate the various chemical parameters in the effluent, ensure the desired level of nutrient uptake, and provide additional treatment capacity if possible. Some land treatment systems require vegetation that will generate certain surface flow patterns or remove certain chemicals or nutrients from the wastewater. Management of the vegetative cover should also be considered (e.g., harvesting, usability, reestablishment, disposal).

1. Assimilative Capacity

The vegetation selected needs to be able to assimilate the specific type of effluent being applied to the soil. Typical domestic wastewater effluent has different characteristics than industrial waste effluent, which is widely variable depending on the process and pretreatment methods involved. The applicant should address the following conditions or characteristics in order to select the vegetative cover most capable of assimilating the effluent.

i. Hydraulic Load

When a significant hydraulic load is to be placed on the spray field, it is important that the vegetation be able to tolerate the wetness and still provide assimilative capacity to remove the chemical constituents of concern. Under certain conditions, vegetation should be selected that will take up and transpire significant quantities of water, thereby lessening the hydraulic loading to the groundwater and decreasing the potential for groundwater mounding.

ii. Anions

Anions, particularly nitrate (NO_3^-), are generally not afforded significant renovation by the soil profile. Therefore, the major assimilative/renovative pathway for anions is vegetative uptake. The fraction of all anionic species not removed by vegetation moves largely unchanged into the groundwater where dilution takes place. A crop that can remove significant quantities of anions (mostly NO_3^-) from the soil water/effluent will lessen the impact of those parameters on groundwater. This is an especially important consideration if background groundwater anion concentrations are elevated.

iii. Cations and Metals

a) Cationic species include heavy metals and phosphorous. Cations are typically complex and tightly held within the soil. However, certain processes within the treatment system may cause them to become mobile. Certain vegetation will show the effects of toxicity to certain metal species at much lower concentrations than others. Even essential cations like iron, chromium, potassium, copper, manganese, zinc, boron, molybdenum, and phosphorus may be toxic if levels significantly exceed those required for growth.

b) While uptake of cations can be a major benefit of a vegetative species, the level of metal concentrations and other soil/effluent factors need to be kept in equilibrium. Typical farm management operations such as liming and fertilizing may need to be limited as they can complicate the relationships within the system over time, as cationic concentrations build in the soil. Evaluation of the removal of cations requires specialization in the area of agronomy and should be performed by an agronomist.

iv. Oil, Grease, and Organics

a) Oil, grease, and organics as discussed in this section refer to plant and animal-based fats and oils and not petroleum byproducts, and are generally discouraged from relying on land treatment for renovation. **Petroleum products are not amenable to soil renovation and should not be considered for land treatment**.

b) The soil's microbial population accounts for most of the breakdown of oils, greases, and organics. However, treatment is greatly inhibited by lower temperature, and soil pores may clog causing the system to malfunction.

c) Vegetation will assimilate certain organics and metabolites of organic compounds. The organics will typically be stored within the plants' tissue and may become toxic to the plant or render the vegetation unsuitable for some uses after harvest. Oil or grease may also clog the surface of plants, significantly reducing or halting transpiration. These consequences should be evaluated as well as the effect of applying oily or greasy wastewater on the vegetation. If the plants' transpiration is significantly reduced or halted due to "clogged" surfaces, the application may be self-defeating.

2. Site-Specific Considerations

The vegetation chosen should provide control against erosion and runoff, as well as assisting with effluent renovation. Well-established vegetation enhances infiltration and shallow soil percolation. Steeper slopes typically require a vegetation cover having well-developed roots that will aid in holding the soils in place. It is important that land treatment be limited to areas containing growing vegetation.

3. Management and Economic Considerations

i. Well-managed land treatment systems will successfully treat effluent at the design flows and will be aesthetically acceptable. These systems can also be economically beneficial to the operator by providing return on the harvested vegetation, by reducing the cost of conventional treatment, and/or by eliminating the need for stream discharge of effluent.

ii. A schedule of anticipated vegetation maintenance and seasonal operation should be provided with the permit application. To avoid damage to the soil and destruction of the spray field by maintenance operations, this schedule should be altered when there are wet soil conditions. Harvesting and other vegetation management activities should be conducted when no effluent is being applied to the spray field or effluent is being temporarily stored. Planning for additional wastewater storage may be required to account for maintenance practices (e.g., mowing, reestablishment, harvesting).

iii. The proposal for a land treatment system should include a vegetation management plan and address the following management and operational considerations:

a) Vegetation Establishment and Maintenance

1) The plan should address the different methods and durations for establishment of type of vegetation to be planted. Some vegetation may take only a few weeks to reach a stage of growth when land treatment could commence. However, slower growing plants, such as trees, may take several months or longer to become established. A "cover crop" with a rapid growth habit should be planted to reduce the risk of erosion if the proposed vegetation will take a significant period of time to reach full establishment. Further, the season of the year should be considered

since few types of vegetation can be established in late fall or winter.

2) A maintenance plan should be developed to assess soil fertility, liming and control of weeds, pests, or other conditions that could affect the functionality of the system.

b) Harvesting

1) Excess vegetation should be harvested or removed from the site periodically. If this does not occur, the parameters of concern that have been taken up by the vegetation may simply return to the soil causing a buildup and potential overload of some system.

2) Typically, forage crops should be harvested several times per year while in an active growth stage (as opposed to entering senescence) when they are assimilating nutrients at optimum rates. Application to sites where crops have been completely removed is not permitted.

3) Forest crops should also be harvested periodically, although typically less frequently than forage crops. After the initial 1 – 2 years of growth, when a root system has been established, growth rates and nutrient uptake increase and remain relatively constant until maturity is approached. This can take 20 – 25 years for southern pines and 50 – 60 years for hardwoods. During this stage, stem harvesting is commonly practiced to ensure removal of constituents of concern from the system. Once maturity is reached and growth rates slow, whole tree harvesting takes place to ensure maximum removal of constituents of concern. Whole tree harvesting may also be practiced well in advance of maturity with a short-term rotation management plan.

c) Usage/Disposition

The ultimate disposition of harvested vegetation should be addressed. Some crops have an inherent value and may be utilized or sold, whereas some vegetation is planted simply to provide uptake of certain contaminants. The proposal should indicate whether the crop is intended for animal consumption, industrial usage, horticultural usage, landfilling, or other uses.

d) Natural Range

An obvious consideration in the selection of a plant species is whether it will survive in the climate or on the specific site. A plant species may possess the proper assimilative capacity, provide required tolerances, and yield positive economic returns upon harvest; however, if the species cannot survive the climate or site-specific conditions, these attributes are all irrelevant.

11. PROCESS DESIGN – DRIP IRRIGATION

11.1. General

a. A subsurface drip irrigation system distributes pretreated wastewater effluent into the soil at shallow depths typically ranging from 6-12 inches below the surface. Small volumes of wastewater are sent to drip zones at time-dosed intervals through a pressurized network of flexible 0.5-inch tubing containing inline pressure-compensating emitters. The design objective is to minimize soil saturation while achieving equal distribution. Drip irrigation systems operate daily throughout the year.

b. The design criteria presented in this manual are based on the use of drip technology for dispersal of treated wastewater into the soil for further percolation and renovation; these design criteria are not applicable to crop or vegetation irrigation systems.

c. Subsurface drip irrigation system soil loading rates are determined by a qualified soil scientist based on evaluation of soil morphologic properties as described in Chapter 6 of this manual. Hydraulic conductivity testing will then either confirm or reduce the loading rate.

d. A general guideline to delineate sufficient area for a drip system during field soils evaluations is to consider a footprint loading concept. Generally, deep well-drained sandy and loamy textured soils should receive no more than 2 inches of treated wastewater per acre per week. This roughly equates to 7,400 gallons per acre per day footprint loading if dispersal tubing is designed for two-foot spacing. Finer textured soils such as clay loams or soils with evidence of a seasonal high water table should receive no more than 1 inch of treated wastewater per week and more severe sites limited to receiving up to 0.5 inch per week. The footprint loading concept is intended only as a baseline to estimate project land area needs during field evaluation.

e. In order to function properly, it is critical that drip irrigation areas have established permanent vegetative cover before system installation begins. This protects shallow drip irrigation components from being adversely affected by site preparation equipment. A plan to prepare the site and establish vegetation is also submitted to DEP for approval as part of the planning process. Once the system is installed, dispersal areas can be maintained as meadows, regularly mowed turfgrass, or woods, and restricted for low-impact passive use only.

f. Drip irrigation systems generally consist of the following main components; design of each system component should follow manufacturer's recommendations:

   1. Wastewater pretreatment

2. Filtration

3. Pump tank/Pumps/Floats

4. Dosing controls/PLC

5. Drip irrigation network with several zones consisting of supply lines, air release valves, drip irrigation tubing and return lines.

g. Drip system components should be integrated in the system design; the function of one component is necessary for the function of the others. Flow meters are required in the design of a drip irrigation system for influent and effluent volumes.

11.2. Wastewater Pretreatment

a. For domestic wastewater projects, the design engineer's report should include information demonstrating the system will be able to achieve a minimum of secondary treatment, unless site conditions require more advanced treatment to ensure protection of groundwater quality.

b. Secondary treatment for domestic wastewater is capable of achieving the following effluent quality concentration levels:

Parameter[3]	Unit	Minimum	Monthly Average	Weekly Average	Instantaneous Maxiumum
5-day CBOD[1]	mg/L	---	25	40	50
TSS[1]	mg/L	---	30	50	60
pH	S.U.	6.0			9.0
Total Nitrogen[2]	mg/L		10		20

[1] Based on 30-day average concentration
[2] Necessary unless waived by hydrogeologic study
[3] Other parameters may be required for a project

c. Drip tubing applies effluent beneath the ground surface; therefore, disinfection is generally not necessary. Disinfection may be required for sites with sandy soils or shallow fractured rock.

d. For facilities required to submit sewage facilities planning prior to applying for a land treatment system permit, the need for more advanced treatment specific for nitrogen is determined at the time of sewage facilities planning by a hydrogeologic study.

e. At the time of publication of this manual, crop uptake/removal of treated wastewater nitrogen by vegetation over drip irrigation areas has not been studied or quantified. Therefore, no allowances for nitrogen removal by the crop or soil are available.

11.3. Filtration

a. Filtration after pretreatment and prior to dosing is critical to remove all particles greater than 100-115 microns in size to reduce the risk of drip tubing emitter clogging. Screen filters, disk filters and can be used to meet this condition.

b. All filters need periodic flushing, cleaning, and replacement to maintain proper operation of the system and avoid costly repair. Programmed automatic and regular filter flushing via PLCs is recommended.

c. Pressure gauges installed upstream and downstream of the filters are recommended to detect when cleaning is necessary.

d. The system should be designed to automatically backflush filters and provide a plan for when hand cleaning and media replacement needs to be conducted.

11.4. Pump Tank/Pumps

a. The pump tank provides flow equalization and some storage of the pretreated effluent. It is recommended that a drip system design incorporate additional volume for 3 days of emergency effluent storage. This is a general recommendation; some system operators may request more storage capacity.

b. Pumps should be sized to handle both dosing and flushing flow rates, filter pressures, and be capable of maintaining a minimum of 2.0 feet per second (fps) of velocity at the distal end of the drip tubing during flushing of the laterals to minimize build-up of bacterial growth in the drip irrigation tubing.

c. The system should be designed so that the effluent pumped during the drip tubing flushing cycle is returned to the head of the pretreatment unit.

d. The pumping capacity should allow two zones to be dosed simultaneously except during flushing cycles.

e. Pump tank and pump design should be based on engineering practices and follow manufacturer's specifications.

f. Overall drip system dosing pump run times should allow sufficient time for resting, filter backflush, and general maintenance.

g. DEP's *Domestic Wastewater Facilities Manual* (362-0300-001) provides additional information on pumps and pump tanks.

h. It is recommended that lightening arresters and surge protectors be considered in the design of the drip system to protect the electrical components.

i. Tank levels should be monitored at all times. At a minimum, alarms for high level and low level should be provided.

11.5. Dosing Controls

a. Dosing controls regulate the quantity of effluent sent to the drip fields for dosing and flushing events and when the events occur. PLCs are used to control dosing volumes and frequency, to alternate doses between zones, and to flush lines and backflush filters. PLCs are utilized for system operation and performance monitoring.

b. It is important that the PLCs have the ability to collect data on pump starts, run times, number of doses, number of flush cycles, gallons sent to each zone, and flow rates during dosing. It is important that the facility operator have the ability to access the data on the PLC screen. Information on the PLC capabilities to achieve these requirements should be presented in the permit application.

c. Monitoring flow rates during operation can assist in detecting emitter clogging or leaks in the distribution system.

d. Predetermined variations in flow rates can be entered into the PLC to automatically shut the system down in the event of clogging or leakage due to tubing or manifold breakage.

e. If the generation of wastewater flows will start low and gradually build over time due to the phasing of development, the engineer's report should provide information for construction and operation of drip zones to meet flow demand and time frames.

f. Experience has shown that drip fields that are not routinely dosed have more problems with animal damage to the tubing and are also more susceptible to operational problems during cold winter periods.

11.6. Drip Irrigation Network

a. A drip dispersal network is comprised of several zones consisting of supply lines, supply manifolds, return manifolds and return lines, and drip tubing laterals. Drip tubing is typically 0.5-inch diameter flexible polyethylene, with in-line drip emitters embedded at 2-foot spacing.

1. A drip zone is a collection of drip tubing laterals that will operate at the same time during dosing and flushing events.

2. A drip tubing lateral is the length of drip tubing connected to one supply line and one return line at each end. Drip laterals may consist of one or more runs.

3. A drip tubing run is defined as one continuous length of tubing installed on contour that is either connected to a supply and return line or another run.

4. It is important that drip tubing emitters be pressure-compensating to provide a constant rate of flow over a specified pressure range.

5. Drip emitters are to be evenly spaced within the tubing, typically every two feet.

b. Drip irrigation system soil loading rates should be assigned by a qualified soil scientist based on soil test pit evaluations and further verified by field hydraulic conductivity testing of the most restrictive horizon.

1. Soil properties such as drainage class, depth to limiting zone, and soil textural and structural properties are used in part as a basis for loading rate development.

2. Assign soil loading rates in units of gallons per linear foot (gal/lf) of drip tubing per day. Loading rates generally range between 0.18 gal/lf for moderately well-drained soils up to 0.34 gal/lf for deep well-drained soils. For secondary treated effluent, 10% of saturated hydraulic conductivity results should be used for confirmation of these rates. For tertiary treated effluent, up to 15% of saturated hydraulic conductivity results may be used for confirmation.

c. Drip runs are typically designed and installed on 2-foot centers, providing an overall grid distribution pattern in the dispersal area.

1. The spacing of the drip tubing runs can be modified to meet certain site conditions such as slope.

2. Tubing run spacing should be designed and installed between 1-3 feet to achieve equal distribution of effluent across the dispersal area.

d. Drip tubing runs interrupted by obstacles such as large tree trunks or boulders can consist of solid tubing containing no emitters around the obstacle to join sections of tubing containing emitters prior to and after the obstacle.

1. If a drip field contains a significant number of obstacles, records should be kept during installation to track the amount of non-emitter tubing installed per lateral; this will affect zone dosing and dispersal capacity.

2. When planning and designing a drip system in areas containing trees, stony soils, or boulders, it is advised that additional area be provided so that enough tubing can be installed.

e. Drip zone design configuration and layout should be based on site-specific features and conditions.

1. Zones should be designed to maximize length on contour.

2. On-site elevations and contours should be closely evaluated prior to designing drip zones. If drip tubing cannot be installed within contour variance, permitted dispersal capacity could be lost.

3. Convergent land topography, which could concentrate subsurface flow, should be avoided for drip tubing layout.

4. When designing the drip system, consideration should be given to the ability to construct supply and return lines without disturbing drip tubing areas.

5. Slopes 18-25% present significant installation challenges and should be avoided if possible.

f. The length of time each zone should operate during a dose is based on soil properties and full pressurization of the tubing.

1. Drip emitter dose volumes per dosing event should be approximately 0.04-0.20 gallons.

2. For clayey soils, dose run time can be from 6 to 12 minutes with emitter discharge rates ranging from 0.04 to 0.12 gallons per emitter per dose.

3. For soils without significant clay content, dose run time can be about 20 minutes, or 0.20 gallons per emitter per dose.

4. Dose volumes may be as low as 3.5 times the volume of drip tubing of the zone being dosed; this is to insure adequate pressurization for equal distribution.

g. Prior to installation, the ground contours of each land treatment drip irrigation area should be marked and used as guides to install tubing on contour.

1. Drip tubing should be installed on contour with the maximum elevational change within the variance recommended by the manufacturer for proper operation.

2. Track and record the amount of tubing installed per zone and subzone during installation. These records are to be provided to the permittee and design engineer and used for as-built plans and evaluation of drip system effluent disposal capacity.

h. Forward flushing for all zones should be automated to occur on a regular schedule based on a set number of days or dosing cycles. Drip zones should be forward flushed on an individual basis.

i. It is important that each drip zone contain an air release valve located at an elevation above the highest drip line to provide for drainage through emitters after each dose.

j. In order to verify the adequacy of the design, it is important that the design engineer's report provide adequate information to confirm that the treated wastewater dispersal capacity needs for project flows have been met or exceeded.

1. It is important that the linear feet of tubing proposed for each zone be in accordance with soil loading rates assigned by the soil scientist.

2. Calculations for each zone flow rate are as follows:

   - Drip tubing length per zone/2-foot emitter spacing = number of emitters
   - Number of emitters * emitter flow rate 0.61 gallons per hour (gph) = zone dosing rate
   - gph/60 minutes = zone dosing rate in gpm

3. Provided zone dosing run times, the number of doses per day, and zone capacity.

4. Provide the area covered by tubing in each zone.

5. Verification that the daily capacity of each zone and overall total drip area is in accordance with soil loading rates and project capacity needs should be included in the report.

k. Prior to programming time and dose controls for start-up of the drip fields, the design engineer should revise dosing calculations based on the length of tubing documented in the system as-built records and determine if the minimum drip system capacity provided in the permit application has been met during the tubing installation.

l. Research and experience have shown that the ability for a drip system to function over the winter is dependent on the proper system design and installation.

1. All main supply and return lines should be installed below frost depth, generally a minimum of 3 feet deep in southeastern Pennsylvania and possibly deeper in other regions.

2. All valve boxes, connections, and lines conveying effluent that are installed above the frost line should be insulated. Specifications for the type of insulation material and placement should be detailed in the design provided with the permit application.

3. Provisions should be made for any portion of the dispersal system installed above the frost line to be drained of free-standing water while not in operation. All dispersal system drainage should be disposed of properly.

4. Piping profiles with elevations should be included on the design to document drain down.

5. To promote tubing water drain out though the emitters into the soil after dosing or flushing events cease, elevate all flexible loops connecting tubing runs above the tubing level; this is critical to prevent freezing of tubing in the winter.

6. Maintaining an adequate vegetative cover over the drip irrigation areas during the winter can assist in preventing freezing of components. As a general recommendation, allowing 6 inches or more of vegetative cover to remain over the winter can provide some additional insulation to drip-field components. Generally, vegetative cover should be established before the installation of the drip tubing.

m. Soil compaction within a drip irrigation area could restrict water movement in the soil and result in system malfunction. It is critical that the drip irrigation area be protected from compaction during site preparation, system construction, and ongoing maintenance activities.

   1. The drip irrigation area should be protected from all vehicular and unnecessary equipment traffic. Low-impact equipment should be used.

   2. Any activity on the area should be limited to passive use and low maintenance.

   3. It is critical that no materials be stockpiled on drip areas at any time.

   4. Mowing or maintenance should not be done during wet weather or if the ground surface is wet or saturated.

11.7. Underground Injection Control Provisions

a. Under federal regulations at 40 CFR Part 144, a subsurface fluid distribution system is a Class V injection well. EPA is directed by the federal Safe Drinking Water Act (SDWA) to establish minimum federal requirements for state and tribal Underground Injection Control (UIC) programs to protect underground sources of drinking water from contamination caused by underground injection activities. All Class V injection wells are required to meet UIC program requirements.

b. Owners and operators of subsurface fluid distribution systems shall meet state and federal UIC program requirements. The minimum federal requirements for Class V wells prohibit injection that allows the movement of fluids containing any contaminant into underground sources of drinking water if the presence of that contaminant may cause a violation of any primary drinking water regulation or may adversely affect public health. The system owner/operator is obligated to provide inventory information (including facility name and location, legal contact name and address, ownership information, nature and type of injection wells, and operating status of the injection wells) to EPA's regional UIC program.

c. As provided on EPA's UIC in EPA Region 3 webpage, the EPA Region 3 UIC program coordinator may be contacted at:

US EPA Region 3
Source Water & UIC Section (3WD22)
4 Penn Center
1600 John F. Kennedy Blvd.
Philadelphia, PA 19103-2029
Phone: 215-814-5469

d. Additional information may be obtained from EPA's Class V Wells webpage. The EPA injection well reporting form may be obtained from EPA's UIC Reporting Forms for Owners and Operators webpage.

12. PROCESS DESIGN - LARGE VOLUME ONLOT SEWAGE SYSTEMS

12.1. General

a. A large volume onlot wastewater sewage system is a method of land treatment where wastewater is applied to the soil for final treatment of the effluent at volumes in excess of 10,000 gallons per day (gpd). These systems use the soil for renovation of chemicals, nutrients, and pathogens by applying the effluent to the soil through seepage beds, trenches, or above-ground mounds. The type of absorption area constructed will depend on the thickness of the aerobic portion of the soil above a limiting zone.

b. Limiting zones are defined in [25 Pa. Code § 71.1] and are generally defined as: a water table; rock fragments with insufficient fines between the them; bedrock with open channels; and bedrock or other soil condition that significantly impedes infiltration of water.

c. Large volume onlot land treatment can be used to treat and infiltrate effluent from industrial, commercial, or domestic sources provided the soil is able to assimilate the constituents of concern in the waste stream. The most common use for large volume onlot systems is for the treatment of domestic wastewater (sewage effluent). The following sections of this manual address the planning and design process for selecting appropriate sites and components required for a large volume onlot domestic wastewater system. The process for large volume onlot commercial and industrial waste treatment and land treatment follows the same site evaluation process but may require different pretreatment and permitting. The applicant should contact the regional DEP office to discuss the project prior to planning and design.

d. A large volume onlot sewage system treats sewage flows in excess of 10,000 gpd using soil renovation for final treatment of the effluent. These systems are regulated by 25 Pa. Code Chapters 71, 72, and 73. These systems are part of a municipality's official plan for sewage management; therefore, the submission of sewage facilities planning is required for new or altered large volume onlot sewage systems. Large volume domestic wastewater disposal systems are permitted by the Department under Pennsylvania's Clean Streams Law, through WQM permits. These permits are beyond the permitting authority of the local agency (via sewage enforcement officers). Local agencies' permitting authority is limited to onlot systems that provide treatment and disposal designed for less than 10,000 gpd.

e. The domestic wastewater system design must be consistent with the requirements of 25 Pa. Code Chapter 73 which will ensure application rates that allow for aerobic renovation and residence time of effluent in the soil. The design is required to address the nutrient loading and biological concerns associated with domestic sewage. Large volume systems have the potential for groundwater mounding, which can inhibit the renovative capacity of the soil.

f. The reader is directed to 25 Pa. Code Chapters 71, 72, and 73 for direction on planning, design, and permitting requirements for use of a large volume domestic wastewater system for land treatment of effluent. Additional information can be found on DEP's Act 537 Sewage Facilities Program webpage.

12.2. Basic System Components

a. Large volume onlot systems generally consist of the following main components:

1. Building sewer,

2. Pretreatment system,

3. Distribution method, and

4. Absorption area.

b. The building sewer includes the conveyance piping from the individual residence to the treatment tanks. The pretreatment system will reduce the concentrations of solids and biochemical oxygen demand in the sewage prior to discharging the effluent to the absorption field via the distribution method. The distribution method selected will transport the effluent from the treatment tanks to the absorption area and distribute the effluent evenly across the absorption bed. The effluent is applied to the soil in the absorption area for final renovation under aerobic conditions before passing on to the groundwater.

12.2.1. Building Sewers

The building sewer functions as the transport mechanism for raw domestic sewage to flow from a single building to the treatment tank. It also provides a means for clearing blockage between the hose and the tank by means of a cleanout. Building sewers are regulated under 25 Pa. Code § 73.21.

12.2.2. Pretreatment system

a. The pretreatment system may include a single treatment tank, or a series of treatment tanks, sized appropriately to handle the peak flow volume of sewage.

b. The number and type of tanks needed will depend on the type and degree of pretreatment required prior to discharging the effluent to the absorption field.

c. Typical domestic wastewater pretreatment system includes septic and aerobic tanks or wastewater treatment plants. Septic tanks have two chambers, separated by baffles that allow for the separation of solids, floatables, and decanting of effluent. Aerobic tanks are secondary treatment tanks that receive effluent and contain aeration devices that drive the digestion process from the anaerobic state to aerobic.

d. Septic tanks and aerobic tanks are regulated under 25 Pa. Code §§ 73.31 and 73.32, respectively. Wastewater treatment plants are regulated under 25 Pa. Code Chapter 91. Design standards for wastewater treatment plants are contained in DEP's *Domestic Wastewater Facilities Manual* (362-0300-001).

12.2.3. Distribution System Design

a. For large volume onlot systems, a pressurized distribution system consisting of a dosing tank, pump, and a distribution system of manifolds and laterals is used to transport the effluent to the absorption area.

b. The method used to distribute the effluent is dependent on the size and type of absorption field and the distance from the treatment tanks to the absorption area.

c. Topographic considerations also influence design.

d. It is important that the lines and distribution system be designed to provide for even application of the effluent across the entire absorption area.

e. Distribution systems allowed for use in large volume systems are discussed in the regulations under 25 Pa. Code §§ 73.41 and 73.43 – 73.46.

f. Gravity distribution is not allowed for large volume systems.

g. Cleanouts should be installed in the distribution system piping for sand mounds and trench systems.

12.2.4. Absorption Areas

a. In general, the absorption area of a land treatment system is the land used for infiltration of effluent for final renovation through natural physical, chemical, and biological processes within the soil matrix.

b. Only undisturbed areas should be considered for soils evaluation for absorption areas.

c. 25 Pa. Code § 73.1 defines an absorption area as a component of an individual or community sewage system where liquid from a treatment tank seeps into the soil; it consists of an aggregate-filled area containing piping for the distribution of liquid and the soil or sand/soil combination located beneath the aggregate.

d. It is important to protect the soil in and directly around and absorption area because the soil characteristics described and tested during planning will be used for design. Any alteration, such as compaction, will change the soils renovative capacity.

12.3. System Design Considerations

Three important considerations for designing the large volume system include the selection of the type of absorption area, the rate at which you can apply the effluent, and the nitrogen concentration and additions to the aquifer.

12.3.1. Absorption Area Selection

a. There are three basic absorption systems used in conventional onlot systems, each of which is dependent upon specific site conditions; these systems are:

   1. In-ground seepage bed and trench systems,

   2. Subsurface sand filters, and

   3. Elevated sand mounds.

b. The in-ground seepage bed and trench systems are used where limiting zones are at a sufficient depth (greater than 60 inches) to allow the installation of absorption areas 1-3 feet below the surface, while still maintaining 4 feet of separation between the aggregate in the bed and the liming zone.

   1. The maximum slope of the undisturbed soil of a proposed absorption area where a seepage bed may be permitted is 8.0%.

   2. The maximum slope of the undisturbed soil of a proposed absorption area where a trench system may be permitted is 25%. For slopes between 15% and 25%, detailed design in relationship to elevation should be provided.

c. Subsurface sand filters are used where the limiting zone is greater than 72 inches from the ground surface and the percolation rate within the upper 3 feet of the soil profile is greater than 90 minutes per inch, and the percolation rate below 36 inches is between 3 and 90 minutes per inch; these systems use sand to replace the shallow soil that has unsuitable infiltration rates.

d. Elevated sand mounds are above-ground seepage beds built on top of sufficient thickness of sand and a minimum of 20 inches of suitable native soil to achieve the 4 feet of vertical separation above the limiting zone. The maximum slope of the undisturbed soil, to the extremities of the berm, of a proposed absorption area where elevated sand mound or trenches may be permitted is 12%. Slopes up to 15% may be accommodated with additional design considerations for sites with percolation rates ranging from 3 to 30 minutes per inch. Contact the appropriate DEP regional office for details.

12.3.2. Application Rates

a. General

The absorption area should be designed using the flows specified in Section 3.1.2 of this manual.

b. Absorption area

1. As provided in 25 Pa. Code § 73.16(b)(1), only the bottom of the aggregate area of the bed or trench shall be used in calculating the absorption area requirements.

2. The applicant should base the actual design application rate on the most conservative value from the site test results presented in Chapter 6 and Chapter 7. These results include the data from the percolation testing and the hydraulic conductivity testing of the most restrictive subsurface soil horizon, as well as the results of the groundwater mounding analysis.

3. Table A in 25 Pa. Code § 73.16 shall be used in calculating the square footage of absorption area. Table A includes allowances for garbage grinders, automatic washing machines or dishwashers, and water softeners.

c. Substitute

When a substitute for aggregate, such as a leaching chamber, large-diameter pipe, or other material or device, is used in the absorption area, 25 Pa. Code § 73.16(b)(1) applies.

12.3.3. Nitrogen Loading Rates

a. Onlot disposal systems convert organic nitrogen to nitrate-nitrogen through the action of nitrifying bacteria in the aggregate, sand, and unsaturated soils that make up the absorption area.

b. It is important that the applicant conduct hydrogeologic evaluations to consider the potential impact of nitrate-nitrogen on existing or potential downgradient groundwater uses.

c. For the purpose of these evaluations, nitrate-nitrogen is considered to be loaded to the groundwater at 45 mg/L.

d. Mass balance calculations of the dispersed and diluted nitrate-nitrogen are used to document that the waters of the Commonwealth will be protected.

e. 25 Pa. Code §§ 71.62(c)(2) and (c)(3), and Component 2 of DEP's Sewage Facilities Planning Module describe why and when these studies are required, and how they should be conducted.

f. Proposals for additional treatment of nitrogen to reduce the impact to groundwater are required to document consistent, reliable nitrogen reduction.

12.4. Alternate Onlot Systems

The information presented in Sections 12.2 and 12.3 of this manual are for conventional onlot systems. Alternate technologies are not listed in 25 Pa. Code Chapter 73 as conventional systems. DEP has design criteria for alternate systems available on the Department's Onlot Alternate Technology Listings webpage.

The DEP regional office sewage facilities planning section should be consulted during the planning process for design requirements and considerations involving alternative systems.

12.5. Site Preparation

Site preparation varies with the proposed system configuration. However, the following are some site preparation and protection factors common to construction of all absorption areas:

a. The primary concern is the possibility of affecting the soil by heavy equipment needed to excavate or construct the system. To avoid potential problems with compaction or smearing:

1. Allow only light equipment on the site to conduct soil profile examinations and permeability testing.

2. Rope off the proposed absorption area including a 10-foot buffer area and prohibit entry of any heavy equipment.

3. Before allowing any equipment on the site to construct the system, conduct this soil moisture test: lightly squeeze the soil in your hand, then bounce it lightly in your hand or tap it with your finger. If the sample crumbles or breaks up immediately, the site can be worked. **Do not proceed if the soil moisture is too high; compaction and smearing of the soil will adversely affect the system functionality**.

4. Use trench system designs where practical. Construction equipment should be kept out of the excavated area during trench construction.

5. When large absorption areas are being constructed, use a trackhoe or other equipment that can operate from a position outside the bed area. Long and narrow system designs allow for less in-bed excavation and materials handling. Construct elevated sand mounds from the upslope side only.

b. Cut and remove all vegetation prior to excavation of the system. Avoid areas with large trees.

c. For elevated sand mounds, cut trees at the ground surface and leave stumps in place. Remove boulders or surface rocks. With light equipment, chisel plow the surface of the absorption area and berm. Rototilling should be avoided entirely.

12.6. Underground Injection Control Provisions

a. EPA is directed by the federal SDWA to establish minimum federal requirements for state and tribal UIC Programs to protect underground sources of drinking water from contamination caused by underground injection activities. A large volume subsurface infiltration domestic wastewater system that receives any amount of industrial or commercial wastewater or that receives solely domestic wastewater from multiple family residences or from a nonresidential establishment and has the capacity to serve 20 or more persons per day is considered a Class V shallow non-hazardous injection well under federal regulations. Under 40 CFR Part 144, a Class V drainage well is any bored, drilled, or driven shaft, or dug hole that is deeper than its widest surface dimension, or an improved sinkhole, or a subsurface fluid distribution system. All Class V injection wells are required to meet UIC program requirements.

b. Owners and operators of large volume subsurface infiltration domestic wastewater systems shall meet federal UIC program requirements. The minimum federal requirements for Class V wells prohibit injection that allows the movement of fluids containing any contaminant into underground sources of drinking water, if the presence of that contaminant may cause a violation of any primary drinking water regulation or may adversely affect public health. The system owner/operator is obligated to provide inventory information (including facility name and location, legal contact name and address, ownership information, nature and type of injection wells, and operating status of the injection wells) to EPA's regional UIC program.

c. The Department does not have primacy for the UIC program. The applicant receives approval from EPA Region 3 for Class V UIC wells. As provided on EPA's UIC in EPA Region 3 webpage, the EPA region 3 UIC program coordinator may at contacted at:

US EPA Region 3
Source Water and UIC Section (3WD22)
4 Penn Center
1600 John F. Kennedy Blvd.
Philadelphia, PA 19103-2029
Phone: 215-814-5469

d. Additional information may be obtained from the EPA's Class V Wells webpage. The EPA injection well reporting form may be obtained from EPA's UIC Reporting Forms for Owners and Operators webpage.

13. PERMITTING

13.1. General

a. In order to preserve and improve the purity of the waters of the Commonwealth, Pennsylvania's Clean Streams Law requires that any municipality or person contemplating the construction of wastewater treatment works and related appurtenances shall, with the exception of certain sewer extensions, first obtain permit(s) from DEP.

b. WQM permits are an authorization to construct and operate sewage collection and conveyance systems, and sewage and industrial wastewater treatment facilities. WQM permits are also required for disposal of sewage and industrial waste via land treatment, underground injection, and wastewater reuse.

13.1.1. Permit Review Process and Permit Decision Guarantee

DEP's *Policy for Implementing the Permit Review Process and Permit Decision Guarantee (PDG)* (021-2100-001) establishes a standardized review process and processing times for all of DEP's permits. For the permit applications to which the PDG applies, DEP guarantees to provide permit decisions within the specific timeframes provided applicants submit complete, technically adequate applications that address all applicable regulatory and statutory requirements in the first submission. The process ensures that staff will follow a Department-wide standard process for receiving, prioritizing, accepting, reviewing, denying, and approving applications for permits or other authorizations.

13.1.2. Standard Operating Procedures

a. DEP establishes standard operating procedures (SOPs) as a means to implement the PDG and to provide program-specific instructions to program staff in the review process of permit applications. Implementation of these SOPs will ensure consistent procedures for reviewing permit applications across the Department.

b. The SOPs can be found on DEP's website by visiting www.dep.pa.gov; use the search feature to search for "Standard Operating Procedures."

13.2. Act 14 of 1984

a. Act 14 of 1984 amended the Commonwealth's Administrative Code to state that DEP shall require every applicant for a WQM permit under Pennsylvania's Clean Streams Law to give written notice to each municipality in which the activities are located.

b. Act 14 of 1984 applies to both sewage and residual wastewater permits. For more detailed information on how to comply with Act 14 of 1984, refer to DEP's guidance document, *Industrial Wastewater Management* (362-0300-004).

13.3. Newspaper Publication

a. Section 307 of Pennsylvania's Clean Streams Law requires that public notice of every application for an industrial waste permit be given by notice published in a newspaper of general circulation, published in the locality where the permit is applied for, once a week for four weeks.

b. For more detailed information on how to comply with Section 307 of Pennsylvania's Clean Streams Law, refer to the DEP's guidance document, *Industrial Wastewater Management* (362-0300-004).

13.4. General Information Form

a. DEP's *General Information Form (GIF)* (0210-PM-PIO0001) contains information on proposed projects which can be evaluated to determine whether coordination with other programs or whether other DEP permits will be required in addition to the permit for which the application is being submitted.

13.5. WQM Permit Application Form

An application must be submitted for an individual WQM permit using DEP's *WQM Permit Application Package* (3850-PM-BCW0400).

13.6. WQM Permit Modules

The *WQM Permit Application Package* is modular. Treatment unit processes that are being constructed or modified as a part of the project will require the submission of the appropriate module for the unit process being constructed or modified. *Module 1 – Treatment Plant Summary* is required for all WQM permits. *Module 14 – Spray Irrigation* will be required for spray irrigation projects. Other appropriate modules will be required for other treatment unit processes. Land treatment projects will also require the submission of *Module 19 – Supplementary Geology and Groundwater Information*. If storage impoundments, such as lagoons, are being constructed as a part of the project, the application will also require the submission of *Module 20 – Impoundments*.

13.7. Application Fee

The application fee for WQM permits for land treatment of wastewater is specified in 25 Pa. Code § 91.22. A check payable to the Commonwealth of Pennsylvania shall accompany the permit application package.

13.8. Engineer's report

13.8.1. Project description

a. A design engineer's report is the heart of the permit application and: identifies and evaluates wastewater related problems; assembles basic information; presents criteria and assumptions; describes system reliability for each unit operation with the largest unit out of service; reviews organizational and staffing requirements; offers a conclusion; and outlines time schedules and procedures to implement the project. The document includes sufficient detail to demonstrate that the proposed project meets applicable criteria.

b. For detailed information on what should be included in a design engineer's report, refer to DEP's *Domestic Wastewater Facilities Manual* (362-0300-001).

13.8.2. Pretreatment

In addition to the information identified in DEP's *Domestic Wastewater Facilities Manual* (362-0300-001) for the engineer's report, the report should give details about the treatment of the wastewater effluent that is being proposed for the land treatment system, including effluent quality results.

13.8.3. Storage

Design specifics should be included in the engineer's report for any proposed storage facilities, such as tanks or impoundments/lagoons.

13.8.4. Land treatment area

The engineer's report should contain a map of the property being proposed for land treatment that includes property boundaries and the areas on the property that will be used for land treatment. All soil tests should be shown on the map as well as proposed surface and/or groundwater monitoring points. The report should include, at a minimum, all the information from the professional soil scientist's site evaluation and the licensed professional geologist's site evaluation. Data may be referenced in the report with the full reports added as appendices.

13.8.5. Application rates

The engineer's report should give supporting information on, and calculations of, the proposed application rates. It should include rates from the soils report and from the hydrogeologic report, and indicate which rate is limiting. For spray or drip irrigation applications, design application rates and hydraulic loading rates should be included. Proposed application rates should be based on the more conservative rate developed between the soils evaluation or hydrogeologic analysis.

13.8.6. Design of distribution systems

The engineer's report should provide details on the design of the distribution system, including the materials used and construction methods. The report should indicate how the land treatment area will be protected from damage during construction, operation and maintenance, and freezing.

13.8.7. Groundwater monitoring system

a. Groundwater monitoring systems ensure that groundwater from beneath the application areas does not leave the site carrying contamination above any applicable MCL. The groundwater monitoring plan should be designed to consider the location of the application area and direction of groundwater flow. In addition, monitoring wells may be necessary to monitor treatment facilities that are constructed with liners. The well locations should be determined using groundwater elevation contour maps produced from test well data and other hydrogeologic information. It is ultimately the applicant's responsibility that monitoring wells are properly sited and constructed to adequately monitor the groundwater coming from the site.

b. No new wells should be installed until the permit is issued. Test wells that are installed during the planning stage but are not later used as monitoring wells, should be properly decommissioned as per Pennsylvania's Water Well Drillers License Act (Act 610 of 1955) and the well abandonment procedures detailed in Chapter 7 of DEP's *Groundwater Monitoring Guidance Manual* (383-3000-001).

c. The engineer's report should propose a plan detailing the locations of groundwater monitoring wells, the hydrogeologic rationale for choosing each location, the sampling technique that will be used, including the well purging method, and any other details supporting the adequacy of the monitoring system to prevent pollution of the waters of the Commonwealth.

d. The finalized groundwater monitoring program will be incorporated into the final issued permit. As such, it is important that the proposed groundwater monitoring plan provided with the permit application include the following elements:

   1. The number of wells to be used in the groundwater monitoring program.

2. A site plan showing the existing or proposed locations of the groundwater monitoring wells and surface water monitoring points, if applicable.

3. The proposed frequency of sample collection from the monitoring wells.

4. The parameters for which the groundwater sample will be analyzed.

5. Wells to be decommissioned referencing the site plan.

6. Monitoring wells to be installed referencing the site plan.

7. The monitoring program to be implemented at least 6 months prior to operating the land treatment system including the lagoons. (This is to establish a baseline of groundwater quality before the system begins operation).

8. A plan to measure groundwater elevations prior to purging the monitoring wells.

9. A groundwater contour map.

10. Method of purging of the groundwater monitoring well and allowing the well to recover at least 90% of its volume prior to sample collection.

11. Collecting the groundwater sample within the top 5 feet of the aquifer. (For domestic sewage, nitrate-nitrogen is the contaminant of concern and it is considered a "floater" on the aquifer. Other contaminants may need to be sampled differently).

13.8.8. Monitoring frequencies

The engineer's report should include a monitoring schedule for the land application project. Include sample types, analytical parameters, and collection locations.

13.8.9. Vegetation management plan

The vegetation management plan developed in Section 8.2.6 of this manual should be included in the engineer's report.

13.9. Plan Sheets

a. Detailed plans consist of plan views, elevations, sections, and supplementary views which, together with the specifications and general layouts, provide the working information for the contract and construction of the system facilities.

b. Details on plan sheets are provided in DEP's *Domestic Wastewater Facilities Manual* (362-0300-001), as supplemented by the information specified in this section of this manual.

13.10. Specifications

a. Complete signed and sealed technical specifications are to be submitted for the construction of sewers, wastewater pumping stations, wastewater treatment plants, land treatment systems, and all other appurtenances, and are to accompany the plans.

b. Details on specifications are provided in DEP's *Domestic Wastewater Facilities Manual* (362-0300-001), as supplemented by the information specified in this section of this manual.

13.11. Permit Conditions

a. The permit should include special conditions addressing system installation and operation, including, but not necessarily limited to:

1. Crop management,
2. Number of wells,
3. Names of wells,
4. Well purging protocols,
5. Sampling parameters,
6. Sampling frequency and reporting requirements, and
7. A requirement for periodic review of the data collected by appropriately licensed professionals.

b. A supplemental form should be provided for reporting.

c. In addition, a permit may also require reporting on groundwater quality. The permit may contain special conditions requiring groundwater reports, such as a groundwater background report, an annual groundwater report, and a comprehensive groundwater evaluation.

13.12. Term

Permits for land treatment of wastewater systems should be issued for a period of 5 years, then reevaluated and renewed based on existing performance.

13.13. Renewal

The permittee should compile operating performance data and submit a renewal application at least 180 days prior to the expiration date of the permit. The comprehensive groundwater evaluation should be included as a part of the application.

14. CONSTRUCTION

14.1. Protecting Soil Permeability

a. When soil moisture levels are high or equipment is too heavy, soils may smear or compact, thereby losing their natural permeability. This can occur in the absorption area and around the fringe of the system. Clayey or loamy soils are especially susceptible to smearing or compaction. Since subsurface infiltration systems depend upon both vertical and lateral movement of liquids through the soil, any loss of permeability may impact system function.

b. To avoid potential problems with compaction or smearing, the following design considerations and construction precautions are recommended:

1. Long and narrow system designs allow for less in-bed excavation and materials handling.

2. For drip irrigation systems, small-diameter undergrowth should be removed with hand equipment only, to retain the permeability of the upper soil horizons. Avoid areas with large trees.

3. Isolate the proposed absorption area including a 10-foot buffer area with high-visibility fencing and prohibit entry of any heavy equipment.

4. Before allowing any equipment on the site to construct the system, conduct a soil moisture test. Lightly squeeze the soil in your hand, then bounce it lightly in your hand or tap it with your finger. If the sample crumbles or breaks up immediately, the site can be worked. **Do not proceed if the soil moisture is too high; compaction and smearing of the soil will adversely affect the system functionality**.

5. When large absorption areas are being constructed, use a trackhoe or other equipment that can operate from a position outside of the absorption area.

6. At no time should any material be stockpiled on the absorption area.

7. It is critical that care be exercised during construction to prevent undue compaction and damage to the soils and system.

8. Only lightweight, low-compaction equipment (less than 15,000 pounds; less than 6.5 pounds per square inch ground pressure) should be used on or in the absorption area.

14.2. Erosion and Sedimentation Control

It is important to prevent soil erosion and control sedimentation from any project involving earth disturbance by implementing best management practices (BMPs). Directions for erosion and sedimentation control are presented in DEP's *Erosion and Sedimentation Pollution Control Program Manual* (363-2134-008). Erosion and sediment control plans and permits may be required for the construction and operation of the land treatment system. The permittee shall obtain all necessary permits, approvals, and/or registrations under 25 Pa. Code Chapters 102 (relating to erosion and sediment control), 105 (relating to dam safety and waterway management) and 106 (relating to floodplain management) prior to commencing construction of the facilities authorized by a WQM permit, as applicable. The permittee should contact the DEP office that issued the WQM permit if there are any questions concerning the applicability of additional permits.

14.3. Completion of Construction

a. The facilities shall be constructed in accordance with the terms and conditions of the WQM permit. The permit may require that the project be constructed under the supervision of a Pennsylvania-licensed professional engineer in accordance with the approved reports, plans, and specifications.

b. A Pennsylvania-licensed professional engineer may be required to certify that construction of the permitted facilities was completed in accordance with the application and design plans submitted to DEP, using DEP's *WQM Post-Construction Certification* form (3800-PM-WSFR0179a).

c. Submit the certification to DEP before the facility is placed in operation.

d. Submit as-built drawings, photographs (if available), and a description of all deviations from the application and design plans to DEP within 30 days of certification.

e. If applicable, obtain a certification from the supplier for each source of aggregate used in construction of the system, verifying the aggregate meets the grading and quality (hardness and cleanliness) design requirements. This certification shall be submitted to DEP with the engineer's post-construction certification.

15. SITE MONITORING AND REPORTING

15.1. Monitoring Methods

a. Land treatment systems are monitored to ensure they are not causing groundwater or surface water pollution. Each monitoring system should be site-specific and appropriate to the treated wastewater. The characterization of the wastewater targets the appropriate biological and chemical parameters for monitoring. An understanding of the chemical and physical characteristics of the treated wastewater is important to rule out fate and transport differentiation, and adsorption or absorption phenomena.

b. Common monitoring methods that may be utilized include taking groundwater samples from monitoring wells, piezometers, lysimeters, facility monitoring ports, and springs and measuring depth to groundwater in and around the land treatment system and absorption area.

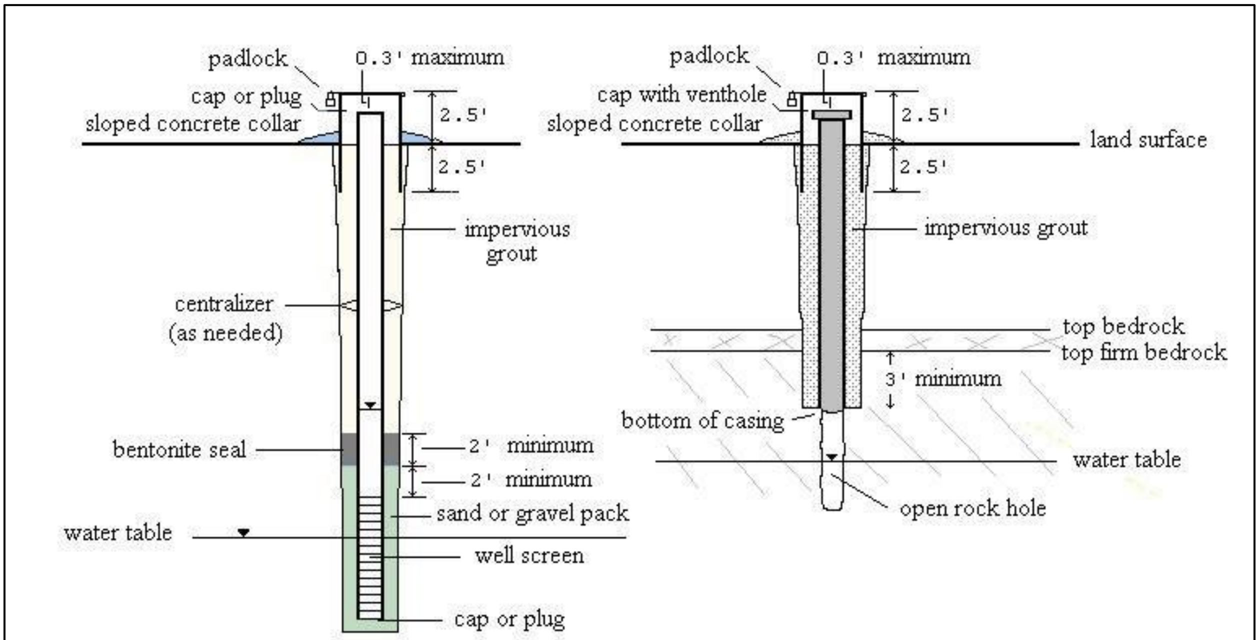
c. Additional information on groundwater monitoring is available in DEP's *Groundwater Monitoring Guidance Manual* (383-3000-001).

15.1.1. Monitoring Wells and Piezometers

a. Monitoring wells and piezometers are commonly used to assess groundwater in Pennsylvania. Water table wells, a type of monitoring well, are typically used for land treatment systems.

b. Water table wells are designed to contain the water table within the open or screened interval. These wells are constructed such that the uppermost (shallowest) portion of the groundwater table is monitored. Shallow groundwater is usually the receiving water of the Commonwealth. Piezometers are small-diameter wells, generally non-pumping, with a very short well screen or section of slotted pipe at the end that is used to measure the hydraulic head at a certain interval below the water table. Figure 15-1 shows recommended construction details for monitoring wells. Piezometers should be constructed similarly.

Figure 15-1. Typical overburden (left) and bedrock (right) water table monitoring wells.



c. Water table wells may be placed in either unconsolidated or bedrock aquifers.

d. A groundwater elevation contour map is drawn from measurements of the depth to water taken from the monitoring wells.

e. Monitoring wells lend themselves to monitoring floating contaminants (such as petroleum products) or those contaminants newly introduced to the groundwater, since such contaminants will be at the top of the groundwater. Newly introduced and floating contaminants tend to stratify and form concentration gradients, with higher concentrations at the top of the water table, and decreasing concentrations at greater depth.

f. Over-application of nitrogen-carrying wastewaters alone or in combination with fertilizers will initially produce stratification of nitrate-nitrogen in the groundwater beneath a land treatment site. As over-application continues, distinct stratification may disappear as deeper groundwater becomes contaminated from its shallower groundwater source.

g. In most cases, groundwater level data from piezometers that do not intercept the water table and wells that do intercept the water table may be horizontally incompatible due to differences of hydraulic head with depth. However, these data may be compatible in assessing the vertical hydraulic gradient at the site.

15.1.1.1. Design Considerations

a. Monitoring well design will vary based upon the different hydrogeologic conditions encountered across Pennsylvania. Design also depends upon the chemical parameters to be monitored.

b. Because construction will require patience, intensive data collection, and monitoring well construction experience, the consulting hydrogeologist should understand the total project as well as the goals of the monitoring program. Complete records of the drilling procedures, strata descriptions, construction procedures, and materials used should be kept on file at the land treatment facility and in the DEP files. It is standard design practice that monitoring wells and piezometers both have the following construction features: (1) a locking well cap, (2) a protective, steel standpipe of larger diameter than the actual well casing, (3) a well casing, commonly constructed of standard steel, stainless steel, PVC plastic, or an inert substance, as conditions or parameters warrant, and (4) grouting of the annular space between the casing and the drilled hole. The casing should be labeled with its permanent designation.

c. Installation of screened wells should include appropriately sized screen slots, sand or gravel, and lengths of screens. The sand or gravel pack should be 1-3 feet above the top of the screen. A bentonite seal approximately 2 feet thick should be placed on top of the sand pack. The bentonite seal is followed by cement-bentonite grout and well completion.

d. A pressure grout seal provides monitoring wells with protection from surface water intrusion. A neat (no sand or stone), 5% bentonite clay, portland cement mix should be pumped into the casing annular space from the bottom up. The bentonite adds a certain pliability to the portland cement, making it expand and contract better while decreasing the cement's permeability. A cement seal should be placed around the top of the well bore and shaped so that surface water flows away from the casing.

e. Another method of grouting is to use a pure bentonite clay slurry. Bentonite clay is characterized by an extremely low permeability. A concrete or portland grout mix should be used to seal the top 3 feet of the annular space.

f. If pH is a parameter of concern, portland cement should only be used to grout that portion of the well above the highest level of the water table. The annular space between the bottom casing and the top of the water table can be grouted with a bentonite clay slurry or bentonite clay pellets. Bentonite clay pellets should be carefully introduced to the annular space to prevent bridging of the pellets prior to settling.

g. It is standard practice for all monitoring wells to be cased and sealed with a grout seal. If the initial boring does not encounter a water-bearing zone of suitable yield (sufficient to yield enough water to obtain a sample) within the interval between the static water level table and 100 feet below the static water bearing zone, the boring should be abandoned and another boring should be drilled nearby. If the well is to be an open-hole construction, the open-hole interval needs to cut the water table. If the well is to have a screen, the screened interval needs to cut the water table and be open to the water-bearing zone. It is important that the monitoring well deliver a sample over the entire year.

h. It is important that wells be constructed in accordance with the above design criteria so that they provide quality data points. The wells also need to be installed carefully to prevent them from being a conduit for untreated water to flow into groundwater.

i. After construction, the wells should be developed until the water is clear. Some development methods include over-pumping, mechanical surging, jetting, and air-lift pumping.

j. A large quantity of literature is available on drilling techniques, and well construction practices and materials. Some suggested references are *Groundwater and Wells* (Driscoll, F. G., 1986) and the National Ground Water Association website.

15.1.1.2. Location

a. Only by knowing the direction of groundwater flow can effective monitoring well locations be chosen. The groundwater mounding assessment also needs to be taken into account as it may indicate a predicted change in the direction of groundwater flow. To establish baseline groundwater quality, it is important that at least one monitoring well be located upgradient of the land treatment area. It is standard practice that a minimum of two wells be located downgradient of the application area, as indicated by the known groundwater flow direction. Additional wells may be required at large sites or at sites in areas with a complex hydrogeologic framework. Wells are placed in sufficient quantity to characterize the quality of the dispersion plume from the land treatment operation. If, after time, wells do not detect wastewater constituents for a given discharge, further exploration may be necessary to assure that the plume is not escaping detection, either horizontally or vertically.

b. Ideally, a monitoring well network would intercept a plume and encounter lower concentrations of contaminants farther from the land treatment facility. Such a monitoring system would demonstrate the plume diluting to concentrations approaching background.

15.1.2. Facility Monitoring Port

A monitoring port is a valve or spigot from which a sample can be drawn. At least one should be located and designed to produce a representative sample of the partially treated effluent just prior to application to the soil absorption area.

15.1.3. Springs

The sampling of springs may occur after the spring is examined for its appropriateness to monitor the application site. Adjacent small springs originating from the soil or bedrock at the site may help to monitor the local impact of a site but should only be used if the parameters monitored are not altered by the ecosystem of the spring. Large springs from carbonate aquifers should not be used as they may monitor entire or adjacent aquifers and not present an accurate assessment of groundwater beneath the application area. A professional geologist may propose to use springs as monitoring sources with proper justification, subject to DEP approval.

15.2. Sampling Plan

Each site proposal needs to outline a plan that describes the frequency and method of sampling for each chemical and biological parameter designated for monitoring.

15.2.1. Monitoring Frequency

It is important that the applicant propose a sampling schedule for each monitoring point. The monitoring schedule should present a sampling frequency for each parameter. Some parameters may require sampling more often than others depending upon site-specific conditions. Most applications will propose sampling with a combination of parameters sampled quarterly and annually.

15.2.2. Sampling Procedure

a. Monitoring of the groundwater below the system will serve to show that such waters are being protected. Depending upon the site, the test wells installed during the initial site investigation may serve as monitoring wells to track the impact of the absorption areas on the groundwater. Additional wells may be needed to ensure adequate groundwater monitoring. A sampling plan should be drafted and proposed to DEP. Groundwater sampling may be required quarterly. The sampling plan will include an appropriate well purging method and a discussion of the procedure. After the well is purged, the well should be allowed to recover to 90% of its pre-purge water level. The well is then sampled for the constituents of concern.

b. It is important that all groundwater samples be representative of the water in the aquifer and not water that has remained stagnant in the borehole. Therefore, the wells need to be sufficiently purged. During the purging of the well, frequently monitor the parameters of temperature, pH, turbidity, and specific conductance. These parameters should be measured in-line if possible. When the measurements have stabilized, the groundwater that is being removed can be assumed to be formation water. In the absence of monitoring equipment, 3-5 borehole volumes can be used as an approximation of sufficient purging. A description of the purging and sampling method should be included in the permit application. Sampling methods, equipment, and protocols can be found in DEP's *Groundwater Monitoring Guidance Manual* (383-3000-001).

c. Have samples analyzed by a DEP-accredited laboratory.

d. Use the test procedures (methods) for the analysis of pollutants or pollutant parameters approved under 40 CFR Part 136.

e. It is critical that the test procedures (methods) for the analysis of pollutants or pollutant parameters be sufficiently sensitive. A method is sufficiently sensitive when 1) the analytical method minimum detection level is at or below the level of the effluent limit established in the permit for the measured pollutant or pollutant parameter; or 2) the method has the lowest minimum detection level of the analytical methods approved under 40 CFR Part 136.

f. For each measurement or sample taken, record the following information:

   1. Sample identification (usually the well number, or unique ID#);

   2. Location, date, and time of sampling or measurements;

   3. Name(s) of person(s) collecting sample; and

   4. Date(s) the field analyses were performed.

g. Samples must be analyzed and submitted in accordance with the permit conditions.

15.3. Reporting

Once a permit is issued, the permit special conditions typically require three different reports connected to the groundwater monitoring program:

a. Groundwater Background Report

The groundwater background report is a one-time report that provides the details of the groundwater monitoring program. A site plan showing the location of the monitoring wells and the as-built construction details. Groundwater elevations and a narrative of the system are also provided. The report is updated when needed. It is due 60 days after permit issuance.

b. Annual Groundwater Report

This report is due to DEP 28 days after the anniversary date of permit issuance. It provides all the groundwater data generated by the site in the previous 5 years. A professional geologist does not need to complete the report because no interpretation of groundwater data is being required. The important aspect of this report is that DEP is reviewing the data every year. Each report received should be acknowledged by DEP. If a problem is present, DEP should address the problem(s) in the acknowledgement.

c. Comprehensive Groundwater Evaluation

This report is submitted at the time of the 5-year permit renewal. Because data interpretation is required, a professional geologist is required to submit this report. This report requires the consultant to revisit the data and make a conclusion regarding system performance and whether a threat to public health is present. Issues are resolved prior to permit renewal.

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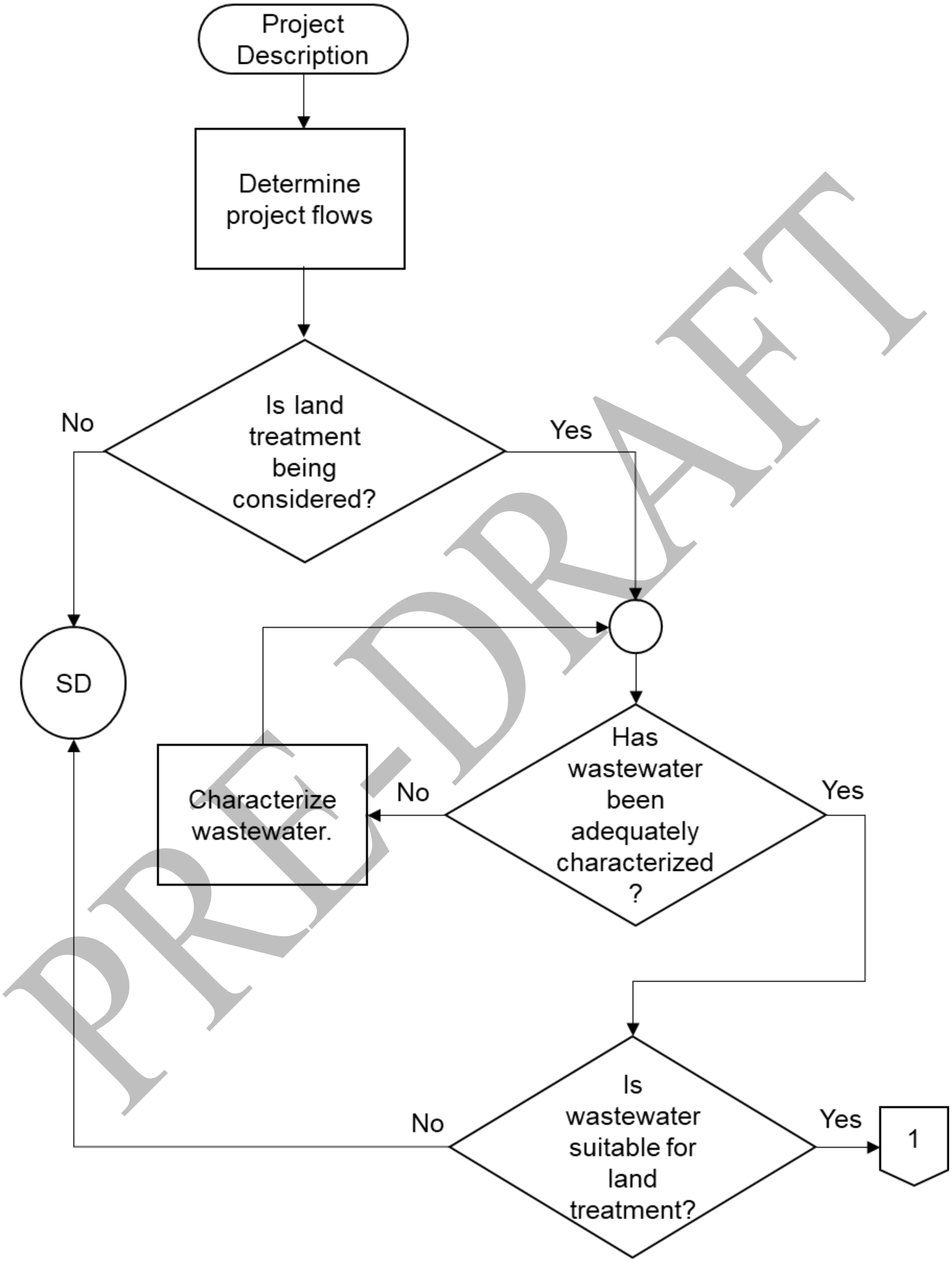
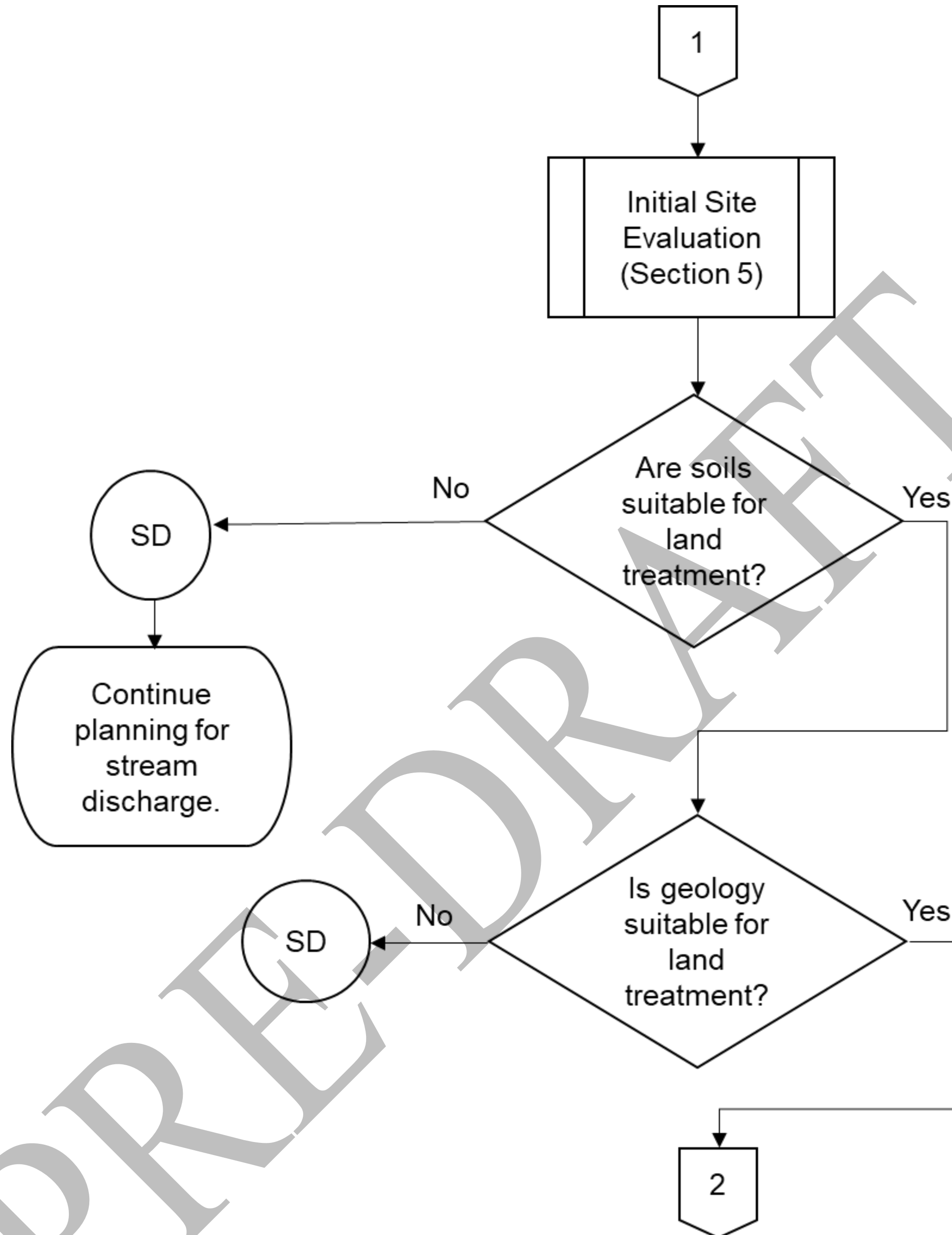
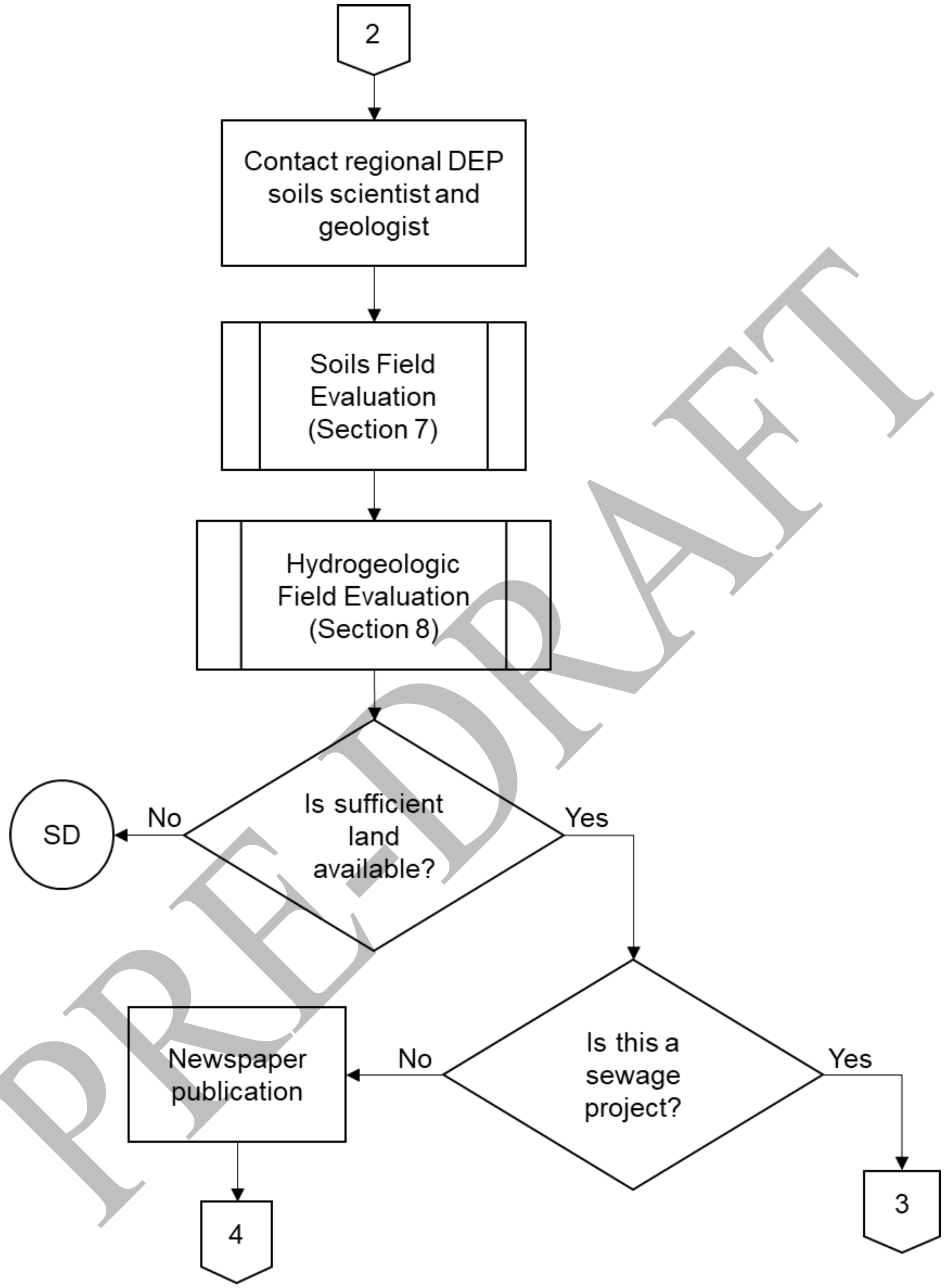
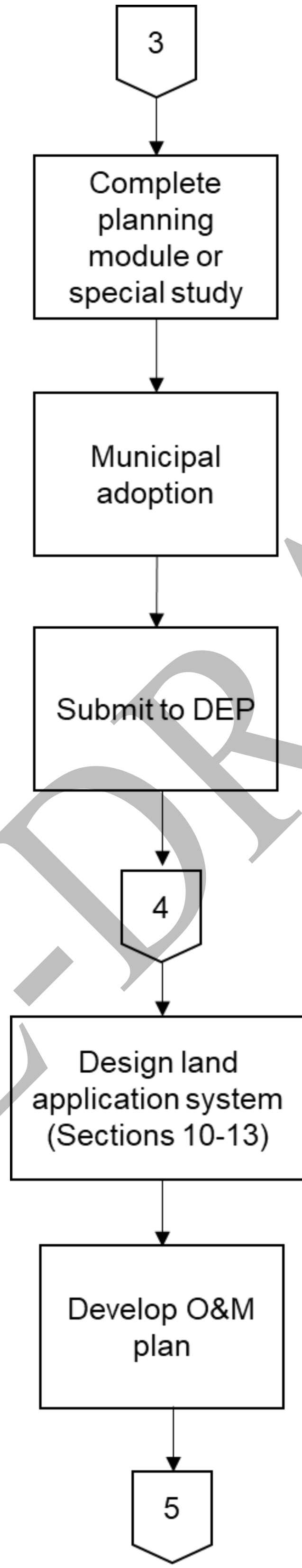
Appendices

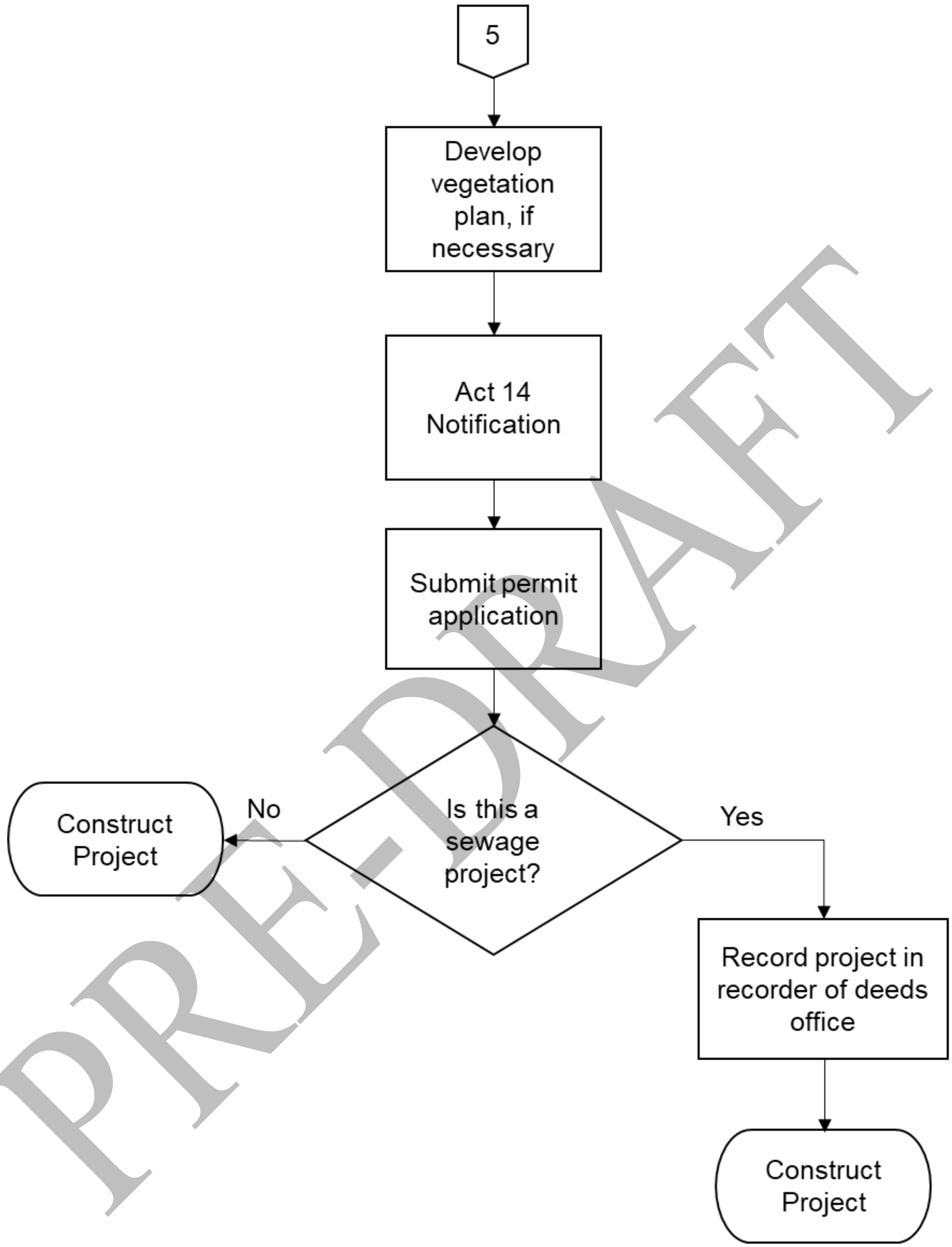
Appendix A – Process Flow Diagram




1
Initial Site Evaluation (Section 5)
Are soils suitable for land treatment?
No
Yes
SD
Continue planning for stream discharge.
Is geology suitable for land treatment?
No
Yes
SD
2


2
Contact regional DEP soils scientist and geologist
Soils Field Evaluation (Section 7)
Hydrogeologic Field Evaluation (Section 8)
Is sufficient land available?
No
SD
Yes
Is this a sewage project?
No
Newspaper publication
Yes
4
3


3
Complete planning module or special study
Municipal adoption
Submit to DEP
4
Design land application system (Sections 10-13)
Develop O&M plan
5


5
Develop vegetation plan, if necessary
Act 14 Notification
Submit permit application
Is this a sewage project?
No
Construct Project
Yes
Record project in recorder of deeds office
Construct Project

Appendix B – Soil Log Form

Project: ____________________ Test Pit: ______________ Date: _____________ Slope: _____________ L.Z.: ____________ DOP: ________________

Horizon	Boundary				Color	Rock Frags		Texture		Structure							Consistence		Mottles			Comments
	Top	Bottom	dist	topo													dry	moist	abun	size	cont	
			a cl g d	s w Ir b		round gr cb st bd very extremely	flat sh fl st bd	c cl sc scl slc slcl	si sil l sl ls s	gr vf f m co vc	pl vn tn m tk vk	sbk- abk vf f m co vc	pr vf F m co vc ef	ma	sg	grade 1 2 3	lo s sh h vh eh	lo vf fr fi vfi efi	f c m Color	f m c vc ec	f d pr	
			a cl g d	s w Ir b		round gr cb st bd very extremely	flat sh fl st bd	c cl sc scl slc slcl	si sil l sl ls s	gr vf f m co vc	pl vn tn m tk vk	sbk- abk vf f m co vc	pr vf F m co vc ef	ma	sg	grade 1 2 3	lo s sh h vh eh	lo vf fr fi vfi efi	f c m Color	f m c vc ec	f d pr	
			a cl g d	s w Ir b		round gr cb st bd very extremely	flat sh fl st bd	c cl sc scl slc slcl	si sil l sl ls s	gr vf f m co vc	pl vn tn m tk vk	sbk- abk vf f m co vc	pr vf F m co vc ef	ma	sg	grade 1 2 3	lo s sh h vh eh	lo vf fr fi vfi efi	f c m Color	f m c vc ec	f d pr	
			a cl g d	s w Ir b		round gr cb st bd very extremely	flat sh fl st bd	c cl sc scl slc slcl	si sil l sl ls s	gr vf f m co vc	pl vn tn m tk vk	sbk- abk vf f m co vc	pr vf F m co vc ef	ma	sg	grade 1 2 3	lo s sh h vh eh	lo vf fr fi vfi efi	f c m Color	f m c vc ec	f d pr	

Appendix C – Sample Notification Letter

Dear (Municipal Secretary:) or
Dear (County Commissioners:)

The purpose of this notice is to inform you of intent to submit an application to the Pennsylvania Department of Environmental Protection (DEP) for the following:

Permit Application Type:	
Application Contact:	
Project Location:	
Project Description:	
DEP Contact Information:	

Acts 67 and 68 of 2000, which amended the Municipalities Planning Code (MPC), direct state agencies to consider comprehensive plans and zoning ordinances when reviewing applications for permitting of facilities or infrastructure and specify that state agencies may rely upon comprehensive plans and zoning ordinances under certain conditions as described in Sections 619.2 and 1105 of the MPC.

Enclosed is a General Information Form (GIF) completed for this project. Please review the enclosed GIF for the accuracy of answers provided with regard to land use aspects of this project; please be specific and focus on relationship to zoning ordinances. If you wish to submit comments for a land use review of this project, it is important that you respond within 30 days to the DEP Regional Office referenced in this letter. If there are no land use comments received by the end of the comment period, DEP will assume that there are no substantive land use conflicts and proceed with the normal application review process.

This letter serves as your notification of (Company Name) intent to submit an application to DEP as required by Act 14, which amended the Commonwealth of Pennsylvania's Administrative Code and Acts 67, 68, and 127, which amended the Commonwealth's Municipalities Planning Code.

Sincerely,
(Name)

Enclosure

Appendix D – Hydrogeologic Report Components

A hydrogeologic report, signed and sealed by a professional geologist, should be submitted to DEP as part of the planning submission (domestic wastewater projects) or WQM permit (industrial projects). The report should be organized in a concise manner and contain the following information:

1. An electronic or paper copy of all raw data.

2. A final representative description of the hydrogeologic framework of the project area (hydrogeologic conceptual model). Describe in detail any observations and observation locations and supply appropriate citations for information from published literature.

3. A detailed description of the aquifer testing and analysis used to complete the groundwater mounding assessment.

4. Plot plan of appropriate scale that clearly depicts the following:

    a. All test wells and observation wells.

    b. Location of all surface waters including springs on or near to the site.

    c. Pre-pumping water table elevation contours or potentiometric surface; show natural groundwater flow direction or directions.

    d. Any additional sources of similar contamination within the area or on properties adjacent to the project area.

    e. All wells, public and private, on all adjacent properties. All wells within 400 feet of the proposed land treatment site. All public wells and water supply intakes within 1 mile of the site. Describe the extent of any public water service suppling water to properties in the area of the land treatment site.

    f. All nearby surface water features within the area of the project.

    g. Geologic formations underlying the proposed site. Illustrate and geologic contacts or faults at the site.

5. Well log for each test and observation well showing for each well drilled:

    a. Lithology

    b. Depth to all formation changes

    c. Depth to all water-bearing zones with associated yields

    d. Static water level

e. Type, size, and depth of all casing(s)

f. Amount, type, and depth of grout

g. Open-hole or screened intervals/gravel pack, if any

6. Aquifer test information and data:

a. Pre-pumping static water level

b. Raw drawdown and recovery data from the test well and all observation points. Include time since pumping began (in minutes), water elevations (from below ground level), drawdown (in feet and tenths), and discharge (in gpm).

c. Depth of test pump setting

d. Starting and ending time of test cycle

e. Pumping rate

f. Time-drawdown curves for test well and observation wells

g. Time-recovery curves for test well and observation wells

h. Distance-drawdown curves using data from observation points

i. Identification and explanation of irregularities, abrupt slope changes, etc., in graphs

7. Aquifer characteristics **- show references for the methods used**:

a. Hydraulic conductivity

b. Transmissivity

c. Storage coefficient

d. Specific capacity

8. All additional information that describes the hydraulic characteristics of the aquifer and demonstrates the suitability of the proposed source.

9. Groundwater mounding analysis and results **- show references for the methods used**.

10. Dispersion plume analysis and results **- show equations used and calculations**.

Appendix E – Storage Volume Calculations

Example E-1 Storage Volume Requirements Using Storage Water Balance Calculations

Conditions

1. Annual wastewater hydraulic loading rate, L_w = 4 ft/yr
2. Total yearly flow is 96,342,074 gal, with monthly flow rates given in Column (2) of the table.
3. Assume total land treatment area of 75 acres.

Calculations

1. Tabulate the design monthly hydraulic loading rate as indicated in Column (1) of Table E-1.

$$L_w = \left(\frac{4\,ft}{yr}\right)\left(\frac{12\,in}{ft}\right)\left(\frac{yr}{12\,mo}\right) = 4\,\frac{ft}{mo}$$

2. Convert actual volume of wastewater available each month to units of depth (cm). Results are tabulated in Column (3) of Table E-1. For example, for April:

$$W_a = \frac{Q_m}{A_w}\left(\frac{1\,ft^3}{7.48\,gal}\right)\left(\frac{1\,acre}{43{,}560\,ft^2}\right)\left(\frac{12\,in}{ft}\right) = \frac{Q_m}{27{,}152.4 \bullet A_w}$$

3. Compute the net change in storage each month by subtracting the monthly hydraulic loading rate from the available wastewater, as indicated in Column (4) of Table E-1. For April,

$$\Delta S = 5.18\,in - 4.00\,in = 1.18\,in$$

4. Compute the cumulative storage at the end of each month by adding the change in storage during one month to the accumulated quantity from the previous month, as indicated in Column (5) of Table E-1. For May,

$$Cum\ Storage = 0\,in + 1.18\,in = 1.18\,in$$

5. Calculate the required storage volume using the maximum cumulative storage.

$$V_s = (9.05\,in)(75\,acre)\left(\frac{1\,ft}{12\,in}\right)\left(\frac{43{,}560\,ft^2}{acre}\right) = 2{,}464{,}325\,ft^3$$

Example E-1, continued

Table E-1. Initial Estimation of Storage Volume Requirements Using Water Balance Calculation

Annual Wastewater Hydraulic Loading Rate, ft/yr =	4
Total Land Treatment Area, acre	75

Month	(1) L_w, in	(2) Q_m, gal	(3) W_a, in	(4) Change in Storage (ΔS), in	(5) Cumulative Storage, in
April	4	10,558,036	5.184580643	1.184580643	0
May	4	11,217,913	5.508616933	1.508616933	1.184580643
June	4	13,197,544	6.480725803	2.480725803	2.693197576
July	4	11,217,913	5.508616933	1.508616933	5.173923379
August	4	11,877,790	5.832653223	1.832653223	6.682540312
September	4	9,238,281	4.536508062	0.536508062	8.515193535
October	4	6,598,772	3.240362902	-0.759637098	9.051701598
November	4	3,959,263	1.944217741	-2.055782259	8.2920645
December	4	3,959,263	1.944217741	-2.055782259	6.236282241
January	4	3,959,263	1.944217741	-2.055782259	4.180499982
February	4	3,959,263	1.944217741	-2.055782259	2.124717723
March	4	6,598,772	3.240362902	-0.759637098	0.068935464
		96,342,074			9.051701598
Required Storage Volume, ft^3 =		2,464,325.76			

Example E-2. Calculations to Determine Final Storage Volume Requirements

Conditions

1. Monthly evapotranspiration (ET) and precipitation (Pr) data indicated in Table E-2, Columns (1) and (2).
2. Assume seepage from pond is negligible.
3. Initial conditions and estimated storage volume from Example E-1.
4. Assume initial storage pond depth of 4 m.

Calculations

1. Using the initial estimated storage volume and an assumed storage pond depth compatible with local conditions, calculate a required surface area for the storage pond:

$$A_s = \frac{2{,}464{,}325\ ft^3}{10\ ft} = 246{,}433\ ft^2$$

2. Calculate the monthly net volume of water gained or lost from storage due to precipitation, evaporation, and seepage. For example, for April,

$$\Delta V_s = (0.8\ in - 5.2\ in - 0\ in)(246{,}433\ ft^2)\left(\frac{1\ ft}{12\ in}\right) = -90{,}359\ ft^3$$

3. Estimated lake evaporation in the local area should be used for E, if available. Lake evaporation data is given in Appendix F of this manual. Potential ET values may be used if no other data are available. Tabulate monthly values and sum to determine the net annual ΔV_s. Results are tabulated in Column (3) of Table E-2.

4. Tabulate the volume of wastewater available each month (Q_m), given in Example E-1.

5. Calculate an adjusted field area to account for annual net gain/loss in storage volume.

$$A'_w = \frac{-1{,}074{,}035 ft^3 + 96{,}342{,}074\ gal\left(\frac{1\ ft^3}{7.48\ gal}\right)}{(4\ ft)} = 2{,}951{,}480 ft^3$$

6. Calculate the monthly volume of applied wastewater using the design monthly hydraulic loading rate and adjusted field area:

$$V_w = \left(\frac{4\ ft}{yr}\right)\left(\frac{yr}{12\ mo}\right)(2{,}951{,}480 ft^3) = 983{,}827\ ft^3$$

7. Calculate the net change in storage each month by subtracting the monthly applied wastewater (V_w) from the sum of available wastewater (Q_m) and net storage gain/loss (ΔV_s) in the same month. Results are tabulated in Column (6) of Table E-2. For example, for April,

$$\Delta V_s = -90{,}359 ft^3 + 10{,}558{,}036\ gal\left(\frac{1 ft^3}{7.48\ gal}\right) - 983{,}827 = 337{,}317\ ft^3$$

8. Calculate the cumulative storage volume at the end of each month by adding the change in storage during one month to the accumulated total from the previous month. The maximum monthly cumulative volume is the storage volume requirement used for design. Results are tabulated in Column (7) of Table E-2. For this example, design

$$V_s = 2{,}202{,}048\ ft^3$$

9. Adjust the assumed value of storage pond depth (d_s) to yield the required design storage volume:

$$d_s = \frac{2{,}202{,}048\ \text{ft}^3}{246{,}433\ ft^2} = 8.94\ ft$$

Table E-2. Final Design of Storage Volume Calculations

Annual Wastewater Hydraulic Loading Rate, ft/yr =	4
Assumed Depth of Storage Basin, ft =	10
Area of Storage Basin, ft^2 =	246,432.58
Adjusted Field Area, ft^2 =	2,951,480

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Month	ET, in	Pr, in	ΔV_s Net gain/loss, ft^3	Q_m, gal	V_w, ft^3	ΔV_s, ft^3	Cumulative Storage, ft^3
April	5.2	0.8	-90,359	10,558,036	983,827	337,317	-
May	7	0.2	-139,645	11,217,913	983,827	376,249	337,317
June	8.6	0.1	-174,556	13,197,544	983,827	605,994	713,566
July	9.4	0	-193,039	11,217,913	983,827	322,855	1,319,560
August	8.7	0	-178,664	11,877,790	983,827	425,449	1,642,416
September	5.8	0.1	-117,055	9,238,281	983,827	134,182	2,067,865
October	4.3	0.3	-82,144	6,598,772	983,827	-183,782	**2,202,047**
November	2	0.5	-30,804	3,959,263	983,827	-485,318	2,018,265
December	1	1	0	3,959,263	983,827	-454,513	1,532,947
January	0.9	1.2	6,161	3,959,263	983,827	-448,353	1,078,434
February	2	1.1	-18,482	3,959,263	983,827	-472,996	630,081
March	3.8	1.1	-55,447	6,598,772	983,827	-157,085	157,085
Annual			-1,074,035	96,342,074			2,202,047

Calculated Storage Depth, ft = 8.94

Appendix F – Pan Evaporation Data
(in inches/month)

Location	January-March	April	May	June	July	August	September	October	November-December
F.E. Walter Dam (Northeast PA)	0	3.45	4.87	5.63	6.07	5.16	3.56	2.48	0
Landisville (Southeast PA)	0	0	5.68	6.77	6.83	5.64	3.98	2.82	0
Raystown Dam (Central PA)	0	0	5.61	6.05	6.24	5.73	4.28	2.94	0
Jamestown (Northwest PA)	0	0	4.38	4.91	5.11	4.24	3.43	1.75	0
Ford City (West Central PA)	0	0	5.46	6	6.29	5.55	4.3	2.87	0
Confluence (Southwest PA)	0	3.58	4.47	5.15	5.41	4.57	3.3	2.3	0

Appendix G – Standard Spray Irrigation Loading Rates

Table G-1. Example Southeastern PA Standard Loading Rates,
Deep Well-Drained Soils

Month	Spray Days	In/Ac/Wk	Gal/Ac/Wk	Gal/Ac/day	Gal/Ac/Mo
November	26	1.75	47,542	6,792	176,592
December	15	0.50	13,583	1,940	29,100
January	9	0.50	13,583	1,940	17,460
February	9	0.50	13,583	1,940	17,460
March	23	1.50	40,750	5,821	133,883
April	27	1.50	40,750	5,821	157,167
May	31	2.00	54,333	7,762	240,622
June	30	2.50	67,917	9,702	291,060
July	31	2.50	67,917	9,702	300,762
August	31	2.50	67,917	9,702	300,762
September	30	2.50	67,917	9,702	291,060
October	31	2.00	54,333	7,762	240,622
				Total Gal/Ac/Year	2,196,550
Total	293			Average Gal/Ac/Day	6,018

Table G-2. Example Southeastern PA Standard Loading Rates,
Deep Moderately Well-Drained Soils

Month	Spray Days	In/Ac/Wk	Gal/Ac/Wk	Gal/Ac/day	Gal/Ac/Mo
November	26	0.50	13,583	1,940	50,440
December	15	0.50	13,583	1,940	29,100
January	9	0.50	13,583	1,940	17,460
February	9	0.50	13,583	1,940	17,460
March	23	0.50	13,583	1,940	44,620
April	27	1.00	27,167	3,881	104,787
May	31	1.00	27,167	3,881	120,311
June	30	1.50	40,750	5,821	174,630
July	31	1.50	40,750	5,821	180,451
August	31	1.50	40,750	5,821	180,451
September	30	1.00	27,167	3,881	116,430
October	31	1.00	27,167	3,881	120,311
				Total Gal/Ac/Year	1,156,451
Total	293			Average Gal/Ac/Day	3,168