GUIDELINES FOR SLOW-RATE LAND TREATMENT OF WASTEWATER VIA SPRAY IRRIGATION

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1.0 INTRODUCTION

1.1 Purpose

This document provides guidelines and criteria for the planning, design, and operation of slow-rate land treatment systems in Georgia. It is a revision/update of previous versions of the document and reflects lessons learned from construction and operation of land application systems through the intervening years. These guidelines and criteria do not apply to systems utilizing overland flow, drip irrigation, constructed wetlands, or rapid infiltration.

The term slow-rate land treatment as used in this document refers to the treatment of wastewater by spray irrigation onto land to support vegetative growth. These systems are to be designed and operated so that there is no direct discharge to surface waters. The irrigated wastewater evaporates and transpires to the atmosphere or enters the groundwater through percolation. Organic constituents in the wastewater are stabilized by soil bacteria. Organic and ammonia nitrogen are taken up by plants, nitrified by soil bacteria, lost to the atmosphere through denitrification, and minimally leached into the groundwater. Phosphorus and other constituents are adsorbed in the soil profile and taken up by plants. Properly designed and operated land treatment systems produce a percolate water of high quality and thus protect ground and surface water resources.

The criteria in this document apply primarily to domestic wastewater. Land treatment systems for industrial and animal wastes will be evaluated on an individual basis, since treatment requirements for those wastes may differ significantly from those for domestic wastewater.

Finally, **this document is not intended to be a cookbook**. The design and operation of land treatment systems are very site-specific. Hydrogeologic conditions vary widely throughout the State and site assessment and monitoring requirements may vary not only from region to region, but even from site to site within the same region.

1.2 Sources of Information

The Environmental Protection Division (EPD) recommends the following additional sources of information for the planning, design and operation of slow-rate land treatment systems.

1.2.1 Organizations

a. Georgia Automated Environmental Monitoring Network
b. The Irrigation Association
c. Natural Resources Conservation Service
d. National Oceanic and Atmospheric Administration
e. United States Environmental Protection Agency
f. University of Georgia College of Agricultural & Environmental Sciences
g. University of Georgia Warnell School of Forestry and Natural Resources

2.0 PROCEDURES FOR STATE REVIEW AND APPROVAL

2.1 Proposal for Land Treatment

The *Georgia Water Quality Control Act* and the *Georgia Rules and Regulations for Water Quality Control* govern procedures necessary to gain State of Georgia approval for slow-rate land treatment systems. The steps outlined in Table 2.1-1 are in accordance with the Act and Rules. These steps are explained in the following sections. Projects funded under the State Revolving Loan Fund Program (SRF) (Title VI of the *Federal Clean Water Act*) must meet certain federal requirements in addition to the steps listed in Table 2.1-1.

2.1.1 Site Inspection and Concurrence

The owner, the owner's engineer or agent must submit to EPD a letter of intent to develop a slow-rate land treatment system. The letter should indicate the projected design flow for this system and proposed source(s) of project funding. The letter should also request a site inspection. Accompanying the letter of intent should be a Site Selection and Evaluation Report. The report must identify potential land treatment sites and provide a preliminary environmental and soil evaluation of selected sites. Table 2.1-2 outlines information generally needed in the Site Selection and Evaluation Report. Additional information may be required as needed.

Upon receipt of the report, an EPD representative will inspect the selected site(s). A preliminary site concurrence or denial letter will be written based on an engineering and geologic evaluation of site conditions. It should be noted that site concurrence is preliminary and pertains only to general wastewater treatment and application to the land. The letter will indicate what requirements are necessary to proceed with the project. Site concurrences for slow-rate land treatment are valid for one year. If detailed design has not begun within this period, EPD may choose to reevaluate the project.

2.2 Environmental Information Document and Design Development Report

After a site has been selected by the owner and accepted by EPD as suitable for slow-rate land treatment, the owner must complete an Environmental Information Document (EID) and prepare a Design Development Report (DDR). The EID is to be developed prior to the DDR, and is recommended for all projects but required for municipal projects. The EID shall be a short and concise document that adequately discusses the environmental impact of the proposed project and is not expected to be a complete environmental impact study. The preparer of the document should consider the environmental impacts identified in the latest edition of EPD's *Environmental Information Document Guidance*. All areas may not be pertinent for each project and the degree of detail will vary depending on the project size and location. The DDR must bear the stamp of a Professional Engineer registered in the State of Georgia, and should include, but is not limited to, the information outlined in Tables 2.2-1 and 2.2-2.

When the EID is completed and prior to submitting it for EPD review, the owner must conduct at least one public meeting. The purpose of the meeting is to allow public input regarding the proposed project, its purpose, its design, and its environmental impacts. The meeting date and time must be advertised at least 30 days in advance in local newspapers with circulation covering all areas impacted by the project. The owner must make provisions to receive written comments from the public. Minutes of the public meeting, proof of advertisement, and opinions derived from the meeting must be submitted to EPD with the EID. The DDR can be completed and submitted for review once the public input from the EID has been evaluated and acted upon.

2.3 Permitting of Slow-Rate Land Treatment Systems

2.3.1 Trust Indenture

In order to ensure continuity of operation and maintenance, a trust indenture is required for all privately-owned facilities. The permittee must attempt to acquire a trust indenture with a local government. If a local government is not willing to serve as a trustee, EPD will consider allowing a non-governmental entity as trustee. In either case, we recommend that appropriate financial security be provided to allow continued operation of the system. Typically, the financial security is in the form of a bond or letter of credit with the minimum amount being equal to the cost of major component replacement, as well as projected operation and maintenance costs of the facility, for three years. EPD has developed a sample trust indenture document that is available upon request.

2.3.2 Public Notice, Draft and Final Land Application System (LAS) Permits

Upon EPD concurrence with the DDR and EID, the owner of the proposed facility must submit a written application for a Georgia Land Application System (LAS) Permit. Upon receipt of a completed application for this permit, EPD will prepare a draft LAS Permit and public notice for the project. One copy of the public notice will be transmitted to the owner for local advertisement and one copy will be published by EPD. The cost of the local advertisement is to be borne by the owner.

A 30-day comment period follows the publication date of each public notice. If no significant adverse public comments are received, a final LAS Permit may be issued for the slow-rate land treatment system.

2.3.3 Operations Manual

An outline for the scope of the Operations Manual (OM) required for the system is presented in Appendix Section 6.1. The OM is written by the owner or owner's engineer during construction of the system. In order to allow time for EPD input, we recommend that a draft manual be submitted to EPD by the time construction of the facility is 50% complete. The OM must address wastewater application rates, spray field cycling, monitoring requirements, harvesting schedules, maintenance schedules, and all other information necessary for successful operation of the system.

Table 2.1-1
STEPS FOR EPD REVIEW AND APPROVAL OF SLOW-RATE LAND TREATMENT SYSTEMS

1.0 Letter of Intent, Site Selection & Evaluation Report submitted to EPD by owner or owner's representative
    1.1 EPD conducts site inspection
    1.2 Site concurrence or denial issued by EPD

2.0 Environmental Information Document, required for municipal systems
    2.1 Owner holds public meeting
    2.2 Submitted with minutes from public meeting

3.0 Design Development Report
    3.1 Submitted for EPD review
    3.2 Accepted by EPD as the basis for facility design
    3.3 Permit application sent to owner

4.0 Application for permit to apply treated wastewater to land
    4.1 Permit application completed and submitted to EPD
    4.2 Application reviewed and checked against DDR and EID
    4.3 Trust Indenture executed for privately owned facilities

5.0 Land Application System (LAS) Permit drafted by EPD
    5.1 Industrial pretreatment requirements included, if necessary
    5.2 Draft permit and monitoring requirements sent to owner for comment
    5.3 Draft permit modified if necessary

6.0 Public Notice
    6.1 Public notice drafted by EPD
    6.2 One copy transmitted to owner for advertisement, one copy advertised by EPD
    6.3 Public comment period
    6.4 Public notice requirements completed

7.0 Final Land Application System (LAS) Permit issued
    7.1 Signed by Division Director
    7.2 Sent to facility owner

8.0 Plans and Specifications
    8.1 Submitted for EPD review
    8.2 Checked against accepted DDR
    8.3 Approved by EPD for construction

9.0 Operations Manual

- 9.1 Submitted by owner for EPD review
- 9.2 Accepted by EPD

10.0 Certification of Construction Completion
- 10.1 Submitted to EPD by design engineer
- 10.2 EPD conducts facility inspection to verify compliance with approved plans and specifications and readiness to operate

11.0 Authorization to commence operation
- 11.1 Owner submits written request to EPD to commence operation at design flow
- 11.2 EPD issues written authorization

Table 2.1-2
SITE SELECTION AND EVALUATION REPORT
(REQUIRED INFORMATION FOR EACH SITE UNDER CONSIDERATION)

1.0 Site Description
- 1.1 Location map
- 1.2 Topographic map
- 1.3 Soil survey map
- 1.4 Known cultural or historic resources (cemeteries, archaeological sites, etc)

2.0 Site Soil Characteristics
- 2.1 United States Soil Conservation Service soil series classifications
- 2.2 Narrative description for same including:
  - 2.2.1 Texture
  - 2.2.2 Permeability
  - 2.2.3 Slope
  - 2.2.4 Drainage
  - 2.2.5 Depth to seasonal high water table
  - 2.2.6 Depth to bedrock
  - 2.2.7 Erodibility

3.0 100-year flood elevation for site (Either give the elevation or provide supporting documentation as to how it was determined that the site is not within the 100-year flood zone).

4.0 Existing vegetative cover

5.0 Existing land use

6.0 Present land owner

Table 2.2-1
DESIGN DEVELOPMENT REPORT
RECOMENDED INFORMATION

1.0 Site Description
    1.1 Location map
    1.2 Climate
    1.3 Geology (including subsurface hydrology)
    1.4 Groundwater Potentiometric Surface Map
    1.5 Topography
    1.6 Access
    1.7 Identify water supply wells within 2500 L.F. of facility

2.0 Scaled drawing with 2-foot elevation contours showing the preliminary site layout, including
    2.1 Preapplication treatment facility
    2.2 Storage pond(s)
    2.3 Spray fields (show field number/designation, usable acreage, and total acreage)
    2.4 Buffer zones
    2.5 Hand auger, test pit and soil boring locations
    2.6 Access roads and utilities
    2.7 Watercourses
    2.8 Drainage Structures
    2.9 Flood Elevations
    2.10 Residences and habitable structures within or adjacent to site

3.0 Design wastewater characteristics (influent to preapplication treatment and treated effluent to spray fields). If the project involves an existing facility, then actual, recent data must be used
    3.1 Average and peak daily flows
    3.2 Industrial Flows
    3.3 Biochemical Oxygen Demand [a]
    3.4 Total Suspended Solids
    3.5 Ammonia Nitrogen, Total Kjeldahl Nitrogen, Nitrate and Nitrite
    3.6 Total Phosphorus
    3.7 Chloride
    3.8 Sodium Adsorption Ratio [b]
    3.9 Electrical Conductivity
    3.10 Metals/Priority Pollutants [c]

4.0 Water balance and determination of design wastewater loading rates for each sprayfield (if appropriate)

5.0 Nitrogen balance and selection of cover crop and management scheme

6.0 Background groundwater samples

7.0 Phosphorus and other constituent loading rates

8.0 Determination of wetted field area(s) and required storage volume

9.0 Process design for preapplication treatment facility
  9.1 Schematic of pump stations and unit processes
  9.2 Basin volumes, loading rates, hydraulic detention times, etc.
  9.3 Capacity of pumps, blowers and other mechanical equipment (information for the irrigation pump station must accompany plans and specifications submittal)
  9.4 Preliminary hydraulic profile

10.0 Detailed Soil Investigation Report (reference Table 2.2-3)

a Chemical Oxygen Demand or Total Organic Carbon may be substituted for industrial wastewaters where appropriate.

b Sodium Adsorption Ratio = $\frac{\mathrm{Na}^{+1}}{\mathrm{SQRT}\ [(Ca^{+2} + Mg^{+2})/\ 2]}$

Where Na^{+1}, Ca^{+2} and Mg^{+2} in the wastewater are expressed in milliequivalents per liter (meq/l) and SQRT represents "square root of".

c Metal and priority pollutant analysis is required for all industrial wastewaters and municipal wastewater systems that receive industrial process wastes. Analyses required depend on the particular process wastewater being discharged and will be determined on a case-by-case basis. However, <u>in all cases the presence of industrial process wastewaters must be identified.</u>

Table 2.2-2
DETAILED SOIL INVESTIGATION REPORT RECOMENDED INFORMATION

1.0 Site description
  1.1 Location map
  1.2 Topographic map
  1.3 Soil Survey map
  1.4 Hand auger, test pit and soil boring locations

2.0 Soil series descriptions (each soil series present)
  2.1 Texture
  2.2 Permeability
  2.3 Slope
  2.4 Drainage
  2.5 Depth to seasonal high water table
  2.6 Depth to bedrock
  2.7 Erodibility

3.0 Soil characteristics (each soil series present)
  3.1 Hand auger, test pit and soil boring logs
    3.1.1 Soil horizons
    3.1.2 Depth to groundwater
    3.1.3 Depth to rock
  3.2 Unified Soil Classification
  3.3 Results from saturated hydraulic conductivity testing
  3.4 Results from soil chemistry testing
    3.4.1 pH
    3.4.2 Cation Exchange Capacity
    3.4.3 Percent Base Saturation
    3.4.4 Phosphorus Absorption
    3.4.5 Nutrients (N,P,K)
    3.4.6 Agronomic trace elements
    3.4.7 Sodium Absorption Ratio
  3.5 Engineering properties of soils proposed for pond construction
    3.5.1 Clay content
    3.5.2 Permeability
    3.5.3 Plasticity

4.0 Identification of subsurface conditions adversely affecting vertical or lateral drainage of the site

5.0 Delineation of soils and areas suitable and not suitable for land treatment

6.0 Determination of design percolation for each soil type

2.4 Engineering Plans and Specifications

2.4.1 Review

After EPD concurrence with the DDR, the owner must submit detailed construction plans and specifications that have been completed in accordance with EPD’s current rules and guidelines. Pump curves and hydraulic calculations for the distribution system must accompany the plans and specifications, and each of these items will be reviewed for consistency with the DDR and accepted engineering standards. Upon review of the plans and specifications and issuance of the final LAS Permit, a letter approving the plans and specifications for construction can be written. This approval is valid for one year. If construction has not begun within this period, the project may require reevaluation.

IMPORTANT: Plans and specifications will not be approved for construction until a final LAS Permit for the facility has been issued. Detailed design work undertaken prior to permit issuance is at the owner's risk. Approval for construction of a privately-owned LAS is contingent upon execution of a trust indenture and issuance of the final permit (ref. Sec 2.3.1).

2.4.2 Construction

EPD may choose to make interim inspections of projects under construction to ascertain their progress and adherence to the approved plans and specifications. Upon project completion, the design engineer or owner must certify to EPD, in writing, that the project was constructed in accordance with the approved plans and specifications. Upon receipt of this certification, an EPD representative will inspect the completed facility. When the facility is verified as being complete and operational, the permittee must submit to EPD a written request for authorization to operate the facility at the permitted flow limits. Once all of these steps are completed, EPD will issue a letter to the permittee formally authorizing operation under the facility's LAS Permit.

3.0 GUIDELINES AND CRITERIA FOR DESIGN

3.1 Suitability of Sites for Land Treatment

3.1.1 Location

There are two, often contradictory, requirements for slow-rate land treatment sites: proximity to the wastewater source and a large tract of suitable, undeveloped land. Additional considerations include a moderate degree of isolation, ease of access, soil suitability, availability of utilities, and protection from flooding. Land treatment systems can be developed on agricultural land and in forests. Irrigation of public areas, such as golf courses, cemeteries, green areas, and parks, are considered urban water reuse projects and a separate set of guidelines applies to such systems.

3.1.2 Topography

Maximum grades for wastewater spray fields are generally limited to 7 percent for row crops, 15 percent for forage crops and 30 percent in forests. Sloping sites promote lateral subsurface drainage and make ponding and extended saturation of the soil less likely than on level sites.

Convex landscapes with low drainage density are the ideal landscape for land application, allowing uniform distribution of effluent across the landform and optimal land utilization. Areas with high drainage density (the number of intermittent and perennial streams per unit area) are indicative of lower landscapes that receive significant volume of storm water input. In addition, the required drainage buffers will reduce the usable area and economic feasibility. Concave landscapes tend to concentrate water and should be either avoided or considered for lower than typical applications.

3.1.3 Soils

In general, soils with a USDA Natural Resources Conservation Service permeability classification of moderate to moderately rapid (0.6 to 6.0 inches/hour) are suitable for wastewater irrigation. However, groundwater and drainage conditions must also be suitable. Soils that are poorly drained, have high groundwater tables, or restrictive subsurface soil layers are not suitable for slow-rate land treatment without drainage improvements.

3.2 Soil Investigations

3.2.1 General

Soil investigations for land treatment differ greatly from investigations for foundations, roads, and other civil engineering works. As a result, different investigative and testing methods are required. The land treatment soil investigation must characterize the permeability and chemical properties of the soil profile that will act as the media for tertiary wastewater treatment and final disposal. It must also determine the elevation of the seasonal high groundwater, establish the groundwater flow direction and gradient, and identify any subsurface conditions that may limit the vertical or lateral drainage of the land treatment site. The number of soil samples necessary to supply all of this information will be dependent on the nature of the particular site and is a matter of professional judgment. The specific information required for design is outlined in Table 2.2-2.

3.2.2 Saturated Hydraulic Conductivity Testing

Saturated vertical hydraulic conductivity testing is required for the most limiting horizon of each soil series present. The most limiting soil horizon for each soil type should be determined from soil survey information. A minimum of three (3) tests for each soil series should be performed. **If the proposed site is to be clear-cut, the permeability tests must be done following the clear-cutting and establishment of a vegetative cover**. However, clear-cutting and site disturbance should be kept to a minimum wherever possible. Testing for saturated horizontal hydraulic conductivity is additionally required when subsurface drainage systems are planned or when lateral subsurface drainage is the predominant drainage mechanism for the land treatment site.

Acceptable methods for saturated hydraulic conductivity testing are listed in Table 3.2-1. Percolation tests as performed for septic tank drain fields are not acceptable.

The identification of the limiting layer is critical to development of feasible loading rates. Many impeding layers are obvious, such as compacted or brittle layers, rock and water tables. In soils without these features, identifying the limiting layer is more difficult.

3.2.3 Soil Chemical Testing

The pH, Cation Exchange Capacity, and Percent Base Saturation, of each soil series must be determined from samples taken from the A and B horizons. These chemical tests determine the retention of wastewater constituents in the soil and the suitability of the soil for different cover crops. A minimum of three (3) samples for each soil series should be taken. Testing for soil nutrients (nitrogen, phosphorus, and potassium) and agronomic trace elements may be included if appropriate for the vegetative management scheme.

Soil chemical testing should be conducted in accordance with the latest methodology published by the American Society of Agronomy, USEPA, or other recognized authority.

Table 3.2-1
HYDRAULIC CONDUCTIVITY TEST METHODS

1.0 Saturated Vertical Hydraulic Conductivity [a]

1.1 Laboratory Tests: [b]

Constant Head Method (coarse-grained soils)	ASTM D 2434-68 AASTHO T 215-70 Bowles (1978), pp 97-104 Kezdi (1980), pp 96-102
Falling Head Method [c] (cohesive soils)	Bowles (1978), pp 105-110 Kezdi (1980), pp 102-108

1.2 Field Tests:

Ring Permeameter Method	Boersma (1965) U.S. EPA (1981), pp 3-22 to 23
Double Tube Method	Bouwer and Rice (1966) U.S. EPA (1981), pp 3-22 to 24
Air-Entry Permeameter Method	Bouwer (1966) Reed and Crites (1984), pp 176 to 180 Topp and Binns (1976) U.S. EPA (1981), pp 3-22 to 27
Constant Head Permeameter	Amoozegar (1989) Soil Sci. Soc. Am. J. 53:1356-1361

2.0 Saturated Horizontal Hydraulic Conductivity [a, d]

2.1 Field Tests:

Auger Hole Method [c]	Reed and Crites (1984), pp 165 to 168 U.S. EPA (1984), pp 3-31 to 35
Slug Test	Bouwer and Rice (1976)

[a] Other methods, properly documented, may be accepted by EPD. However, "standard" percolation tests as performed for septic tank drain fields are not acceptable.

[b] These tests require <u>undisturbed</u> field samples properly prepared to ensure saturation. Reconstructed field samples are not acceptable. A description of the field sampling technique should accompany the laboratory testing results.

[c] Methods recommended by EPD.

[d] Testing for saturated horizontal hydraulic conductivity is required at land treatment sites where drainage improvements are planned and where lateral, as opposed to vertical subsurface drainage, is the predominant drainage pathway.

3.3 Preapplication Treatment Requirements

3.3.1 General

Land treatment systems have a demonstrated ability to treat high strength organic wastes to low levels. However, such systems require a high degree of management with particular attention paid to organic loading rates and re-aeration of the soil profile between wastewater applications.

EPD requires that all domestic wastewater receive biological treatment prior to irrigation. This is necessary to protect the health of persons contacting the irrigated wastewater and to reduce the potential for odors in storage and irrigation. LAS permits will have a BOD limit of no greater than 50 mg/L.

Some industrial wastewaters may be suitable for direct land treatment by spray irrigation under intensive management schemes. EPD will evaluate such systems on a case-by-case basis.

3.3.2 BOD and TSS Reduction, and Disinfection

Preapplication treatment standards for domestic wastewater prior to storage and/or irrigation are as follows:

a. Restricted Use (No Public Access) - All wastewater must be treated to a 5-day Biochemical Oxygen Demand of 50 mg/L at average design flow and 75 mg/L under peak loads. Total Suspended Solids are limited to 50 mg/L for mechanical systems and 90 mg/L for non-aerated ponds. Disinfection is generally not required for restricted access land treatment sites. EPD may, however, require disinfection when deemed necessary.

b. Limited Use (Controlled Public Access) - All wastewater must be treated to a 5-day Biochemical Oxygen Demand of 30 mg/L at average design flow and 50 mg/L under peak loads. Total Suspended Solids are limited to 30 mg/L. Disinfection is generally required, usually to achieve a fecal coliform limit of 200 MPN/100 mL.

c. Water Reuse (Unlimited Public Access) - Sites open to public access include golf courses, green areas, parks, and other public or private land not expressly closed to the public. Such projects are considered urban water reuse systems and requirements are outlined in separate EPD guidance.

3.3.3 Nitrogen

Maximum nitrogen removal occurs when nitrogen is applied to the site in the ammonia or organic form. Nitrate is not retained by the soil and leaches to the groundwater, especially during periods of dormant plant growth. Therefore, the preapplication treatment system should be designed so as not to produce a highly-nitrified effluent. A description of the anticipated range of nitrogen removal should be included in the DDR.

3.3.4 Treatment and Storage Ponds

At least two treatment cells followed by a storage pond and irrigation pump station are required for all pond preapplication treatment systems. The treatment cells may be aerated, facultative or a combined aerated/facultative system. They may be separated by earthen dikes or floating baffles. However, the storage pond and irrigation pump station must be hydraulically separate from the treatment cells (i.e., pumping must not affect hydraulic detention time in these cells).

IMPORTANT: If initial flows are going to be significantly below design, EPD recommends that the construction be phased. The storage pond should not be built for ultimate flow. Phasing is necessary to avoid erosion, odor, and liner failure problems that can occur in such circumstances.

Ponds used for preapplication treatment must have liners to prevent seepage from exceeding 1/8 inch/day. Either properly constructed clay or synthetic liners may be used. Facultative pond cells should have a length to width ratio of 4:1 (to minimize short circuiting) with a depth of between 3 and 5 feet. Sizing of complete and partially mixed aerated ponds should be based on first-order removal rate kinetic equations and the expected annual temperature variation. A 2-foot freeboard is recommended for all ponds less than or equal to six acres and a 3-foot freeboard is required for all ponds larger than six acres.

Ponds used for storage of treated wastewater must have liners to prevent seepage from exceeding 1/8 inch/day. Because storage ponds fluctuate greatly in water level, it is extremely difficult to maintain an effective clay liner due to drying, cracking, and erosion. EPD highly recommends synthetic liners for storage ponds. If clay liners are used, synthetic or concrete slope protection must be used on interior slopes from six (6) inches above the maximum operational water level to one (1) foot below the lowest operational water level. An appropriate water level must be maintained at all times in clay-lined ponds. EPD recommends the use of multiple outlet points to allow for effluent draw off from different elevations within the storage pond.

Pond dikes must not exceed 3:1 for internal or external slopes. Any pond with a dike taller than 25 feet or which stores in excess of 100 acre-feet (32.6 MG) of water at maximum depth must comply with the Safe Dam Regulations of EPD.

3.4 Soil and Cover Crop Compatibility

Inorganic constituents of effluent from preapplication treatment should be compared with Table 3.4-1 to ensure compatibility with the land application site soils and cover crops.

3.5 Protection of Irrigation Equipment

Prior to pumping to the spray field distribution system, the wastewater must be screened to remove fibers, coarse solids, oil and grease, etc. which might clog distribution pipes or spray nozzles. At a minimum, screens with a nominal diameter equal to the smallest flow opening in the distribution system should be provided. Some sprinkler manufacturers recommend screening to remove solids greater than one third (1/3) the diameter of the smallest sprinkler nozzle. The planned method for disposal of the screenings must be provided.

Pressurized, clean water for backwashing screens should be provided. This backwash may be manual or automated. Backwashed screenings should be captured and removed for disposal.

3.6 Determination of Design Percolation Rate(s)

3.6.1 General

One of the first steps in the design of a slow-rate land treatment system is to develop a design percolation rate. This value is used in water balance calculations to determine design wastewater loading rate(s) and thus spray field area requirements. The percolation rate is a function of soil permeability and drainage. Because different soil types may have different limiting percolation rates and because the soil types may vary from field to field, it may be necessary for a system to have different design percolation rates for each field.

3.6.2 Design Values

The most limiting layer, i.e. A, B, or C horizon, of each soil series must be identified. Any subsurface conditions that limit the vertical or lateral drainage of the soil profile must also be identified. Examples of such conditions are shallow bedrock, a high water table, aquitards, and extremely anisotropic soil permeability. Values of saturated vertical hydraulic conductivity from soil testing are used to develop the design percolation rate.

Values of saturated vertical hydraulic conductivity must be modified by an appropriate safety factor to determine the design percolation rate. The safety factor reflects the influence of several elements, including: the fact that long periods of saturation are undesirable, the uncertainty of test values, the drainage characteristics of the land treatment site, the variation of permeability within the soil series, the rooting habits of the vegetation, the soil reaeration factors, and the long-term changes in soil permeability due to wastewater application. EPD recommends that the design percolation rate at land treatment sites with seasonal high groundwater at depths greater than 5 feet be no more than 10 percent of the mean saturated vertical hydraulic conductivity of the most limiting layer within the first five feet of the surface.

Sites with seasonal high groundwater less than 5 feet from the surface may require drainage improvements before they can be utilized for slow-rate land treatment. The design percolation at such sites is a function of the design of the drainage system. A safety factor not exceeding 10 percent should be applied to field measured values of vertical and horizontal hydraulic conductivity used for design of subsurface drainage systems.

Table 3.4-1
SUGGESTED VALUES FOR INORGANIC CONSTITUENTS IN WASTEWATER APPLIED TO LAND

Based on (Georgia DNR, 1978; U.S. EPA, 1976 & 1981)

Potential Problem and Constituent	No Problem	Increasing Problem	Severe
pH (standard units)	6.5 - 8.4	4.2 - 6.5	< 4.2 or > 8.5
Permeability			
Electrical Conductivity (µmho/cm)	> 0.50		< 0.2
Sodium Adsorption Ratio [a]	2.0		5.0
Salinity			
Electrical Conductivity (µmho/cm)	< 0.75	0.75 - 3.0	> 3.0
Specific Ions - Anions			
Bicarbonate as $CaCO_3$, (meq/L)	< 1.5	1.5 - 8.5	> 8.5
(mg/L)	< 90	90 - 520	> 520
Chloride (mg/L)	< 142	142 - 355	> 355
Specific Ions - Cations			
Ammonia (mg/L as N)	< 5.0	5.0 - 30	> 30
Sodium (meq/L)	< 3.0	> 3.0	
(mg/L)	< 69	> 69	
Specific Ions - Trace Metals			
Arsenic (mg/L)	< 0.1	0.1 - 0.2	0.2 - 2.0
Beryllium (mg/L)	< 0.1	0.1 - 0.2	0.2 - 0.5
Boron (mg/L)	< 0.5	0.5 - 1.4	1.4 - 2.0
Cadmium (mg/L)	< 0.01	0.01 - 0.02	0.02 - 0.05
Chromium (mg/L)	< 0.1	0.1 - 0.2	0.2 - 1.0
Cobalt (mg/L)	< 0.1	0.1 - 0.5	0.5 - 5
Copper (mg/L)	< 0.2	0.2 - 0.4	0.4 - 5
Iron (mg/L)	< 10	5 - 10	10 - 20

Potential Problem and Constituent	No Problem	Increasing Problem	Severe
Lead (mg/L)	< 10	5 - 10	10 - 20
Lithium (mg/L)	< 2.0	2.0 - 2.5	> 2.5
Mercury (mg/L)	no standard		
Molybdenum (mg/L)	< 0.01	0.01 - 0.02	0.02 - 0.05
Nickel (mg/L)	< 0.2	0.2 - 0.4	0.4 - 2.0
Selenium (mg/L)	< 0.02	0.02 - 0.04	> 0.04
Zinc (mg/L)	< 2.0	2.0 - 4.0	4 - 10

a Sodium Adsorption Ratio = $\frac{Na^{+1}}{\text{SQRT }[(Ca^{+2} + Mg^{+2})/ 2]}$

Where Na^{+1}, Ca^{+2} and Mg^{+2} in the wastewater are expressed in milliequivalents per liter (meq/l) and SQRT represents "square root of".

3.7 Determination of Design Wastewater Loading Rate(s)

3.7.1 General

The design wastewater loading rate is a function of:

a. Precipitation.
b. Evapotranspiration.
c. Design percolation rate.
d. Nitrogen loading limitations.
e. Other constituent loading limitations.
f. Groundwater and drainage conditions.
g. Average and peak design wastewater flows.

Therefore, developing the design wastewater loading rate is an iterative process. An initial value is selected from water balance calculations and used to determine wetted field area. This loading rate is then compared to nitrogen and other constituent loading limitations (reference Section 3.8). If the initial value exceeds these limitations, the design wastewater loading rate is reduced and the process is repeated. This iterative process is illustrated in Appendix Section 5.4.

EPD limits design wastewater loading rates (WLR_D) for non-reuse systems to a maximum of 2.5 inches/week and instantaneous wastewater application rates to 0.25 inches/hour. Requests for higher loadings will be evaluated on a case-by-case basis. The design wastewater loading may be fixed at a constant rate or may vary seasonally or monthly but it must account for site-specific climatic and drainage limitations. Also, because a given site may include several different soil types with significant variation in their permeabilities, it is possible that there may be different application rates for different areas of the site. EPD recommends that when this is the case, the fields be laid out to separate the soils with different permeabilities. However, if this is not done and a field includes more than one soil type, the application rate will be limited to the most restrictive soil permeability.

3.7.2 Water Balance

Wastewater loading rates are determined from the following water balance equation:

$$WLR_D = (Evap + Perc) - Precip \qquad \textbf{eq. 3.7.2}$$

Where,	*WLR_D*	=	Design wastewater loading rate (in/month), may not exceed 0.36 x no. of days in the month.
	Evap	=	Potential Evapotranspiration (in/month)
	Perc	=	Design percolation rate (in/month); reference Section 3.6
	Precip	=	Design precipitation (in/month)

Example water balance calculations are presented in Appendix Section 5.4.3. From these calculations, critical water balance months (i.e., months with the smallest allowable hydraulic wastewater loading) are identified. The wastewater loading rate in the critical water balance month is WLR_C.

3.7.3 Potential Evapotranspiration

Reliable field data for evapotranspiration are difficult to obtain. Therefore, values for average monthly potential evapotranspiration generated from vegetative, soil, and climatological data are used in water balance calculations. For row and forage cover crops, EPD suggests use of either the modified Penman or the Blaney-Criddle Method calibrated for local conditions. For forested systems or when data for other methods is not available, the Thornthwaite equation adjusted for sunlight duration and latitude can be used. The Thornthwaite equation and adjustment factors for Georgia are presented in Appendix Section 5.2. In addition to the methods listed, estimates of evapotranspiration can be obtained from published climatological resources, such as the National Oceanic and Atmospheric Association (NOAA) at *www.noaa.gov* or the Georgia Automated Environmental Monitoring Network at *www.georgiaweather.net*.

The method used to estimate average monthly potential evapotranspiration for water balance calculations must be referenced in the DDR. In addition, these values should be based on a minimum record of 30 years of historical climatic data.

3.7.4 Five-Year Return Monthly Precipitation

EPD requires the use of five-year return, monthly precipitation values in water balance calculations. Five-year return values are defined as the 80th percentile value in a 30-year ranked listing of historical monthly precipitation data. This corresponds to:

$$\text{5-Year Return Precip} = \text{Precip(avg)} + (0.85 \times \text{std.dev.}) \qquad \textbf{eq. 3.7.4}$$

Where,	*Precip(avg)*	=	Average monthly precipitation from 30 or more year historic record
	std.dev.	=	Standard deviation for same

The most recent thirty-year records of both monthly precipitation and temperature are available for all of Georgia from numerous published sources. The source of precipitation data used for design must be referenced in the DDR.

3.8 Nitrogen Balance/Cover Crop Selection and Management

3.8.1 General

Land treatment systems should be designed so that nitrate concentration in the percolate does not exceed 7 mg/L. Percolate nitrate concentration is a function of nitrogen loading, cover crop, management of vegetation, and hydraulic loading. The design wastewater loading rate(s) determined from water balance calculations must be checked against nitrogen loading limitations. If for the selected cover crop and management scheme, the proposed wastewater loading rate results in estimated percolate nitrate concentrations exceeding 7 mg/L, either the loading must be reduced or a cover crop with a higher nitrogen uptake rate must be selected.

3.8.2 Nitrogen Balance

Percolate nitrate concentrations are estimated from an annual or seasonal nitrogen balance based on the average design wastewater loading, proposed cover crop, and cover crop management scheme. Example nitrogen balance calculations are presented in Appendix Section 5.4.4, and Tables 5.4-2 and 5.4-3.

In nitrogen balance calculations, all nitrogen not lost to denitrification, ammonia volatilization, or plant uptake is assumed to leach into the groundwater as nitrate. For row and forage crop systems, assumed losses to denitrification should not exceed 10 percent of the total nitrogen applied. In forest systems, assumed denitrification losses should not exceed 15 percent. Assumed losses to ammonia volatilization should not exceed 5 percent of the total ammonia applied. Soil storage of nitrogen should be assumed to be zero. Tables 3.8-1 and 3.8-2 include uptake rates for different cover crops. In all cases, the source of the plant nitrogen uptake rate used for design must be referenced in the DDR.

3.8.3 Cover Crop Selection and Management

Row crops may be irrigated with wastewater only when not intended for direct human consumption. Forage crops irrigated with wastewater must be harvested and dried before feeding to livestock. Unmanaged, volunteer vegetation (i.e., weeds) is not an acceptable spray field cover crop. Disturbed areas in forest systems must be initially grassed and replanted for succession to forest.

Spray field cover crops require management and periodic harvesting to maintain optimum growth conditions assumed in design. Forage crops should be harvested and removed several times annually. Pine and hardwood forest systems should be harvested at intervals as recommended by the local forest service. It is recommended that whole tree harvesting be considered to maximize nutrient removal. However, wastewater loadings following the harvesting of forest systems must be reduced until the hydraulic capacity of the site is restored. The design may require additional spray field area to allow for harvesting and the regeneration cycle.

While relatively high in nitrogen and phosphorus, domestic wastewater is usually deficient in potassium, as well as trace elements needed for vigorous agronomic cover crop growth. High growth rate forage crops typically require supplemental nutrient addition to maintain nitrogen uptake rates assumed in design. A comprehensive nutrient management plan (NMP) is necessary to determine adequate levels of supplementation for the site. The NMP should include:

a. Site maps, including a soil map
b. Location and description of sensitive resource areas
c. Soil, plant, water, and organic material sample analysis results
d. Current and planned crop production sequence or crop rotation
e. Expected yield
f. Quantification of all nutrient sources available
g. Nutrient budget for the crop rotation being planned
h. Recommended rates, timing, and method of nutrient application
i. Operation and maintenance of the nutrient management plan

At least annually, the soils should be evaluated by the local extension office to determine if soil supplements are needed. Industrial wastewaters considered for land treatment should be carefully evaluated for their plant nutrient value, as well as possible salt content, which can hamper plant growth and destroy soil structure.

Table 3.8-1 (EPA TABLE 4-6)
YIELD BASED NITROGEN, PHOSPHORUS, & POTASSIUM UPTAKE OF VARIOUS CROPS

UNITED STATES EPA 2006, PROCESS DESIGN MANUAL
LAND TREATMENT OF MUNICIPAL WASTEWATER EFFLUENTS

			Percent of Dry Harvested Material		
Forage Crops	Dry Weight	Typ. Yield/acre-yr	N	P	K
Barley	48 lb/bushel	50 bushel	1.82	0.34	0.43
		1 ton straw	0.75	0.11	1.25
Corn	56 lb/bushel	120 bushel	1.61	0.28	0.40
		4.5 ton straw	1.11	0.20	1.34
Cotton		600 lbs Lint	2.67	0.85	0.83
		1000 lbs stalks	1.75	0.22	1.45
Grain Sorghum	56 lb/bushel	60 bushel	1.67	0.36	0.42
		3 tons straw	1.08	0.15	1.31
Soybeans [a]	60 lb/bushel	35 bushel	6.25	0.64	1.90
		2 tons stover	2.25	0.22	1.04
Wheat	60 lb/bushel	40 bushel	2.08	0.62	0.52
		1.5 tons straw	0.67	0.07	0.97

Field Crops	Typ. Yield/acre-yr	N	P	K
Alfalfa [a]	4 tons	2.25	0.22	1.87
Bahiagrass	3 tons	1.27	0.13	1.73
Bromegrass	5 tons	1.87	0.21	2.55
Clover-grass	6 tons	1.52	0.27	1.69
Coastal Bermuda Grass	8 tons	1.88	0.19	1.40
Kentucky Blue Grass	2 tons	2.91	0.43	1.95
Orchardgrass	6 tons	1.47	0.20	2.16
Reed Canary Grass	6.5 tons	1.35	0.18	1.66
Ryegrass	5 tons	1.67	0.27	1.42
Switchgrass	3 tons	1.15	0.10	1.90
Tall Fescue	3.5 tons	1.97	0.20	2.00

[a] Legumes will also take nitrogen from the atmosphere.

Table 3.8-2 (EPA TABLE 4-11)
ESTIMATED NITROGEN UPTAKE FOR SELECTED FOREST ECOSYSTEMS WITH WHOLE TREE HARVESTING

UNITED STATES EPA 2006 PROCESS DESIGN MANUAL
LAND TREATMENT OF MUNICIPAL WASTEWATER EFFLUENTS

	Tree Age (years)	Average Annual Nitrogen Uptake (lb/acre/year)
Eastern Forest		
Mixed Hardwoods	40 - 60	200
Red Pine	25	100
Old Field w/ White Spruce Plantation	15	200
Pioneer Succession	5 - 15	200
Aspen Sprouts	-	100
Southern Forests		
Mixed Hardwoods	40 - 60	250
Loblolly Pine with no Understory	20	200
Loblolly Pine with Understory	20	250
Lake States Forests		
Mixed Hardwoods	50	100
Hybrid Poplar [a]	5	140
Western Forests		
Hybrid Poplar [a]	4 - 5	270
Douglas Fir Plantation	15 - 25	200

[a] Short-term rotation with harvesting at 4 - 5 years; represents first growth cycle from planted seedlings.

3.9 Storage Volume

The total storage volume required for land treatment systems consists of three (3) separate storage components such that:

$$\text{Total Storage} = \text{Operational Storage} + \text{Wet-Weather and Emergency Storage} + \text{Water Balance Storage} \qquad \textbf{eq. 3.9}$$

These separate storage components are described in the sections that follow.

3.9.1 Operational Storage

Operational storage is a design parameter. For example, many land treatment systems are designed to apply wastewater 5 days per week and store weekend flows. Facilities that harvest cover crops on a frequent basis may stop irrigation to allow drying of the spray fields. Wastewater storage volume is required during these periods.

3.9.2 Wet-Weather and Emergency Storage

Wet-weather and emergency storage provides for periods when wastewater cannot be applied, i.e. excessive rainfall, saturated soil, equipment failure, etc. EPD has minimum requirements for wet-weather and emergency storage. These are necessary to ensure reliability of the slow-rate land treatment system.

The volume provided for wet-weather and emergency storage must be the greater of 12 days average design flow volume, or:

$$WW/E = \frac{\text{Delta } P \times (30.4 \text{ days/month})}{WLR_C} \qquad \textbf{eq. 3.9.2}$$

Where,	*WW/E*	=	Wet weather/emergency storage (days)
	Delta P	=	20-year variation from 5-year return monthly design precipitation (in). Reference Appendix, Section 6.3
	WLR_C	=	Wastewater loading rate in <u>most</u> critical water balance month (in/month). Reference Section 3.7.2

3.9.3 Water Balance Storage

Water balance storage is a function of wastewater flow, wetted field area and the wastewater loading rate. Therefore, before the water balance storage volume can be determined, the actual, rather than design wastewater loading rate must be calculated. In order to calculate the WLR, the areas necessary to eliminate the operational and the wet-weather and emergency storage volumes as well as the area necessary to treat a normal week's flow at the design loading rate must be calculated. Once the WLR has been calculated, the required monthly water balance storage is determined from water balance calculations and the following equation:

$$WBS = WLR_A - WLR_D \qquad \textbf{eq. 3.9.3}$$

Where,	WBS	=	Required water balance storage (in/month)
	WLR_A	=	Hydraulic wastewater loading rate (in/month); assumes all influent wastewater is applied to the spray fields
	WLR_D	=	Design wastewater loading rate (in/month); Reference eq. 3.7.2

Example calculations of this type are presented in Appendix Section 5.4.7.

3.10 Determination of Wetted Field Area

The wetted field area is subdivided into individual spray fields. Effluent is normally applied once per week per field. This allows for reaeration and drying of the soil profile. A 3-foot zone of aeration must be reestablished between wastewater applications.

The wetted field area is sized to adequately treat four volumes of water; the storage volumes discussed in 3.9 and seven days of the design average daily flow. In equation form, this relationship is represented as:

$$A(wetted) = A(ADF) + A(OP) + A(WW/E) + A(WBS) \qquad \textbf{eq. 3.10}$$

Where,	$A(wetted)$	=	required wetted field area (acres)
	$A(ADF)$	=	area (acres) necessary to treat seven days' average daily flows
	$A(OP)$	=	area (acres) necessary to treat the operational storage (ref. Sect. 3.9.1)
	$A(WW/E)$	=	area (acres) necessary to treat the wet weather/emergency storage (ref. Sect. 3.9.2)
	$A(WBS)$	=	area (acres) necessary to treat the water balance storage (ref. Sect. 3.9.3)

EPD requires that sufficient area be provided so that the operational storage, the wet weather and emergency storage, and the water balance storage can be eliminated within a 90-day period. The necessary areas for treating the operational and wet weather/emergency storage volumes are determined using the wastewater loading rates during the critical water balance month, WLR_C. The necessary area for treating water balance storage is determined using the actual wastewater loading rate, WLR_A. Calculation of each of the area elements is discussed in the following sections.

3.10.1 Area for Average Daily Flow, A(ADF)

The area necessary for distributing the average daily flow is calculated using the following formula:

$$A(ADF) = \frac{7\ \text{days}}{1\ \text{week}} \times \frac{ADF\ \text{gal}}{\text{day}} \times \frac{1\ \text{cf}}{7.48\ \text{gal}} \times \frac{1\ \text{acre}}{43{,}560\ \text{sf}} \times \frac{12\ \text{in}}{1\ \text{ft}} \times \frac{1\ \text{week}}{WLR_D,\ \text{in}} \qquad \textbf{eq. 3.10.1}$$

3.10.2 Area for Operational Storage, A(OP)

The operational storage volume is to be eliminated within a 90-day period. The area A(OP) is based on the critical month WLR and is calculated using the following formula:

$$A(OP) = \text{gal stored} \times \frac{7\ \text{days}}{90\ \text{days}} \times \frac{1\ \text{cf}}{7.48\ \text{gal}} \times \frac{1\ \text{acre}}{43{,}560\ \text{sf}} \times \frac{12\ \text{in}}{1\ \text{ft}} \times \frac{1\ \text{week}}{WLR_C,\ \text{in}} \qquad \textbf{eq. 3.10.2}$$

3.10.3 Area for Wet Weather and Emergency Storage, A(WW/E)

The wet weather and emergency storage volume is also to be eliminated within a 90-day period. Therefore, the equation for calculating A(WW/E) is the same as 3.10.2 with the wet weather and emergency storage volume substituted for the operational storage volume.

$$A(WW/E) = \text{gal stored} \times \frac{7\ \text{days}}{90\ \text{days}} \times \frac{1\ \text{cf}}{7.48\ \text{gal}} \times \frac{1\ \text{acre}}{43{,}560\ \text{sf}} \times \frac{12\ \text{in}}{1\ \text{ft}} \times \frac{1\ \text{week}}{WLR_C,\ \text{in}} \qquad \textbf{eq. 3.10.3}$$

3.10.4 Area for Water Balance Storage, A(WBS)

The water balance storage is also to be eliminated within a 90-day period. The equation for calculating A(WBS) is similar to 3.10.2, with the water balance storage volume substituted for the operational storage volume, and the actual wastewater loading rate, WLR_A, substituted for the critical month, WLR_C.

$$A(WBS) = \text{gal stored} \times \frac{7\ \text{days}}{90\ \text{days}} \times \frac{1\ \text{cf}}{7.48\ \text{gal}} \times \frac{1\ \text{acre}}{43{,}560\ \text{sf}} \times \frac{12\ \text{in}}{1\ \text{ft}} \times \frac{1\ \text{week}}{WLR_A,\ \text{in}} \qquad \textbf{eq. 3.10.4}$$

Example calculations of the wetted field area requirements are contained in section 5.4.7.

3.11 Buffer Zones, Public Access, and Protection of Water Supply Wells

3.11.1 Buffer Zones

Buffer zones are required to protect the public from aerosol sprays. These zones should be maintained in forest, shrubs, or other screening vegetation. Rights-of-way can be used as part of the buffer area. However, these rights-of-way must be exclusive with no possibility of development.

The following minimum buffer zones must be provided for all land treatment systems utilizing spray irrigation:

a. A 150-foot buffer must be maintained between the edge of the wetted field area and all property lines.
b. A 300-foot buffer must be maintained between the wetted field area and any habitable structure.
c. A 150-foot buffer must be maintained between the edge of the wetted field area and any internal and external public roads.
d. Internal roads that are closed to public use do not require buffer zones. However, spray irrigation on these roads is prohibited.
e. A 100-foot buffer is required between the wetted edge of spray fields and the edge of any perennial lake or stream. A 50-foot buffer is required between spray fields and any channelized, intermittent watercourse. If wastewater application causes an intermittent watercourse to become perennial, the 100-foot buffer requirement will then apply.
f. A 150-foot buffer must be maintained between the property line and any part of the preapplication treatment facility and storage pond.
g. A 300-foot buffer must be maintained between any habitable structure and any part of the pretreatment facility and storage pond.

When deemed necessary by EPD, buffer zone requirements may be increased or added based on site-specific conditions.

3.11.2 Public Access

Public access to the spray fields should be discouraged by posting signs and maintaining well-vegetated buffer zones. Fencing of spray fields in remote areas is usually not required. However, fencing and access road gates should be provided along property lines adjacent to residential and other developed areas. Fencing is required at preapplication treatment facilities, pump stations, and holding ponds.

3.11.3 Protection of Water Supply Wells

The potential effect of a land treatment system on a water supply aquifer is site-specific and difficult to predict. Abandoned wells within the treatment site must be identified as well as all public and private water supply wells within 2500 linear feet (L.F.) of the land treatment site. It must be clearly shown (through an evaluation of the depth of the water supply aquifer, its gradient, the condition of the aquitard, the condition of existing water supply wells, and their capacity) that the LAS will not have any effect on those wells. Shallow and poorly constructed wells adjacent to and within the land treatment system will require abandonment and sealing.

3.12 Surface Drainage and Runoff Control

Drainage of storm runoff should be considered in design. Spray fields must be protected against flooding, ponding, and erosion. Runoff from upgradient areas should be channelized through or around the site. However, the collection and channelization of irrigated wastewater must be avoided. Direct application of wastewater to drainage ditches and seasonal watercourses is prohibited.

A properly designed and operated slow-rate land treatment system will not produce direct runoff; i.e., all water applied will either evaporate or infiltrate into the soil profile. Sites that experience direct runoff as a result of wastewater application will be required to reduce hydraulic loading rates. Indirect runoff as a result of interflow, changes in slope, and shallow restrictive soil layers can be expected at some land treatment sites. Indirect runoff is acceptable when it is dispersed over a wide area. However, monitoring of streams affected by such indirect runoff may be required.

3.13 Subsurface Drainage

Sites with a seasonal high water table less than 5 feet from the surface will not be accepted for slow-rate land treatment unless drainage improvements are made. A 3-foot zone of re-aeration between wastewater applications is generally desirable.

3.14 Distribution Systems and Construction

3.14.1 General

Hydraulic calculations for the pump and distribution system must be submitted with the plans and specifications. Spray field pressure variation due to friction loss and static head for solid set, uniformly spaced systems should not exceed +/-10 percent of the design spray nozzle pressure.

IMPORTANT: The spray fields must be laid out so that the irrigation lines generally follow the contours of the site. The engineer must visit the site when the contractor is laying the lines out to verify that they do follow the contours and that the 50-foot buffer is maintained from intermittent streams, including drainage ways that may not have been apparent from the topographical map(s) used to design the system.

Secondary mist nozzles on impact sprinklers should not be used. These saturate the ground around the sprinkler riser and undermine the riser's support. They also make it impossible to inspect operating sprinklers without getting wet.

PVC risers must not be used. EPD recommends that flexible connections be used to connect the risers to the distribution line.

3.14.2 Access, Flow Measurement, and Controls

The layout of spray fields and spray field roads should provide easy access for inspection and maintenance of the distribution system. Control valves should be installed so that they are readily accessible for maintenance and replacement (i.e., either above ground or in a valve pit). We recommend cast iron valve boxes with concrete collars. In addition to control valves for each field, we highly recommend installation of a shut-off valve for each lateral and each sprinkler. Experience has shown that such valves will expedite maintenance of the system. Taps located near the most distant sprinklers must be provided in each field so pressure gauges can be easily used to verify operating pressures and to locate pressure losses. Spray field access roads must be designed for all-weather use. Steep grades should be avoided. Irrigation on access roads is prohibited.

A flow-totalizing recorder is required on the discharge of each irrigation pump station to measure the volume of wastewater applied to the spray fields.

A low-pressure detection system (with sensors in each field for large systems) must be provided to automatically shut down irrigation pumps in the event of force main, submain, or lateral blowout. Similarly, a high pressure shut-off at the irrigation pumps must be provided. In conjunction with these systems there must be an indicator alarm or an autodialer that alerts the operator of an early pump shutdown. Depending on the operational control system for the spray fields, automatic shut-off controls for high intensity rainfall and/or high wind speeds may be required.

3.14.3 Freeze Protection

EPD requires that aboveground piping systems should drain when depressurized. Pipe drains should discharge either to the spray fields or to the storage pond(s) and must not produce runoff.

3.14.4 Construction Disturbance, System Start-up and Testing

Construction activities associated with distribution systems can greatly alter the infiltration rate of spray field soils. Construction disturbance within spray fields must be kept to an absolute minimum. Excessive compaction of surface soils by construction equipment must be avoided. Where land clearing is a part of the construction, final permeability testing must be performed and the permeability must not change more than 15%. The permitted capacity of the system may be decreased by EPD if the permeability is significantly reduced.

Regrading of pipeline trenches must match original contours. Subsidence of trench backfill must be repaired, as this promotes channelization of runoff and erosion. Cuts or benches on slopes are not permissible. These disturbances intercept shallow, subsurface flow also promoting channelized runoff and erosion.

In forested systems, it is necessary to grub only the pipe centerline. Excessive clearing and grubbing should be avoided. Clearing for aboveground piping systems should involve only vegetation that will interfere with operation of the system. All areas disturbed by construction must be re-vegetated immediately. Areas in which seedlings are to be planted must have a cover crop of grass provided during the first three years following planting of the seedlings.

IMPORTANT: Before seeding or sprigging grass or ground cover in all areas of fields disturbed by construction, the land should be plowed to a depth of 16 inches with chisel plows.

Sloped areas may require protection from erosion. The *Manual for Erosion and Sedimentation Control in Georgia*, published by the State Soil & Water Conservation Committee, should be used as a guide for erosion and sedimentation control during construction of land treatment systems.

Pressure testing of the irrigation force mains and laterals must be conducted during installation to avoid damage to spray fields from re-excavation and repair. Extensive flushing is usually necessary to clear distribution system pipes of materials that may clog sprinkler nozzles. Care should be exercised to prevent erosion or flooding of the spray fields during pipeline flushing. Every effort should be made to keep trash and debris out of the distribution system. Sprinklers and drain valves should be checked for proper operation prior to installation.

Bare soil resulting from construction can tolerate only short periods of wastewater application before producing runoff. Irrigation of bare soil compacts the soil surface, reduces the infiltration rate, promotes erosion, and hinders the establishment of vegetation. In addition, the treatment capacity of bare soil is poor. Wastewater irrigation on bare soil is not allowed beyond what is necessary to establish a vegetative cover. Wastewater application at the design rate can begin only when a uniform vegetative cover has been established. Specifications for spray field construction must include a re-vegetation performance standard and this standard must be enforced.

EPD recommends that spray fields be developed before preapplication treatment facilities are constructed. This allows time for a vegetative cover to be reestablished on construction-disturbed areas. Potable, ground, or surface water should be used for distribution system testing and irrigation to establish vegetation. Since one to three growing seasons may be required before newly constructed spray fields can accept the design wastewater loading, this start-up period must be considered in the design and operation of land treatment systems.

4.0 GUIDELINES AND CRITERIA FOR SITE MANAGEMENT

4.1 Operation and Management of Slow-Rate Land Treatment Systems

As discussed in Section 2.3, the facility's LAS Permit will require the owner or owner's engineer to write an Operations Manual (OM). This manual covers operation of both the spray fields and preapplication treatment facility. It provides a management scheme consistent with the basis of design outlined in the DDR. An outline for the scope of the OM Manual is presented in Appendix Section 5.1.

4.2 Monitoring Requirements

4.2.1 General

There are two objectives for a monitoring program at a land application site. The first is to satisfy the permit requirements set by EPD. The second objective is to provide the data necessary to optimize the system's operation. The data to meet the second objective may or may not be the same as that required by the permit. The facility's OM should address the data needs for optimum plant operation.

4.2.2 Preapplication Treatment Facility and Storage Pond(s)

Influent to the preapplication treatment system and treated effluent applied to the spray fields must be monitored. Parameters which may require monitoring under the system's permit include: influent flow, volume of water applied to the spray fields, BOD (influent & effluent), suspended solids (influent & effluent), fecal coliform bacteria, pH (influent & effluent), ammonia nitrogen, nitrate nitrogen, total Kjeldahl nitrogen, total phosphorus, chloride, Na, K, Ca, Mg, metals, and priority pollutants. The parameters included in the permit monitoring requirements and the sampling frequency for those parameters will be determined on a case-by-case basis and will be dependent on site conditions.

4.2.3 Groundwater

A system is required for monitoring the quality of groundwater influenced by the land treatment system. Groundwater leaving the spray site boundaries must meet drinking water standards.

Subsurface geology and the direction of groundwater flow determine the placement and depth of monitoring wells. EPD recommends the development of a groundwater potentiometric surface map prior to startup of the facility. Minimum monitoring well requirements are as follows:

a. One well upgradient or otherwise outside the influence of the land treatment site for background monitoring.
b. One well within the wetted field area of <u>each</u> drainage basin intersected by the land treatment site.
c. Two wells downgradient of the wetted field area in <u>each</u> drainage basin

intersected by the land treatment site. Downgradient wells will be considered compliance points and must be located within 50-ft of the wetted perimeter of the application site(s).

d. For smaller systems, the recommendations listed above may be reduced on a case-by-case basis. Larger sites or sites with complicated surface and/or groundwater drainage may require additional monitoring wells.

e. All monitoring wells must extend to sufficient depth to sample seasonal fluctuations of the unconfined water table. Wells must not extend through confining layers.

f. Monitoring wells must be provided with casings and screens. The casing must be backfilled and sealed to prevent entry of surface water. This seal should include a concrete apron surrounding the well at the surface. Care should be taken to avoid contamination of wells both during and after construction.

g. **IMPORTANT**: Monitoring wells must be numbered and locked.

h. Monitoring wells should follow a labeling convention that utilizes a U, M, and D designation for upgradient, middle, and downgradient well locations, respectively.

EPD suggests that monitoring well construction generally conform to the *Manual for Groundwater Monitoring* which was developed as a reference for the design and construction of groundwater monitoring wells at slow-rate land treatment systems (see Figure 4.2-1). Additional sources for well installation guidance include ASTM Standard D5092, *Standard Practice for Design and Installation of Ground Water Monitoring Wells* or USEPA Science and Ecosystem Support Division's *Design and Installation of Monitoring Wells*.

Monitoring of the groundwater under the LAS permit may require measurement of one or more of the following parameters: depth to groundwater, pH, nitrate nitrogen, total phosphorus, electrical conductivity, chloride, fecal coliform bacteria, metals and priority pollutants. The parameters included in the permit monitoring requirements and the sampling frequency for those parameters will be determined on a case-by-case basis and will be dependent on site conditions. EPD also encourages the installation and monitoring of soil water lysimeters within the wetted field area. These are useful as trend monitoring devices to identify problems before the groundwater system is affected.

4.2.4 Surface Water and Drainage Systems

When a perennial stream traverses or lies at the boundary of a slow-rate land treatment site, water quality monitoring of this stream may be required. The parameters and frequency of monitoring will be specified as a condition in the facility's LAS Permit. Sampling upstream and downstream of the wetted field area as well as flow measurement may also be required.

Land treatment systems incorporating drainage improvements that result in a point discharge to surface waters must apply for a National Pollutant Discharge Elimination System (NPDES) Permit. In addition to requiring an OM, the NPDES Permit will include effluent limits, monitoring parameters, and sampling frequencies for the drainage system. The intent of this monitoring is to ensure complete renovation of the irrigated wastewater before discharge.

4.2.5 Soil

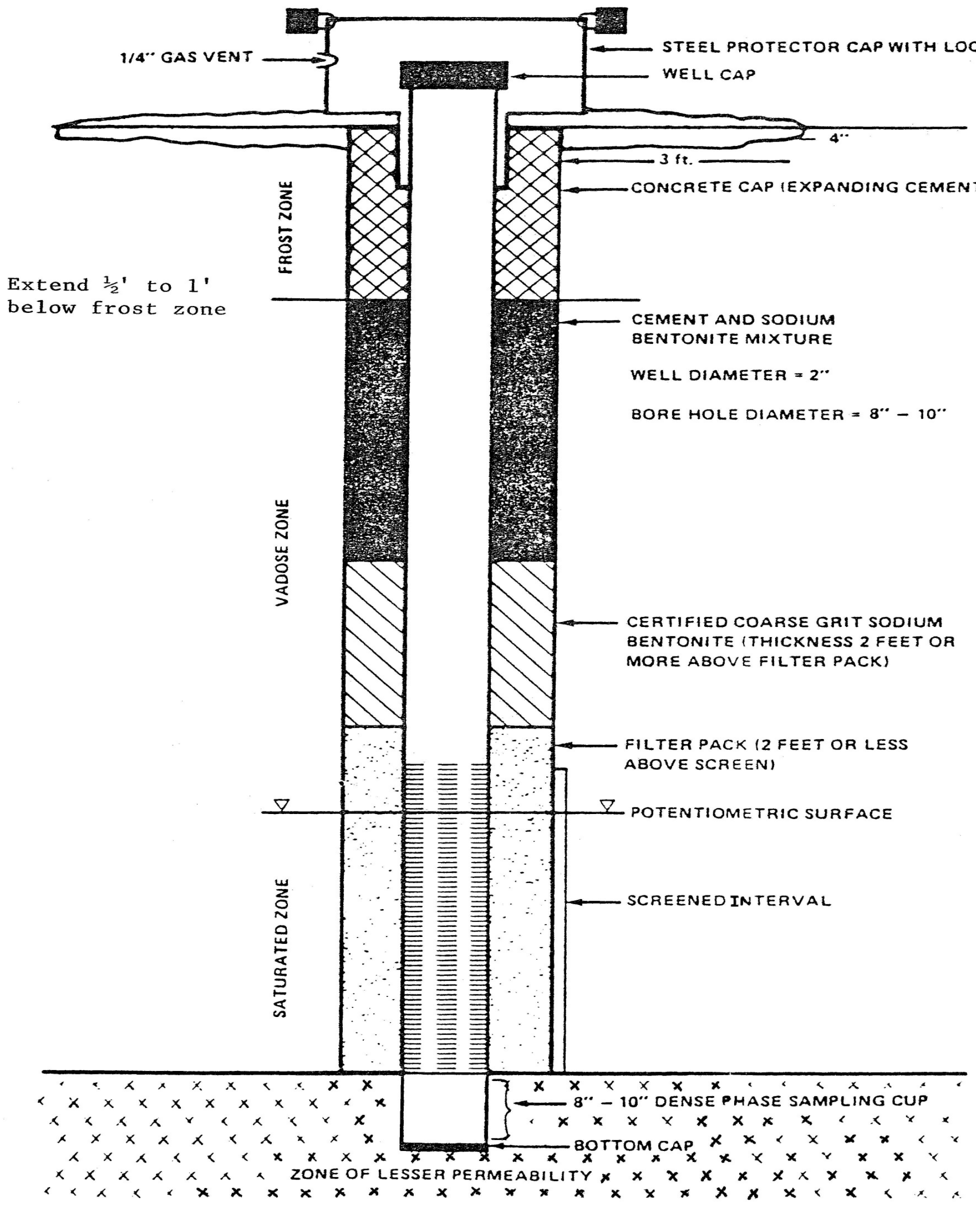
Representative soil samples from each major soil series within the wetted field area must be taken and analyzed according to requirements in the facility's LAS permit. In particular, soil pH is an indicator of changes in soil chemistry. If the soil pH changes significantly, additional analyses may be required.

Land treatment systems receiving industrial process wastes may be required to monitor metals, salts, and priority pollutants in site soils and possibly vegetation. The parameters and frequencies will be determined on a case-by-case basis.

4.2.6 Rainfall and Climatic Data

Monitoring of daily rainfall at the land application site is required. Antecedent precipitation and soil moisture conditions can be correlated to provide an operating scheme for the system. Monitoring of wind speed and direction may also be required.

Figure 4.2-1
GENERAL MONITORING WELL – CROSS SECTION



5.0 APPENDICES

5.1 Operations Manual for Slow-Rate Land Treatment Systems

The manual should include, but not be limited to, the following:

5.1.1 Introduction

A. System Description:
  1. A narrative description and process design summary for the land treatment facility including the design wastewater flow, design wastewater characteristics, preapplication treatment system, and spray fields.
  2. A map of the land treatment facility showing the preapplication treatment system, storage pond(s), spray fields, buffer zones, roads, streams, drainage system discharges, monitoring wells, etc.
  3. A map of interceptor sewers, force mains, and major pump stations tributary to the land treatment facility. Indicate their size and capacity.
  4. A schematic and plan of the preapplication treatment system and storage pond(s) identifying all pumps, valves, and process control points.
  5. A schematic and plan of the irrigation system identifying all pumps, valves, gauges, sprinklers, etc.

B. Discuss the design life of the facility and factors that may shorten its useful life. Include procedures or precautions that will compensate for these limitations.
C. A copy of the facility's Land Application System (LAS) Permit.
D. A copy of the facility’s National Pollutant Discharge Elimination System (NPDES) permit, if applicable.

5.1.2 Management and Staffing

A. Discuss management's responsibilities and duties.
B. Discuss staffing requirements and duties:
  1. Describe the various job titles, number of positions, qualifications, experience, training, etc.
  2. Define the work hours, duties and responsibilities of each staff member.

5.1.3 Facility Operation and Management

A. Preapplication Treatment System:
  1. Describe how the system is to be operated.
  2. Discuss process control.
  3. Discuss maintenance schedules and procedures.

B. Irrigation System Management:
  1. Wastewater Application. Discuss how the following will be monitored and controlled. Include rate and loading limits.
    a. Wastewater loading rate (inches/week)

    - b. Wastewater application rate (inches/hour)
    - c. Spray field application cycles
    - d. Organic nitrogen and phosphorus loadings (lbs/acre/month, etc.)
  - 2. Discuss how the system is to be operated and maintained.
    - a. Storage pond(s)
    - b. Irrigation pump station(s)
    - c. Spray field force main(s) and laterals
  - 3. Discuss start-up and shutdown procedures.
  - 4. Discuss system maintenance.
    - a. Equipment inspection schedules
    - b. Equipment maintenance schedules
  - 5. Discuss operating procedures for adverse conditions.
    - a. Wet weather
    - b. Freezing weather
    - c. Saturated soil
    - d. Excessive winds
    - e. Electrical and mechanical malfunctions
  - 6. Provide troubleshooting procedures for common or expected problems.
  - 7. Discuss the operation and maintenance of back-up, stand-by, and support equipment.
- C. Vegetation and Nutrient Management Plan (NMP):
  - 1. Discuss how the selected cover crop is to be established, monitored, and maintained.
  - 2. Discuss cover crop cultivation procedures, harvesting schedules, and uses.
  - 3. Discuss buffer zone vegetative cover and its maintenance.
  - 4. Discuss winter overseeding requirements
  - 5. Discuss supplemental nutrient requirements
- D. Drainage System (if applicable):
  - 1. Discuss operation and maintenance of surface drainage and runoff control structures.
  - 2. Discuss operation and maintenance of subsurface drainage systems.

5.1.4 Monitoring Program (reference Section 4.2)

- A. Discuss sampling procedures, frequency, location, and parameters for:
  - 1. Preapplication treatment system.
  - 2. Irrigation System:
    - a. Storage pond(s)
    - b. Groundwater monitoring wells
    - c. Drainage system discharges (if applicable)
    - d. Surface water (if applicable)
- B. Discuss soil sampling and testing.
- C. Discuss ambient conditions monitoring:
  - 1. Rainfall
  - 2. Wind speed

    3. Soil moisture
- D. Discuss the interpretation of monitoring results and facility operation:
    1. Preapplication treatment system.
    2. Spray fields
    3. Groundwater
    4. Soils

5.1.5 Records and Reports

- A. Discuss maintenance records:
    1. Preventive
    2. Corrective
- B. Monitoring reports and/or records should include:
    1. Preapplication treatment system and storage pond(s).
        - a. Influent flow
        - b. Influent and effluent wastewater characteristics
    2. Irrigation System
        - a. Wastewater volume applied to spray fields
        - b. Spray field scheduling
        - c. Loading rates
    3. Groundwater Depth
    4. Drainage system discharge parameters (if applicable)
    5. Surface water parameters (if applicable)
    6. Soils data
    7. Rainfall and climatic data

5.2 Thornwaite Potential Evapotranspiration

The Thornthwaite Potential Evapotranspiration (P.E.T.) is defined as "the amount of water which will be lost from the surface completely covered with vegetation if there is sufficient water in the soil at all times for use of the vegetation." The Thornthwaite method is an empirical equation developed from correlations of mean monthly air temperature with evapotranspiration from water balance studies in valleys of the east-central United States, where soil moisture conditions do not limit evapotranspiration (The Irrigation Association, 1983, pp. 112 to 114). The Thornthwaite method is applicable to slow-rate land treatment systems in the southeast United States, including Georgia. It is not applicable to arid and semi-arid regions west of the Mississippi River.

The Thornthwaite equation is outlined below. Note that the results are expressed in inches (in) for a 30-day month. The P.E.T. results must be modified by the actual number of days in each month. Finally, for water balance calculations as described in Section 3.7, a 30-year record of historical climatic data (referred to as the climatological normal) is required to determine monthly temperature normals used in the Thornthwaite equation.

$$P.E.T. = 1.6 \times Ld \times [(10 \times T)/I]^{A} \times (1in / 2.54\ cm)$$ **eq. 5.2.1**

Where,	P.E.T.	=	30-day Thornthwaite Potential Evapotranspiration (in)
	Ld	=	Daylight hours in units of 12 hours (reference Table 5.2-1)
	T	=	Mean (normal) monthly air temperature in degrees Celsius
	I	=	Annual heat index obtained by summing the 12 monthly heat indexes, i, where: $i = (T/5)^{1.514}$
	A	=	Power term derived from annual heat index, I, where: $A = 0.000000675(I)^3 - 0.0000771(I)^2 + 0.01792(I) + 0.49239$

Table 5.2-1
MONTHLY AVERAGE DAYLIGHT HOURS AS A FUNCTION OF LATITUDE

	Daylight (x 12 hours)[a]	
Month	at 30^{O} Latitude	at 35^{O} Latitude
January	0.90	0.87
February	0.87	0.85
March	1.03	1.03
April	1.08	1.09
May	1.18	1.21
June	1.17	1.21
July	1.20	1.23
August	1.14	1.16
September	1.03	1.03
October	0.98	0.97
November	0.89	0.86
December	0.88	0.85

[a] Values for sites between 30 and 35 degrees latitude should be interpolated.

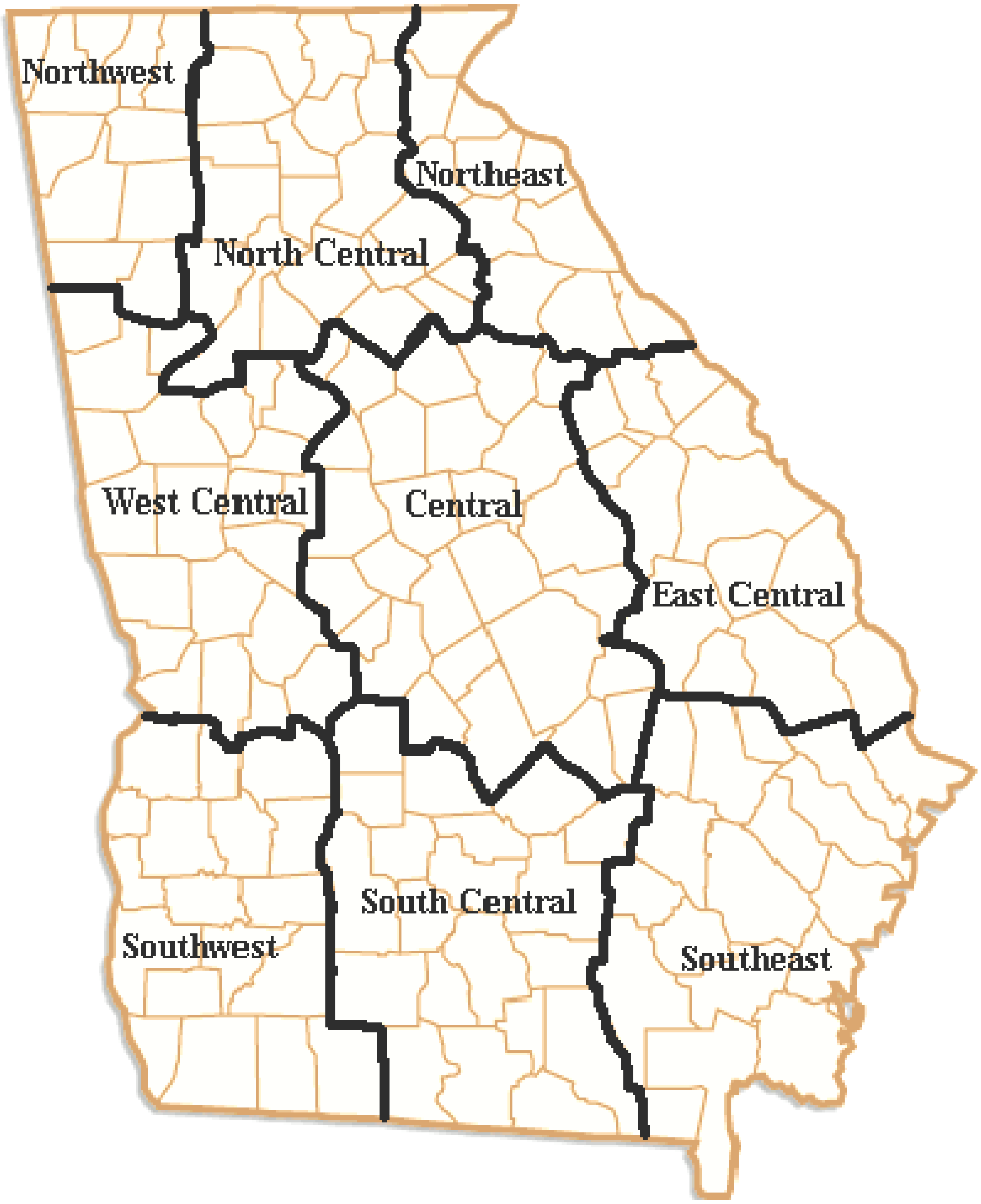
5.3 Delta P Values for Georgia Climatic Divisions

Table 5.3-1
DELTA P VALUES FOR GEORGIA CLIMATIC DIVISIONS
(Reference Figure 5.3-1)

Georgia Climatic Division	Delta P [a] (inches)
Northwest	2.0
North Central	2.5
Northeast	3.0
West Central	2.5
Central	2.0
East Central	2.0
Southwest	2.5
South Central	3.0
Southeast	2.5

[a] 20-year variation from 5-year return monthly precipitation. Derived from National Oceanic and Atmospheric Administration historical rainfall data for Georgia.

Figure 5.3-1
GEORGIA CLIMATIC DIVISIONS



5.4 Example Calculations

5.4.1 Introduction and Assumptions

Design of slow-rate land treatment systems is a process of balancing site limitations against construction and operating costs. The following example calculations are for a hypothetical 4-MGD facility in the North Central Piedmont area of Georgia. They illustrate the basic computations required and the relationship between variables.

The following assumptions were made. They must not be used for real world systems without verification.

a. The average design flow is 4.0 MGD with a daily peak factor of 2 and a weekly peak factor of 1.25.

b. The land treatment site is moderately well drained with seasonal high groundwater more than 5 feet below the surface. The most limiting layer in the soil profile occurs at a depth of 2 to 4 feet. Testing for saturated vertical hydraulic conductivity indicates an average permeability for this layer of 0.00015 cm/s corresponding to 0.213 inches/hour.

c. The annual average precipitation is 49 inches. Evapotranspiration is estimated at the rate computed by the Thornthwaite equation.

d. Nitrogen concentrations in effluent from the preapplication treatment system are as follows:

Total Nitrogen as N	20 mg/L
Ammonia Nitrogen	15 mg/L

e. Nitrogen is applied to the site through rainfall and fixation at a rate of 5 lbs/acre-year.

f. Maximum loss to ammonia volatilization is 5% of the total ammonia applied. Maximum loss to denitrification for pine forest is 15% of the total nitrogen applied. Maximum loss to denitrification for Coastal Bermuda/Ryegrass is 10% of the total nitrogen applied.

g. Conservative net uptake of nitrogen in pine forest with understory growth is 175 lbs/acre-year. Table 3.8-1 shows a nitrogen content of 1.88% for Coastal Bermuda and 1.67% for Ryegrass. Anticipated yields for a double-cropped system are as follows:

   5 tons/acre of Bermuda during summer (April - September)
   1 ton/acre Bermuda, 1.5 tons/acre of Ryegrass during winter (October - March)

   This equates to an estimated crop nitrogen uptake of 188 lbs/acre during the summer and 88 lbs/acre during winter.

h. Delta P from Table 5.3-1 is assumed to be 2.5 inches.

5.4.2 Design Percolation

As stated in Section 5.4.1, the average permeability of the most limiting soil layer is 0.213 inches/hour. As this limiting layer occurs at a depth less than 5 feet, 10 percent of this value will be used for design (reference Section 3.6.2). The design percolation rate becomes:

$$0.10 \times (0.213 \text{ in/hr}) \times (24 \text{ hr/day}) = 0.51 \text{ in/day}$$

5.4.3 Water Balance

Water balance calculations for the hypothetical 4-MGD land treatment system are presented in Table 5.4-1. This table makes use of eq. 3.7.2 to determine maximum allowable monthly hydraulic wastewater loadings.

Thornthwaite potential evapotranspiration and 5-year return monthly precipitation values for Atlanta are used in Table 5.4-1. The table indicates that for the assumed site conditions, the most critical water balance month is March, with a maximum allowable wastewater loading of 8.7 inches, corresponding to a rate of 2.0 inches/week. Therefore, a design wastewater loading rate greater than 2.0 inches/week will require water balance storage. Conversely, no water balance storage will be required for a design wastewater loading rate less than 2.0 inches/week (reference Section 3.9.3).

5.4.4 Nitrogen Balance

The nitrogen balance is used to evaluate wastewater loadings possible under different cover crop and management schemes. Tables 5.4-2, 5.4-3, and 5.4-4 present nitrogen balances for cover crop alternatives of pine forest and grass. Only an annual average is prepared for forested systems. Both summer and winter averages are prepared for grasses and other crops.

To meet a percolate nitrate limit of 7 mg/L, Table 5.4-2 indicates a pine forest cover crop will require a design wastewater loading rate less than 1.75 inches/week. Tables 5.4-3 and 5.4-4 indicate that a crop of Coastal Bermuda/Ryegrass will allow a design wastewater loading rate up to the maximum of 2.5 inches/week in summer and 1.75 inches/week in winter. The final cover crop selected is an economic decision balancing wetted area and storage requirements against operating cost.

Table 5.4-1
WATER BALANCE CALCULATIONS

Month	Evap [a] (in/month)	Perc [b] (in/month)	Precip [c] (in/month)	Wastewater Loading Rates (in/month) [d]	(in/week) [e]
January	0.4	15.8	6.5	9.7	2.2
February	0.5	14.4	6.1	8.8	2.2
March	1.3	15.8	8.5	8.6	2.0 [f]
April	2.5	15.3	6.3	11.5	2.5 [g]
May	4.3	15.8	5.8	14.3	2.5
June	5.6	15.3	5.0	15.9	2.5
July	6.5	15.8	6.8	15.5	2.5
August	6.0	15.8	5.3	16.5	2.5
September	4.2	15.3	4.7	14.8	2.5
October	2.5	15.8	4.2	14.1	2.5
November	1.1	15.3	5.9	10.5	2.4
December	0.5	15.8	6.0	10.3	2.3
Total	35.2	186.4	71.1	150.5	

a Thornthwaite average monthly evapotranspiration. (P.E.T.)
b Number of days per month x 0.51 in/day (design percolation from Section 5.4.2)
c Five-year return, monthly precipitation
d Wastewater loading rate (in/month) = Evap + Perc – Precip.
e Wastewater loading rate (in/week) = WLR (in/month) / 4.42 (weeks/month). The maximum allowable is 2.5 in/week.
f 2.0 in/week (WLR_C) is the lowest value in column 6. In this example the month of March is the most critical water balance month.
g 11.5 in/month / 4.29 weeks/month = 2.7 in/week. Since 2.7 > maximum allowable, 2.5 in/week should be used, as (WLR_D).

Table 5.4-2
NITROGEN BALANCE, PINE FOREST

1. Average Daily Flow ADF (MGD)	4.0 [a]	4.0	4.0	4.0
2. Average Design Wastewater Loading Rate (in/week)	1.25 [b]	1.5	1.75	2.0
3. ADF Wetted Area (acre)	825 [c]	687	589	516
4. Nitrogen Input from Wastewater (lbs/acre-year)	295 [d]	355	414	472
5. Nitrogen Input from Rainfall and Fixation (lbs/acre-year)	5 [e]	5	5	5
6. Total Nitrogen Input (lbs/acre-year)	300 [f]	360	419	477
7. Ammonia Volatilization @ 5% of Ammonia applied (lbs/acre-year)	11 [g]	13	16	18
8. Denitrification @ 15% of Total Nitrogen applied (lbs/acre-year)	44 [h]	53	62	71
9. Net Plant Uptake and Storage (lbs/acre-year)	175 [i]	175	175	175
10. Nitrogen Leached by Percolate (lbs/acre-year)	70 [j]	118	166	214
11. Precipitation (in/year)	49 [k]	49	49	49
12. Wastewater Applied (in/year)	65 [l]	78	91	104
13. Potential Evapotranspiration P.E.T. (in/year)	35 [m]	35	35	35
14. Percolate (in/year)	79 [n]	92	105	118
15. Estimated Percolate Total Nitrogen (mg/L)	3.9 [o]	5.7	7.0	8.0

a	Given value, 4 MGD
b	Selected design loading(s)
c	$\frac{\text{7 days/week x 4,000,000 gal/day x 12 in/ft}}{\text{7.48 gal/cu ft x 43,560 sq ft/acre x 1.25 in/week}}$
d	Given Total Nitrogen value = 20 mg/L: $\frac{\text{20 mg/L x 4 MGD x 8.34 lb/gal x 365 day/year}}{\text{Line 3 value}}$
e	Constant from atmosphere, 5 lbs/acre-year
f	Line 4 value + Line 5 value
g	Given Ammonia Nitrogen value = 15 mg/L: $\frac{\text{15 mg/L x 4 MGD x 8.34 lbs/gal x 365 day/year x 0.05}}{\text{Line 3 value}}$
h	Line 6 value x 0.15
i	Given, based on selected cover crop
j	Line 6 value - Line 7 value - Line 8 value - Line 9 value
k	Given, average precipitation value
l	Line 2 value x 52 wks/year
m	From Table 6.4.1
n	Line 11 value + Line 12 value - Line 13 value
o	$\frac{\text{Line 10 value x 453,600 mg/lb}}{\text{Line 14 value x 102,750 L/acre-inch}}$

Table 5.4-3
NITROGEN BALANCE, COASTAL BERMUDA/RYEGRASS, SUMMER

1. Average Daily Flow ADF (MGD)	4.0	4.0	4.0	4.0
2. Average Design Wastewater Loading Rate (in/week)	1.75	2.0	2.25	**2.5**
3. ADF Wetted Area (acre)	589	516	458	412
4. Nitrogen Input from Wastewater (lbs/acre-period)	207 [a]	236	266	296
5. Nitrogen Input from Rainfall and Fixation (lbs/acre-period)	2.5	2.5	2.5	2.5
6. Total Nitrogen Input (lbs/acre-period)	210	239	269	299
7. Ammonia Volatilization @ 5% of Ammonia applied (lbs/acre-period)	8	9	10	11
8. Denitrification @ 10% of Total Nitrogen applied (lbs/acre-period)	21	24	27	30
9. Net Plant Uptake and Storage (lbs/acre-period)	188	188	188	188
10. Nitrogen Leached by Percolate (lbs/acre-period)	0 [b]	18	44	70
11. Precipitation (in/period)	24	24	24	24
12. Wastewater Applied (in/period)	46	52	59	65
13. Potential Evapotranspiration P.E.T. (in/period)	29	29	29	29
14. Percolate (in/period)	40	47	53	60
15. Estimated Percolate Total Nitrogen (mg/L)	0.0	1.7	3.6	5.1

[a] For this example, it is assumed that a constant amount of Nitrogen is applied to the field throughout the year. Actual design should take into account seasonal variations in N input.
Given Total Nitrogen value = 20 mg/L: $\frac{\text{20 mg/L x 4 MGD x 8.34 lb/gal x 182.5 day/period}}{\text{Line 3 value}}$

[b] Calculated amount of Nitrogen leached by percolate is negative.

Table 5.4-4
NITROGEN BALANCE, COASTAL BERMUDA/RYEGRASS, WINTER

1. Average Daily Flow ADF (MGD)	4.0	4.0	4.0	4.0
2. Average Design Wastewater Loading Rate (in/week)	1. 5	**1.75**	2.0	2.25
3. ADF Wetted Area (acre)	687	589	516	458
4. Nitrogen Input from Wastewater (lbs/acre-period)	177	207	236	266
5. Nitrogen Input from Rainfall and Fixation (lbs/acre-period)	2.5	2.5	2.5	2.5
6. Total Nitrogen Input (lbs/acre-period)	180	210	239	269
7. Ammonia Volatilization @ 5% of Ammonia applied (lbs/acre-period)	7	8	9	10
8. Denitrification @ 10% of Total Nitrogen applied (lbs/acre-period)	18	21	24	27
9. Net Plant Uptake and Storage (lbs/acre-period)	88	88	88	88
10. Nitrogen Leached by Percolate (lbs/acre-period)	68	93	118	144
11. Precipitation (in/period)	25	25	25	25
12. Wastewater Applied (in/period)	39	46	52	59
13. Potential Evapotranspiration P.E.T. (in/period)	6	6	6	6
14. Percolate (in/period)	58	65	71	78
15. Estimated Percolate Total Nitrogen (mg/L)	5.2	6.4	7.4	8.2

5.4.5 Operating Scheme

The operating scheme for the hypothetical 4-MGD facility is as follows:

a. The average initial design wastewater loading rate during summer will be 2.5 inches/week. The actual loading rate will be somewhat less than 2.5 inches/week during normal operation because the additional acreage needed for treating the operational storage, water balance storage and wet weather/emergency storage will be used to treat the normal daily flows. This will be done in order to maintain the cover crop regardless of whether there is any water in storage.

b. The average initial design wastewater loading rate during winter will be less than or equal to 1.75 inches/week.

c. The maximum allowable instantaneous application rate is 0.213 in/hr (ref. 5.4.1-b). For this example an instantaneous application rate of 0.20 in/hr will be used.

d. The cover crop will be Coastal Bermuda overseeded in the winter with Ryegrass. The crop will be harvested and sold.

e. Normal operation will be five (5) days per week. The flow from the other two days will be stored. Since the system will normally be operated five days per week, the wastewater volume applied each day is:

$$[(7 \text{ days/week})/(5 \text{ days/week})] \times 4 \text{ MGD} = 5.6 \text{ MGD}$$

5.4.6 Storage Volume Requirements

As discussed in Section 3.9, the required storage volume consists of three (3) <u>separate</u> storage components.

a. Operational Storage

The operating scheme selected for design calls for irrigation five days per week with storage of two days' flow. The required operational storage is:

$$(7 \text{ days} - 5 \text{ days}) \times 4 \text{ MGD} = 8 \text{ MG}$$

For this example it is assumed that harvesting of the grass will not occur during the wet weather months. Therefore, no additional storage will be needed for fields out of service due to harvesting since the wet weather storage volume will be available.

b. Wet Weather and Emergency Storage

Minimum requirements for wet weather and emergency storage are discussed in Section 3.9.2. These are the greater of 12 days flow or the results of eq. 3.9.2 .

For the hypothetical facility, Delta P from Table 5.3-1 is 2.5 inches. The maximum allowable hydraulic wastewater loading rate in the most critical water balance month (March) from Table 5.4-1 is 8.6 inches/month. By eq. 3.9.2:

$$\frac{2.5 \text{ inch x } 365 \text{ days/year}}{12 \text{ month/year x } 8.6 \text{ in/month}} = 8.8 \text{ days}$$

8.8 days is less than the 12-day minimum storage requirement. Therefore, the required wet weather and emergency storage is:

12 days x 4 MGD = 48 MG

c. Water Balance Storage

As discussed in section 3.9.3, the water balance storage is a function of hydraulic loading rate, which is a function of the total wetted field area. Therefore, before the water balance storage can be determined the wetted field area must be defined.

5.4.7 Wetted Field Area Determination

The area required for the spray site is the total of four separate components, as discussed in Section 3.10.

A(wetted) = A(ADF) + A(OP) + A(WW/E) + A(WBS)

Substituting the appropriate loading rates and the appropriate volumes into equations 3.10.1 and 3.10.3 results in the following wetted area requirements:

$$A(ADF) = \frac{7 \text{ days/wk operation x } 4{,}000{,}000 \text{ gpd x } 12 \text{ in/ft}}{7.48 \text{ gal/cf x } 43{,}560 \text{ sf/acre x } 1.75^{a} \text{ in/wk}}$$

[a] This site is nitrogen-limited in the winter at 1.75 in/week (see nitrogen balance). If the site were hydraulically limited, the design wastewater loading rate, (WLR_D) would be used.

A(ADF) = 589 acres

$$A(WW/E) = \frac{12 \text{ days storage x } 4{,}000{,}000 \text{ gpd x } 7 \text{ days/wk x } 12 \text{ in/ft}}{7.48 \text{ gal/cf x } 43{,}560 \text{ sf/acre x } 90 \text{ days x } 1.75^{b} \text{ in/wk}}$$

[b] 1.75 in/wk is the most critical wastewater loading rate, WLR_C, since the site is nitrogen-limited in winter at 1.75 in/wk (see nitrogen balance).

A(WW/E) = 79 acres

$$A(OP) = \frac{2 \text{ days storage x } 4{,}000{,}000 \text{ gpd x } 7 \text{ days/wk x } 12 \text{ in/ft}}{7.48 \text{ gal/cf x } 43{,}560 \text{ sf/acre x } 90 \text{ days x } 1.75^{b} \text{ in/wk}}$$

$$A(OP) = 13 \text{ acres}$$

With these areas determined the next step is to define the necessary water balance storage and the wetted field area associated with that storage. The actual wastewater loading rate (WLR_A) is:

$$WLR_A = \frac{7 \text{ days/wk x } 4{,}000{,}000 \text{ gpd x } 12 \text{ in/ft}}{7.48 \text{ gal/cf x } 43{,}560 \text{ sf/acre x } 681^{c} \text{ acres}}$$

[c] A(ADF) 589 acres + A(WW/E) 79 acres + A(OP) 13 acres = 681 acres

$$WLR_A = 1.51 \text{ in/wk}$$

Table 5.4-5 combines eq. 3.7.2 and 3.9.3 to determine the required water balance storage volume, V(WBS), for a loading rate of 1.51 in/wk. The table indicates a water balance storage requirement of 0.0 inches over the wetted area. Storage for the most critical month (March) is:

$$V(WBS) = \frac{0.0 \text{ in. x } 681 \text{ acres x } 7.48 \text{ gal/cf x } 43{,}560 \text{ sf/acre}}{12 \text{ inches}} = 0 \text{ MG}$$

Substituting the appropriate values into eq. 3.10.4:

$$A(WBS) = \frac{0 \text{ gal x } 7 \text{ days/wk x } 12 \text{ in/ft}}{90 \text{ days x } 7.48 \text{ gal/cf x } 43{,}560 \text{ sf/acre x } 1.51 \text{ in/wk}}$$

$$A(WBS) = 0 \text{ acres}$$

The total area necessary for this land treatment system is:

A(ADF) + A(OP) + A(WW/E) + A(WBS) = A(TOTAL)

589 acres + 13 acres + 79 acres + 0 acres = 681 acres

Table 5.4-5
WATER BALANCE STORAGE

Month	WLR_A [a] (in/month)	WLR_D [b] (in/month)	WBS [c] (in/month)	Sum WBS [d] (in/month)
January	6.7 [e]	9.7 [f]	0.0	0.0
February	6.1	8.8	0.0	0.0
March	6.7	8.6	0.0	0.0
April	6.5	11.5	0.0	0.0
May	6.7	14.3	0.0	0.0
June	6.5	15.9	0.0	0.0
July	6.7	15.5	0.0	0.0
August	6.7	16.5	0.0	0.0
September	6.5	14.8	0.0	0.0
October	6.7	14.1	0.0	0.0
November	6.5	10.5	0.0	0.0
December	6.7	10.3	0.0	0.0

a Based on the number of days per month and the actual wastewater loading of 1.51 in/week, assumes all influent wastewater is applied to spray fields.
b Values from Table 5.4-1
c WBS = Water balance storage, reference eq. 3.9.3. A negative WBS value indicates that no WBS is required for that month. A positive WBS value indicates that WBS is required for that month.
d Cumulative sum of WBS values
e $\frac{\text{31 days/month}}{\text{7 days/week}}$ x 1.51 in/wk = 6.7 inches/month
f 6.7 - 9.7 = -3, the value is negative which indicates that no WBS is required for this month