8.200 Wastewater Treatment Lagoons, Land Application, and Subsurface Irrigation Systems Reorganization

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10 CSR 20-8.200 Wastewater Treatment *[Ponds (Lagoons)]* Lagoons and Land Application

PURPOSE: The following criteria have been prepared as a guide for the design of waste-water treatment ponds (lagoons). This rule is to be used with rules 10 CSR 20-8.110–10 CSR 20-8.220 for the planning and design of the complete treatment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission as regards adequacy of design, submission of plans, approval of plans and approval of completed ~~[sewage works]~~ ***wastewater treatment plant. It is not reasonable or practical to include all aspects of design in these standards. The design engineer should obtain appropriate reference materials which include but are not limited to: copies of design manuals such as Water Environment Federation's Manuals of Practice, and other wastewater pumping station design manuals containing principles of accepted engineering practice.*** *Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. These criteria are ~~[taken largely from Great Lakes-Upper Mississippi River Board of State Sanitary Engineers Recommended Standards for Sewage Works and are]~~ based on the best information presently available,* ***including the Great Lakes-Upper Mississippi River Board of State and Provicial Public Health and Environmental Managers.*** *These criteria were originally filed as 10 CSR 20-8.030* ***and 10 CSR 20-8.220****. It is anticipated that they will be subject to review and revision periodically as additional information and methods appear. Addenda or supplements to this publication will be furnished to consulting engineers and city engineers. If others desire to receive addenda or supplements, please advise the Clean Water Commission so that names can be added to the mailing list.*
Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(1) Definitions. Definitions as set forth in the Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule, unless the context clearly requires otherwise. Where the terms "shall" and "must" are used, they are to mean a mandatory requirement insofar as approval by the *[agency]* **Missouri Department of Natural Resource (department)** is concerned, unless justification is presented for deviation from the requirements. Other terms, such as "should", "recommend", "preferred" and the like, indicate *[discretionary requirements on the part of the agency and deviations are subject to individual consideration]* **the preference of the department for consideration by the design engineer**.

(A) Deviations. Deviations from these rules may be approved by the department when engineering justification satisfactory to the department is provided. Justification must substantially demonstrate in writing and through calculations that a variation(s) from the design rules will result in either at least equivalent or improved effectiveness. Deviations are subject to case-by-case review with individual project consideration.

(B) Land application is the application of wastewater at rates up to the maximum amount which can be renovated by the soil—plant filter without detrimental effects to surface or groundwater soils or crops. Land application installations are to be used where the waste contains pollutants which can be successfully renovated through organic decomposition and the adsorptive, physical and chemical reactions in the soil and vegetation. The land application of wastewater may recharge the local groundwater or reemerge into streams; therefore, the quality, direction and rate of movement and local use of the groundwater, present and future, are important considerations in evaluating a proposed site. It is essential to maintain an aerated zone in the soil to provide good vegetative growth and removal of nutrients. A groundwater mound may develop after the system is in use. Major factors in the design of land application systems are topography, soils, geology, hydrology, weather, agricultural practice, crop, use of crop, adjacent land use, equipment selection and installation.

(C) No Discharge Lagoon. A no-discharge lagoon is a lagoon system consisting of one or multiple cells designed to hold the one and ten year storm event, plus a minimum of sixty days of wastewater without discharging. No discharge lagoons are used in the series with a surface or subsurface land application.

(D) Subsurface Land application or irrigation is a method of dispersing effluent from a wastewater treatment facility into subsurface soil uniformly and under unsaturated soil conditions allowing for efficient water use and nutrient uptake by vegetation.

(E) Retrofits. Retrofits as used in this chapter refer to physical, chemical, and biological modifications to an existing lagoon system to improve the quality of the effluent or allow the facility to achieve no discharge.
(F) Wastewater reuse is the application of wastewater for maximum economic return from the cropping system. Application rates will approximate the irrigation deficit and normally will not exceed twenty four inches (24") (60 cm) per year.

(2) *[Exceptions. This rule shall not apply to facilities designed for twenty-two thousand five hundred (22,500) gallons per day (85.4 m^3) or less (see 10 CSR 20-8.020 for the requirements for those facilities).]* **Applicability. This rule shall apply to all wastewater treatment facilities. This rule shall not apply to animal feeding operations, animal manure management systems or otheragricultural waste management systems. Design guide and criteria for these facilities are found in 10 CSR 20-8.300. This rule shall not apply to sludge storage lagoons or the land application of sludge. Design guides and criteria for these facilities are found in 10 CSr 20-8. 170.**

(3) General. This rule deals with generally used variations of treatment *[ponds]* **lagoons** to achieve secondary treatment including controlled discharge pond systems, flow-through pond systems**,** *[and]* aerate pond systems**, lagoon retrofits and land application**.
(A) *[Ponds]***Lagoons** utilized for equalization*[, percolation, evaporation]* and sludge storage will *[not be discussed in this rule]* **be discussed in 10 CSR 20-8.150 and 10 CSR 20-8.170**. **Wastewater reuse beyond land application and subsurface discharge is not discussed in this rule.**
(B) Industrial Wastes. Consideration shall be given to the type and effects of industrial wastes on the treatment process. It may be necessary to pretreat industrial discharges. Industrial wastes shall not be discharged to lagoons or to land application system without assessment of the effects the substances may have upon the treatment processor requirements in accordance with state and federal laws. Whenever industrial wastes are a significant part of the wastewater flow, the department may require more stringent seepage limitations and liner design considerations.

(A) *[Supplementary]* **Lagoon** Field Survey Data.

1. The location and direction of all residences, commercial developments, parks, recreational areas and water supplies, including a log of each well if available within one-half (1/2) mile (0.8 km) of the proposed [pond] **lagoon and land application site** shall be included *[in the engineer's report]*.

2. Land use zoning adjacent to the proposed *[pond]* site shall be included.

3. A description, including maps showing elevations and contours, of the site and adjacent area shall be provided. Due consideration shall be given to additional treatment units and/or increased waste loadings in determining land requirements. Current ~~*[United States Geological Survey and Soil Conservation Service]*~~ **National Resources Conservation Service (NRCS) County Soil Surveys** maps may be considered adequate for preliminary evaluation of the proposed site. **The purpose of the investigation is to assemble available information to determine if soil borings and soil tests are required to design a pond which will meet the seepage requirements. The investigation should be done using data such as ~~[Soil Conservation Service (SCS)]~~ National Resources Conservation Service (NRCS) County Soil Surveys, U.S. Geological Survey topographic maps and the required geological evaluation from the Department of Natural Resources, Missouri Geological Survey. Visual inspection of the area noting topography, wet areas, vegetation and ditching is useful and may be necessary, particularly if maps are not detailed and/or soil maps do not exist. Information gathered from this investigation should be particularly useful in evaluation of the site with regard to estimating possible soil variability and suitability.**

4. The location, depth and discharge point(s) of any field tile in the immediate area of the proposed site shall be identified.

5. A geological evaluation of the proposed lagoon site prepared by the *[Division of Geology and Land Survey (DGLS)]* **Missouri Geological Survey** shall be submitted. To obtain this geological evaluation of the proposed site, the engineer shall submit the following information to the Department of Natural Resources, *[Division of Geology and Land Survey]* **Missouri Geological Survey,** P.O. Box 250, Rolla, MO *[65401]* **65402**:

A. A layout sheet showing the proposed location. The layout shall include the legal description, property boundaries, roads, streams and other geographical landmarks which will assist in locating the site;

B. Size of the lagoon and/or approximate volume of waste to be treated;

C. Maximum cuts to be made in the construction of the lagoon; and

D. Location and depth of cut for borrow area, if any.

~~*[6. Sulfate content of the primary water supply shall be determined.]*~~

6. **All potential lagoon sites will receive a rating from the geological evaluation. The rating will infer the relative geological limitations for designing and constructing a lagoon at the site in question.**

A. Whenever the geological evaluation indicates that a site has slight limitations, the requirements for additional soils site investigation as set forth in subsection 8 of this rule, may not be required by the department. The department may require that the results of density tests, taken on the finished lagoon liner, be submitted and approved prior to putting the pond into operation.

B. Whenever a site has moderate geological limitations, the department may require one (1) or all of the requirements for a detailed site investigation as set forth in subsection 8 of this rule. The department may require density tests, taken on the finished lagoon liner, be submitted and approved prior to putting the lagoon into operation.

C. Sites that have severe geological limitations for construction of wastewater stabilization lagoons will be reviewed on a case-by-case basis. The department may require artificial liners in these situations. In general, where there is high collapse potential due to bedrock and soil conditions, the use of lagoons will not be allowed. Exceptions may be granted dependent upon the type of liner proposed and where the geological considerations have been thoroughly evaluated so that the risk of groundwater contamination is minimized.

D. Where liners are used in storage or treatment basins for wastewaters of an industrial nature, the summary of design data shall document that the liner or storage structure material is capable of containing the wastewater for at least twenty (20) years and shall specify repair or replacement procedures in the event of leakage or damage to the seal. Secondary containment or leakage detection and collection devices shall be considered for corrosive or reactive wastewaters and for toxic materials. The department may require leakage testing and submittal of density tests and/or coefficient of permeability on the finished liner prior to placing the structure into operation.

7. Data from all soil borings conducted by a professional soil testing laboratory to determine subsurface soil characteristics and groundwater characteristics, including elevation, at the proposed site and their effect on the construction and operation of a *[pond]* **lagoon** shall also be provided.

A. All boring holes shall be filled and sealed.

B. The permeability characteristics of the pond bottom and pond seal material shall also be studied.

C. At the facility plan stage particle size analysis, Atterburg limits, standard *[Procter]* **Proctor** density (moisture-density relations) or permeability coefficient may be required on a case-by-case basis to reflect soil characteristics.

D. *[At the twenty percent (20%) design stage,]* soil analysis of each representative soil material including particle size analysis, Atterburg limits, standard *[Procter]* **Proctor** density (moisture-density relations) and permeability coefficient of the compacted soil as measured in a falling head permeameter or other test procedure acceptable to the agency may be required.

E. Soil borings may be required in each geological area to determine depth to piezometric surface and to bedrock. Recommendations of the *[DGLS]* **Missouri Geological Survey** will be used to establish the required tests at the facility plan. *[and twenty percent (20%) design stages.]*

8. Site Investigation. A preliminary investigation for a lagoon site should be undertaken to screen a study area for potential sites before a detailed site investigation, if required, is undertaken.

1. Detailed Soils Investigation. If a detailed site investigation is needed to substantiate feasibility and design of a project at a selected site with regard to design requirements, the quantity and quality of soil materials on site (and borrow) must be identified and evaluated for use in the pond and/or liner construction. The design concepts and objectives of the investigation should be made clear by the consulting engineer to the qualified soil engineering party doing the field work so that an investigation strategy can be developed and sufficient data collected. Most important, an identification of the volume of the soil needed for the liner must be determined. The department may require the following to be included in the soils investigation:

A. Exploration shall be sufficient to identify and define the quantities and quality of the soil liner materials. The use of test pits, split barrel or thin wall sampling or a combination of these techniques may be used depending on the total area of investigation and the depth to which exploration is needed. The following information, in whole or in part, may be required by the department:

1. Atterburg limits;
2. Standard Proctor density (moisture/density relationships);
3. Coefficient of permeability (undisturbed and remolded);
4. Depth to bedrock;
5. Particle size analysis; and

6. Depth to seasonal high groundwater table.

B. Information gathered from the investigation should be presented on a base map drawn to scale and referenced to U.S. Geological Survey datum. Slope, landscape position and other surface features should also be included. Stratigraphy of soils should be shown using cross sections or fence diagrams when soil liner material is to be identified. Copies of original boring and other soil test logs shall also be included. An interpretation of the collected data shall be incorporated into the report. Any site constraints and how they will be dealt with should be discussed.

[(B)] (C) Site Information.

1. Distance from habitation. Lagoon sites should be as far as practicable from habitation or any area which may be built up within a reasonable future period. The agency does not attempt to set any minimum distance from habitation since each case must be judged upon its own merits.

2. Prevailing winds. If practicable, *[ponds]* **lagoons and spray land application sites** should be located so that local prevailing winds will be in the direction of uninhabited areas.

3. Surface runoff. Location of [ponds] **lagoons** in watersheds receiving significant amounts of stormwater runoff is discouraged. Adequate provisions must be made to divert stormwater runoff around the ponds and protect embankments from erosion.

4. Hydrology. Construction of *[ponds]* **lagoons** in close proximity to water supplies and other facilities subject to contamination should be avoided. A minimum separation of four feet (4') (1.2 m) between the bottom of the pond and the maximum groundwater elevation should be maintained where feasible.

5. Groundwater pollution. Proximity of lagoons to water supply located in areas of porous soils and fissured rock formation shall be elevated to avoid creation of health hazards or other undesirable conditions. If the geological report from *[DGLS]* **Missouri Geological Survey** makes suggestions for remedial treatment of the site, the engineer shall comply with the suggestions. In some cases, the engineering geologist requests to visit the site during or after construction. When a request is made, the consulting engineer shall comply with the request.

6. Additional storage volume should be considered for sludge and in northern [climates] Missouri, ice cover.

(5) Basis of Design.

(A) Quality of Effluent. A controlled discharge stabilization *[pond]* **lagoon** (four (4)-cell) will be considered capable of meeting effluent limitations of thirty (30) mg/l biochemical oxygen demand (BOD_5) and thirty (30) mg/l suspended solids. Flow-through stabilization *[ponds]* **lagoons** (three (3)-cell), and aerated lagoon systems will be considered capable of meeting effluent limitations of thirty (30) mg/l BOD_5 and eighty (80) mg/l suspended solids. Flow-through lagoon systems and aerated lagoon systems ~~*[followed by submerged sand filters]*~~ **with retrofits** will be considered capable of meeting effluent limitations of twenty (20) mg/l BOD_5 and twenty (20) mg/l suspended solids **and partial ammonia removal**. Lagoons may be incorporated into irrigation systems or systems utilizing chemical coagulation and filtration to meet the **discharge** requirements of 10 CSR 20-7.015.

(B) Area and Loadings for Discharging Lagoons.

1. Controlled Discharge Stabilization *[Ponds]* **Lagoons** (four (4)-cell). *[Pond]* **Lagoon** design for BOD_5 loadings shall not exceed thirty-four (34) lbs./acre/day (38 km per hectare per day) at the three-foot (3') (1.9 m) operating depth in the primary cells. The primary cell shall be followed by a secondary cell having 0.3 the area of the primary cell and by two (2) storage cells. The two (2) storage cells shall have a volume above the two-foot (2') (0.6 m) level for one (1) month's storage of average daily flow in each cell. At least one hundred twenty (120) days' detention time between the two-foot (2') level (0.6 m) and the maximum operating depth shall be provided in the entire ~~*[pond]*~~ **lagoon** system. Flow can be based on one hundred (100) gallons per capita per day (38 m^3/cap/d) or other values if data is presented to justify the rate. Primary and secondary cells shall be designed for water depths up to a maximum of five feet (5') (1.5 m). The storage cell should be made as deep as possible up to a maximum depth of eight feet (8') (2.4 m).

2. Area and Loadings for Flow-through Stabilization *[Ponds]* **Lagoons** (three (3)-cell). *[Pond]* **Lagoon** design for BOD_5 loadings shall not exceed thirty-four (34) pounds per acre per day (38 km per hectare per day). The second cell must be at least 0.3 the area of the first cell and the third cell 0.1 the area of the first cell. The first and second cells must have a variable operating level of between two feet (2') (0.6 m) and five feet (5') (1.5 m). The third cell must have a variable operating level of between two feet (2') (0.6 m) and eight feet (8') (2.4 m). Detention time of at least one hundred twenty (120) days must be provided. Flows of less than one hundred (100) gallons per capita per day (.38 m^3/cap/d) may be used if data is presented to justify the lower rate.

3. Area and Loadings for Aerated Lagoons. For the development of final design parameters it is recommended that actual experimental data be developed; however, the aerated lagoon design for minimum detention time may be estimated using the following formula:

$$t = \frac{E}{2.3\, K_1 \times (100-E)}$$

where:

t = detention time in the aeration cell in days;

E = percent of BOD_5 to be removed in an aerated ~~*[pond]*~~ **lagoon**; and

K_1 = reaction coefficient aerated lagoon, base 10.

A. For normal domestic sewage the K_1 value may be assumed to be ~~*[.15]*~~ **0.06** per day for Missouri conditions. The reaction rate coefficient for domestic sewage which includes some industrial waste, other waste or partially treated ~~*[sewage]*~~ **wastewater** must be determined experimentally for various conditions which might be encountered in the aerated ~~*[ponds]*~~ **lagoons**. Conversion of the reaction coefficient at other temperatures shall be based on experimental data. Raw ~~*[sewage]*~~ **wastewater** strength should also consider the effect of any return sludges.

~~*[2. [Also, additional] Additional storage volume should be considered for sludge and in northern [climates] Missouri, ice cover].*~~

B. Oxygen requirements generally will depend on the ~~*[BOD_5]*~~ **ammonia** loading, the degree of treatment and the concentration of suspended solids to be maintained. Aeration equipment shall be capable of maintaining a minimum dissolved oxygen level of two (2) mg/l in the *[ponds]* lagoons at all times. **The aeration equipment shall be capable of at least 1.4 pounds of oxygen per pound of BOD removed and where nitrification is required; the aeration equipment shall have the capacity to provide an additional 4.6 pounds. of oxygen per pound. of ammonia nitrogen removal.**

[4. Suitable protection from weather shall be provided for electrical controls. The aeration equipment shall be capable of providing 1.3 pounds of oxygen per pound of BOD_5 (1.3 kg/kg BOD_5) removed. BOD_5 removal shall be based on warm weather rates. Aerated cells shall be followed by a polishing cell with a volume of 0.3 of the volume of the aerated cell (see 10 CSR 20-8.180 for details on aeration equipment).]

C. A sufficient number of aerators shall be provided so that a design level of dissolved oxygen within a particular cell shall be maintained with the largest capacity aerator in that cell out of service.

1. Floating surface aerators should be anchored in at least three and preferably four directions. Interconnection of floating aerators is discouraged. Flexible cables are preferred over rigid ones.

2. Surface aerators should be designed to prevent icing. Consideration should be given to the installation of splash plates for control of misting. For platform mounted aerators, the platform legs should be spaced at a sufficient distance from the aerator to minimize the effect of ice build-up caused by splashing.

D. Aerator design should provide for periodic and major maintenance and repairs and shall provide for removal of the aerators for replacement if necessary. Provisions shall be made for independent operation of each aerator by on/off switches, time clocks, etc.

E. Diffused aeration. The design for compressed air volume requirements shall include the basin aeration requirements together with air used in other channels, pumps, or other air-use demands. The air diffusion equipment shall be capable of maintaining sufficient mixing and oxygen concentration in the aerated volume under maximum seasonal demand conditions. Provisions shall be made for removal of deposits for unclogging of air diffuser openings. Consideration should be given to minimizing the points of access necessary for cleaning.

1. The specified capacity of blowers or air compressors, (particularly centrifugal blowers), shall take into account that the air intake temperature may reach 40°C (104°F) or higher and the pressure may be less than normal. Air filters shall be provided in numbers, arrangement, and capacities to furnish at all times an air supply sufficiently free from dust to protect equipment and prevent clogging of the diffuser system used.

2. The blowers shall be provided in multiple units, so arranged and in such capacities as to meet the maximum air demand with the single largest unit out of service. The design shall also provide for varying the volume of air delivered in proportion to the design load for individual cells of the lagoon system.

3. In the summary of design, calculations shall be provided to verify that blower pressure is sufficient to dewater the diffuser lines at saturation conditions under normal operating depths.

F. Diffusers shall be arranged in each basin to provide tapered aeration with maximum intensity near the inlet. The spacing of diffusers shall be in accordance with the oxygenation requirements of the total process, i.e., the organic loading in each cell. Diffuser spacing should be designed to facilitate adjustments without major revision to air header piping. The arrangement of diffusers should also permit their removal for inspection, maintenance, and replacement without completely dewatering the basin and without shutting off the air supply to other diffusers in the basin.

G. Individual assembly units of diffusers shall be equipped with control valves, preferably with indicator markings for throttling or for complete shut-off. Provisions must be made for subsequent air flow or pressure measurements and necessary air flow adjustments. Diffusers in any single assembly shall have substantially uniform pressure loss and hydraulic residence time.

(C) Area and Loadings for Land Application Storage Basins

1. At a minimum, treatment prior to land application shall provide treatment equivalent to that obtained from a primary wastewater pond cell designed and constructed in accordance with sections(6) and (7) of this rule, except that the pond depth may be increased to include wastewater storage on top of the primary volume.

2. Separate storage cells may also be used. The maximum organic loading on the primary cell(s) at a water depth of three feet (3') shall not exceed thirty-four pounds (34 lbs.) of BOD per acre per day.

3. Storage requirements shall be based on the design wastewater flows and net rainfall minus evaporation expected for a one (1) in ten (10) year return frequency for the storage period selected. The storage volume for wastewater land application storage basins shall be calculated based on the useable volume above the two-foot (2') level. The minimum total days' storage required for no discharge ranges from sixty (60) days in southern Missouri to one hundred twenty (120) days in northern Missouri. These requirements assume that a permanent cover crop is in place and the primary purpose of the system is wastewater treatment. If the system uses row crops, or crop production is the primary goal, storage should be increased to correspond with crop planting and harvesting schedules. See Section (8) of this rule for additional information.

4. The normal operating level for all ponds should be between the two-foot (2') level and the high water level. The normal operating level for all ponds should be between the two-foot (2') level and the high water level.

5. A permanent depth measurement gauge or marker shall be installed in the pond(s) and shall be easily readable at one-foot (1') increments or smaller. The gauge shall be placed in a suitable location where it is easily accessible during routine operations.

(D) Area and Loadings for Lagoons utilized for Flow Equalization

1. General. Flow equalization can reduce the dry weather variations in organic and hydraulic loadings at any wastewater treatment plant. It should be provided where large diurnal variations are expected.

2. Location. Equalization basins should be located downstream of pretreatment facilities such as bar screens, comminutors and grit chambers.

3. Type. Flow equalization can be provided by using separate basins or on-line treatment units. Equalization basins may be designed as either in-line or side-line units.

4. Size. Equalization basin capacity should be sufficient to effectively reduce expected flow and load variations to the extent deemed to be economically advantageous. With a diurnal flow pattern, the volume required to achieve the desired degree of equalization can be determined from a cumulative flow plot over the representative twenty- four (24)-hour period.

5. Operation.

A. Mixing. Aeration or mechanical equipment shall be provided to maintain adequate mixing. Corner fillets and hopper bottoms with draw-offs should be provided to alleviate the accumulation of sludge and grit.

B. Aeration. Aeration equipment shall be sufficient to maintain a minimum of 1.0 mg/l of dissolved oxygen in the mixed basin contents at all times. Air supply rates should be a minimum of 2.0 cfm per one thousand gallons (1000 gal) of storage capacity. The air supply should be isolated from other treatment plant aeration requirements to facilitate process aeration control. Standard process aeration supply equipment may be utilized as a source of standby aeration.

C. Controls. Inlets and outlets for all basin compartments shall be suitably equipped with accessible external valves, stop plates, weirs or other devices to permit flow control and the removal of an individual unit from service. Facilities shall also be provided to measure and indicate liquid levels and flow rates. The total equalization volume shall be large enough to effectively reduce both flow and load variations.

D. Suitable access shall be provided to facilitate the maintenance of equipment and cleaning.

(E) Multiple Units. Parallel cells should be considered for large installations. The maximum size of any cell should be forty (40) acres (16 ha). The system should be designed to permit isolation of any cell without disrupting service of the other cells.

(F) *[Pond]* **Lagoon** Shape. The shape of all cells should be so that there are no narrow or elongated portions. Round, square or rectangular *[ponds]* **lagoons** with a length not exceeding three (3) times the width are considered most desirable. No islands, peninsulas or coves shall be permitted. Dikes should be rounded at corners to minimize accumulation of floating materials. Common dike construction, wherever possible, is strongly encouraged.

[(G) Industrial Wastes. Consideration shall be given to the type and effects of industrial wastes on the treatment process. In some cases it may be necessary to pretreat industrial or other discharges. Industrial wastes shall not be discharged to ponds without assessment of the effects the substances may have upon the treatment processor discharge requirements in accordance with state and federal laws.]

(H) Additional Treatment. Consideration should be given in the design stage to the utilization of additional treatment units as may be necessary to meet applicable discharge standards (see paragraph (4)(A)3. of this rule).

(6) [Pond] **Lagoon** Construction Details.

(A) Embankments and Dikes.

1. Material. Dikes shall be constructed of relatively impervious material and compacted to at least ninety-five percent (95%) standard *[Procter]* **Proctor** density to form a stable structure. Vegetation and other unsuitable materials shall be removed from the area where the embankment is to be placed.

2. Top width. The minimum dike width shall be eight feet (8') (2.4 m) to permit access of maintenance vehicles.

3. Maximum slopes. Inner and outer dike slopes shall not be steeper than three horizontal to one vertical (3:1).

4. Minimum slopes. Inner slopes should not be flatter than four horizontal to one vertical (4:1). Flatter slopes can be specified for larger installations because of wave action but have the disadvantage of added shallow areas being conducive to emergent vegetation. Outer slopes shall be sufficient to prevent surface runoff from entering the ponds.

5. Freeboard. Minimum freeboard shall be two feet (2') (0.6 m). For ~~*[very large cells]*~~, **cells greater than ten acres,** three feet (3') (1.0 m) should be considered.

6. Design depth. The minimum operating depth should be sufficient to prevent growth of aquatic plants and damage to the dikes, bottom, control structures, aeration equipment and other appurtenances. In no case should pond depths be less than two feet (2') (0.6 m). The design water depth for aerated lagoons should be ten to fifteen feet (10–15') (3–4.5 m). This depth limitation may be altered depending on the aeration equipment, waste strength, climatic conditions and geologic conditions.

7. Erosion control. A justification and detailed discussion of the method of erosion control which encompasses all relative factors such as *[pond]* **lagoon** location and size, variations in operating depths, seal material, topography, prevailing winds, cost breakdown, application procedures, etc., shall be provided.

A. Seeding. The dikes shall have a cover layer of fertile topsoil with a minimum thickness of four inches (4") (10 cm) to promote establishment of an adequate vegetative cover wherever riprap is not utilized. Prior to prefilling (in accordance with paragraph (6)(C)3. of this rule), adequate vegetation shall be established on dikes from the outside toe to one foot (1') above the water line measured on the slope. Perennial-type, low growing, spreading grasses that minimize erosion and can be mowed are most satisfactory for seeding of dikes. In general, alfalfa and other long-rooted crops should not be used for seeding since the roots of this type are apt to impair the water holding efficiency of the dikes. Alternate dike stabilization practices may be considered if vegetative cover cannot be established prior to prefilling.

B. Additional erosion protection. Riprap or some other acceptable method of erosion control is required as a minimum around all piping entrances and exits. For aerated cell(s) design should ensure erosion protection on the slopes and bottoms in the areas where turbulence will occur. Additional erosion control may also be necessary on the exterior dike slope(s) to protect the embankment(s) from erosion due to severe flooding of a water course.

C. Alternate erosion protection. Alternate erosion control on the interior dike slopes may be necessary for ponds which are subject to severe wave action. In these cases riprap or an acceptable equal shall be placed from one foot (1') (.3 m) above the high water mark to two feet (2') (0.6 m) below the low water mark (measured on the vertical). *[This protection should also be provided in the storage cells of a controlled discharge (four (4)-cell) pond and the third cell of a flow-through pond (three (3)-cell) where large fluctuations in operating depths will occur.]*

(B) *[Pond]* **Lagoon** Bottom.

1. Soil. Soil used in constructing the pond bottom (not including the seal) and dike cores shall be selected to avoid settlement. Soil shall be compacted with the moisture content between two percent (2%) below and four percent (4%) above the optimum water content and to the specified standard *[Procter]* **Proctor** density but no less than ninety-five percent (95%) standard *[Procter]* **Proctor** density. **Any soil borings and tests to determine characteristics of surface soil and subsoil shall be made part of the summary of design data. The bottom should be cleared of vegetation and debris.**

2. All lagoons shall be sealed so that seepage loss through the seal is as low as possible. The lagoon seal shall cover the bottom and extend up the inner dike slope to where the side slope intersects with the top of the dike. Seals consisting of soils, asphalt, soil cement or synthetic liners may be used provided the permeability, durability and integrity of the proposed materials can be satisfactorily demonstrated for anticipated conditions. Bentonite, soda ash or other sealing aids may be used to achieve an adequate seal in systems using soil.

A. The design permeability of the lagoon seal shall not exceed five hundred (500) gallons per acre per day in areas where potable groundwater might become contaminated or when the wastewater contains industrial contributions of concern. Design seepage rates up to thirty-five hundred (3500) gallons per acre per day may be considered in other areas where potable groundwater contamination is not a problem, provided that the pond cells will maintain adequate water levels to provide treatment and avoid nuisance conditions.

B. Soils having a permeability coefficient of 10^{-7} centimeters per second or less with a compacted thickness of twelve inches (12") will be acceptable as a pond seal for water depths up to five feet (5') and for seepage losses less than five hundred (500) gallons per acre per day. For permeability coefficients greater than 10^{-7} centimeters per second (cm/sec) or for heads over five feet (5') such as an aerated lagoon system, the following equation shall be used to determine minimum seal thickness:

$$t = \frac{H \times K}{5.4 \times 10^{-7} \text{ cm/sec}}$$

where

K = the permeability coefficient of the soil in question;
H = the head of water in the pond; and
t = the thickness of the soil seal.

C. All lagoons shall be prefilled to protect the liner, to prevent weed growth, to reduce odor, to allow measurement of percolation losses and to maintain moisture content of the seal.

D. If measurement of percolation losses is required by the department. In no case shall measured percolation losses exceed one-sixteenth inch (1/16") (1.6 mm) per day per acre or thirty-five hundred (3500) gallons per acre per day, whichever is more lower. In areas where there is a significant potential for groundwater contamination, justification shall be provided before measured percolation losses will be allowed to exceed five hundred (500) gallons per acre per day and in no case shall percolation losses exceed seventeen hundred (1700) gallons per acre per day. Whenever industrial wastes are a significant part of the wastewater flow, the department may require more stringent seepage limitations and liner design considerations.

3. Design. The following criteria are for design and construction of soil liners. Engineering reports, plans and specifications should address these criteria.

A. The soils used for construction of a wastewater stabilization pond liner should meet the following minimum specifications:

1. Be classified under the Unified Soil Classification Systems as Cl, Ch, Gc or Sc;

2. Allow more than fifty percent (50%) passage through a No. 200 sieve;

3. Have a liquid limit equal to or greater than thirty (30);

4. Have a plasticity index equal to or greater than twenty (20); and

5. Have a coefficient of permeability equal to or less than 1×10^{-7} centimeters per second when compacted to ninety percent (90%) of standard proctor density with the moisture content between two percent (2%) below and four percent (4%) above the optimum moisture content;

B. The minimum thickness of the liner is twelve inches (12"). For soils which have a coefficient of permeability greater than 1 × 10^{-7} centimeter per second, liner thickness of more than twelve inches (12") may be required as set forth in subparagraph (13)(A)4.B. of this rule;

C. Normal construction methods will include scarification and compaction of base material to ninety percent (90%) standard proctor density at a moisture content that allows the material to be plastic. Construction of the liner material should be at a moisture content between two percent (2%) below and four percent (4%) above optimum and compaction of lifts generally not exceeding six inches (6") to greater than ninety percent (90%) standard Proctor density. Maximum rock size should not exceed one-half (1/2) of the thickness of the compacted lift. The completed seal shall be maintained at or above the optimum water content until the lagoon is prefilled in accordance with this rule; and

D. If bentonite is proposed to be part of the liner construction, the following must be considered:

1. The bentonite should be high swelling and free flowing for uniform application. The application rate should be a minimum of two pounds (2 lbs.) per square foot. The water content of the soil-bentonite mixture should be at or up to four percent (4%) above the optimum for maximum compaction;

2. The bentonite should be spread with equipment that provides uniform application and minimizes wind drift. The application shall be split, so that one-half (1/2) is applied in one direction and the remaining half in a perpendicular direction on the lagoon floor and dikes. The bentonite shall be mixed into the soil to a uniform depth of at least four inches (4") and the liner should be compacted to at least ninety percent (90%) standard Proctor density without the use of a sheepsfoot roller. The completed liner shall be covered with at least four inches (4") of fine textured soil and the liner shall be hydrated with fresh water prior to introduction of wastewater and kept at or above optimum water content until the pond is prefilled; and

3. At sites where the soils are considered to be aggregated cherty clays, the lagoon bottom below the bentonite seal should be either constructed as embankment or scarified to a depth of twelve inches (12") and compacted in six-inch (6") lifts to at least ninety percent (90%) standard proctor density. At least four inches (4") of fine soil shall be placed on top of the compacted pond bottom for mixing with the bentonite. The maximum size of rocks in the fine soil used for covering the soil-bentonite liner and in the soil-bentonite mixture should be one inch (1").

4. Synthetic Liners. Requirements for thickness of synthetic seals may vary due to liner material but the liner thickness shall be no less than two-hundredths inch (.02") or twenty (20) mil. Consideration should also be given to liners containing reinforcement in appropriate situations, such as sidewall slopes steeper than one to three (1:3) or lagoon depths greater than six feet (6'). Also in areas of cherty or gravelly soils, consideration should be given to using a geotextile under the liner or very thick polyethylene (80 mil) liners. Special care must be taken to select the appropriate material to perform under existing conditions.

A. Proper site preparations for synthetic liners are essential. The subsoil bed shall be sufficiently prepared to insure that all holes, rocks, stumps and other debris are eliminated. The subsoil shall be sieved or the area raked after grading to provide a smooth, flat surface free of stones and other sharp objects. A bedding of two to four inches (2–4") of sand or clean soil free of stones greater than three-eighths inch (3/8") or other sharp objects shall be provided. Soil shall be well compacted and sterilized to kill vegetation. If gas generation from decaying organic material or air pumping from a fluctuating groundwater table is a potential problem, a method of gas venting must be proposed. The method utilized will be dependent on the existing conditions at the site.

B. Liner panels should be laid out to minimize seams with an overlap of four to six inches (4–6"). Careful application of the seaming method is essential. The anchor trench should have a minimum six-inch (6") depth and be placed at least nine to twelve inches (9–12") beyond the slope break at the dike. Care must be exercised in the backfilling of the anchor trench to insure the liner is not damaged. To prevent erosion, mechanical damage to the liner and hydraulic uplifting of the liner, a minimum backfill of twelve inches (12") of sand or finely textured soils on the top of the liner is recommended on the pond floor. On the side slopes this should consist of a minimum twelve-inch (12") primary fill of finely textured soil and possibly a minimum six-inch (6") secondary fill of rip-rap.

C. All seams should be inspected and the inspection reports should be submitted to the department prior to seepage testing if required. It is recommended that installation be done by contractors familiar with potential problems which can be encountered.

D. Where liners are used in storage or treatment basins for wastewaters of an industrial nature, the summary of design data shall document that the liner or storage structure material is capable of containing the wastewater for at least twenty (20) years and shall specify repair or replacement procedures in the event of leakage or damage to the seal. Secondary containment or leakage detection and collection devices shall be considered for corrosive or reactive wastewaters and for toxic materials. The department may require leakage testing and submittal of density tests and/or coefficient of permeability on the finished liner prior to placing the structure into operation.

[(C) Seal

1. Design. Ponds shall be sealed so that seepage loss through the seal is as low as practicably possible. Seals consisting of soils or synthetic liners may be used provided the permeability, durability, integrity and cost effectiveness of the proposed materials can be satisfactorily demonstrated for anticipated conditions. Bentonite, soda ash or other sealing aids may be used to achieve an adequate seal in systems using soil. Results of a testing program which substantiates the adequacy of the proposed seal must be incorporated into and/or accompany the engineering report. Standard ASTM procedures or other acceptable methods shall be used for all tests. Soils having a permeability coefficient of 10- cm/sec or less with a compacted thickness of twelve inches (12") (30.5 cm) will be acceptable as a lagoon seal for water depths up to five feet (5') (1.5 m). For permeability coefficients greater than $10^{-7\ cm/sec}$ *or for heads over five feet (5') (1.5 m) such as an aerated lagoon system, the following formula shall be used to determine minimum seal thickness:*

$$t = \frac{H \times K}{5.4 \times 10^{-7\ cm/sec}}$$

where:
K = the permeability coefficient of the soil in question;
H = the head of water in the lagoon; and
t = the thickness of the soil seal.

2. Normal construction methods will include over-excavation below grade level of twelve inches (12") (30.5 cm), scarification and compaction of base material to ninety-five percent (95%) standard Procter density at moisture content between two percent (2%) below and four percent (4%) above optimum, and compaction of lifts generally not exceeding six inches (6") (15.2 cm) to ninety-five percent (95%) standard Procter density at moisture content between two percent (2%) below and four percent (4%) above optimum. Maximum rock size should not exceed one-half (1/2) of the thickness of the compacted lift. The cut face of dikes must also be over-excavated and compacted in lifts not to exceed six inches (6") (15.2 cm) per lift. Soils containing plastic clay may be excluded from this construction requirement on a case-by-case basis based on particle size analysis and Atterburg limits. In fact, with some clay soils, satisfactory construction cannot be obtained by over-excavation and recompaction. Construction control must include field density. A minimum of two (2) density tests per acre or not less than three (3) tests must be performed for the base and each lift. Permeability tests of field compacted material may be performed at the option of the consulting engineer.

3. Prefilling. The pond shall be prefilled in order to protect the liner, to prevent weed growth, to reduce odor, to allow measurement of percolation losses and to maintain moisture content of the seal. However, the dikes must be completely prepared as described in subparagraphs (6)(A)7.A. and/or B. of this rule before the introduction of water. If the lagoon bottom is allowed to dry, the seal must be recompacted as required in paragraph (6)(C)2.

4. Percolation losses. Measurement of percolation losses shall consider flow into and out of the lagoon, rainfall and evaporation, and changes in water level. Measured percolation losses in excess of one-sixteenth inch (1/16") (1.6 mm) per day will be considered excessive.]

(D) Influent Lines.

1. Material. Cast- or ductile-iron pipe should be used for the influent line to the pond. Unlined corrugated metal pipe should be avoided due to corrosion problems. Other materials selected shall be suited to local conditions. In material selection, consideration must be given to the quality of the wastes, exceptionally heavy external loadings, abrasion, soft foundations and similar problems.

2. Manhole. A manhole shall be installed prior to entrance of the influent line into the primary cell(s) and shall be located as close to the dike as topography permits. Its invert shall be at least six inches (6") (15 cm) above the maximum operating level of the pond and provide sufficient hydraulic head without surcharging the manhole. **Manholes shall be installed per the requirements of 10 CSR 20-8.xxx(x).**

3. Flow distribution. Flow distribution structures shall be designed to effectively split hydraulic and organic loads equally to the primary cells.

4. Influent line(s). The influent line(s) shall be located along the bottom of the pond so that the top of the pipe is just below the average elevation of the pond seal; however, the pipe shall have adequate seal below it.

5. Point of discharge. All primary cells shall have individual influent line(s) which terminate at approximately the center of the cell so as to minimize short-circuiting. Consideration should be given to multi-influent discharge points for primary cells of twenty (20) acres (8 hectares) or larger to enhance distribution of the waste load on the cell. All aerated cells shall have influent lines which distribute the load within the mixing zone of the aeration equipment. Consideration of multi-inlets should be closely evaluated for any diffused aeration systems.

6. Influent discharge apron. The influent line(s) shall discharge horizontally into the shallow saucer-shaped depression. The end of the discharge line(s) shall rest on a suitable concrete apron large enough so that the terminal influent velocity at the end of the apron does not cause soil erosion. A minimum size apron of two feet (2') (0.6 m) square shall be provided.

7. Flow measurement. Influent flow measurement devices shall be installed with accordance to 10 CSR 20-8.140(8)(I).

(E) Control Structures and Interconnecting Piping.

1. Structure. Facilities design shall consider the use of multipurpose control structures, where possible, to facilitate normal operational functions such as drawdown and flow distribution, flow and depth measurement, sampling, pumps for recirculation, chemical additions and mixing and to minimize the number of construction sites within the dikes. As a minimum, control structures shall be accessible for maintenance and adjustment of controls; adequately ventilated for safety and to minimize corrosion; locked to discourage vandalism; contain controls to allow water level and flow rate control, complete shut off and complete draining; constructed of noncorrosive materials (metal on metal contact in controls should be of like alloys to discourage electrochemical reactions); and located to minimize short-circuiting within the cell and avoid freezing and ice damage. Recommended devices to regulate the water level are valves, slide tubes or dual slide gates. Regulators should be designed so that they can be preset to stop flows at any pond elevation.

2. Piping. All piping shall be of cast-iron or other acceptable materials. The piping should not be located within the seal. Seep collars shall be provided on drain pipes where they pass through the pond seal. Backfill around the drain pipe shall be placed and compacted in the same manner as the pond seal. Pipes should be anchored with adequate erosion control.

A. Drawdown structure piping.

(I) Multilevel outlets. The outlet structure on each pond cell, except aerated cells, shall be designed to permit overflow at one-foot (1') (30.5 cm) increments between the two foot (2') (61 cm) level and the maximum operating level. Suitable baffling shall be provided to prevent discharge of scum or other floating materials. Means must be provided to prevent unauthorized variance of the lagoon depth. A flap valve shall be provided at the outlet end of the final cell overflow or drain pipe to prevent entrance of animals or backwater from flooding.

(II) *[Pond]* **Lagoon** drain. All *[ponds]* **lagoons** shall have emergency drawdown piping to allow complete draining for maintenance. These should be incorporated into the previously described structures. Sufficient pumps and appurtenances shall be made available to facilitate draining of individual *[ponds]* **lagoons** if *[ponds]* **lagoons** cannot be drained by gravity.

(III) Emergency overflow. To prevent overtopping of dikes, emergency overflow should be provided.

B. Hydraulic Capacity. The hydraulic capacity for constant discharge structures and piping shall allow for a minimum of two hundred fifty percent (250%) of the design flow of the system. The hydraulic capacity for controlled discharge systems shall permit transfer of water at a minimum rate of six inches (6") (15.2 cm) of pond water depth per day at the available head.

[(7) Submerged Sand Filters.

(A) Applications. Submerged sand filters may be used for solids and BOD_5 removal following waste stabilization ponds and are considered to be both a third lagoon cell and solids removal facility when designed according to the parameters in subsection (7)(B) of this rule.

(B) Design Details.

1. Following nonaerated waste stabilization ponds, the loading shall not exceed five (5) gallons per day per square foot (.2 m^3/m^2/day) of sand. Following aerated waste stabilization ponds, the loading shall not exceed fifteen (15) gallons per day per square foot (.6 m^3/m^2/day) of sand.

2. Clean graded gravel, preferably placed in at least three (3) layers should be placed around the underdrains and to a depth of at least six inches (6") (15 cm) over the top of the underdrains. Suggested gradings for the three (3) layers are: one and one-half inches to three-fourths inch (1 1/2"–3/4") (3.8 cm–1.9 cm), three-fourths inch to one-fourth inch (3/4"–1/4") (1.9 cm–.6 cm) and one-fourth inch to one-eighth inch (1/4"–1/8") (.6 cm–.3 cm).

3. At least twenty-four inches (24") (0.6 m) of clean washed sand should be provided. The sand should have an effective size of 0.3–1.0 mm and a uniformity coefficient of 3.5 or less.

4. Open-joint or perforated pipe underdrains may be used. They should be spaced not to exceed ten-foot (10') (3.0 m) center-to-center.

5. The earth base of the filters should be sloped to the underdrains or the underdrains may simply be placed in the gravel base on the flat bottom of the basin.

6. The depth of liquid above the sand must be adjustable from one to five feet (1–5') (.3 m–1.5 m).

7. At least two (2) cells must be provided with the combined capacity equal to that necessary for the design loading.

8. A vehicle access ramp from the top of the embankment down to the sand surface and running along one (1) side of the filter is a desirable feature for periodic maintenance of the filter.]

[(8) Miscellaneous.

(A) Fencing. The pond area shall be enclosed with an adequate fence to discourage trespassing and prevent entering of livestock. Minimum fence height shall be five feet (5') (1.5 m). The fence may be of the chain link or woven type. Fencing shall not obstruct vehicle traffic or mowing operations on the dike. A vehicle access gate of sufficient width to accommodate mowing equipment shall be provided. All access gates shall be provided with locks.

(B) Access. An all-weather access road shall be provided to the pond site to allow year-round maintenance of the facility.

(C) Warning Signs. Appropriate permanent signs shall be provided along the fence around the pond to designate the nature of the facility and advise against trespassing. At least one (1) sign shall be provided on each side of the site and one (1) for every five hundred feet (500') (150 m) of its perimeter.

(D) Flow Measurement. Refer to 10 CSR 20-8.140(8)(G).

(E) Groundwater Monitoring. An approved system of groundwater monitoring wells or lysimeters may be required around the perimeter of the pond site to facilitate groundwater monitoring. The use of wells and/or lysimeters will be determined on a case-by-case basis.

(F) Laboratory Equipment. Refer to 10 CSR 20-8.140(8)(D).

(G) Pond Level Gauges. Pond level gauges shall be provided.

(H) Service Building. Consideration in design should be given to a service building for laboratory and maintenance equipment.]

(7) Lagoon Retrofits

A. Baffles

1. The purpose of a baffle is to divide a cell with flow diversion baffles to restores the cells full design hydraulic retention time by preventing retention time lost due to short-circuiting. The installation of baffles can also be used to isolate a quiescent settling zone in the lagoon system or to introduce a complete mix zone to increase the removal capacity of a lagoon system that is short on retention time.

2. Floating baffles shall be constructed to the manufacturer's specifications. The floating baffles shall depend on a primary bottom-anchored design for maximum resistance to loads encountered in industrial or municipal lagoons.

3. Baffles shall conform to the side slopes of lagoon where they meet the berm.

4. The flotation collar of the baffle shall be constructed using a long polystyrene foam logs or equivalent sealed in a chamber of the specified baffle curtain material. The flotation material shall be closed cell polystyrene foam (providing a minimum buoyancy of sixty pounds per cubic foot (60 lbs./ ft^3).

B. Covers

1. Membrane covers, either permeable or impermeable, ~~**[when used on an earthen basin manure storage system,]**~~ shall be constructed of high density polyethylene (HDPE) and have a minimum thickness of 2 mil and be ultraviolet and weather resistant. **Other covers may be approved for use on a case-by-case situation by the department.**

A. The HDPE cover shall be secured at the lagoon perimeter utilizing an anchor trench.

B. The anchor trench shall be constructed with rounded corners in order to avoid sharp bends.

2. Seams

A. Large rocks and other objects shall be removed from the trench sides.

B. Extrusion and fusion welding shall be used for field seaming.

C. Trial seams shall be used to verify acceptable environmental conditions. Specimens of the trial seam shall be tested in shear and peel using a field tension meter. The seaming equipment shall not be used if the specimens fail the testing.

D. The cover shall include at least six 6" sample ports that will be used to retrieve wastewater and sludge samples from the lagoon's contents. The sample ports shall prevent the escape of biogas while the port is open. Each port shall have a secured cover or cap.

E. The cover shall include at least three manway hatches located along or near the center of the lagoon. Each hatch shall have a secured cover or cap.

3.Biogas. The cover shall include all necessary collections piping and other conducts to collect and convey the generated biogas handling system. Biogas collection within the cover shall include a central collection conduit located along or near the centerline of the lagoon. This central collection conduit shall allow easy removal of generated gas from the central portion of the lagoon. The gas collection and handling piping shall be HDPE, **stainless steel, or another department approved method**.

4. Stormwater removal. The cover shall include a storm water removal system that conveys collected precipitation to sumps or includes drainage areas in the membrane within the acceptable leakage rate to allow stormwater to train into the lagoon.. The distance between sumps shall not exceed 50 ft. The sumps shall be located at all locations expected to accumulate storm water. Each sump shall discharge the collected storm water to the lagoon contents.

(8) Supplemental Information for Surface **Land Application System.**

1. Location. A copy of the USGS topographic map of the area (seven and one-half (7 1/2)-minute series where published), similar map or aerial photograph showing the exact boundaries of the spray field.

2. A topographic map of the total area under consideration by the applicant at a scale of approximately one inch to fifty feet (1":50') (2.54:15.2 cm) with appropriate contour interval. It should show all buildings, the waste disposal system, the spray field boundaries and buffer zone. An additional map should show the spray field topography in detail with a contour interval of two feet (2') (61 cm) and include buildings and land use on adjacent lands within one-fourth (1/4) mile of the project boundary.

3. Water supply wells which might be affected shall be located and identified as to uses—for example, potable, industrial, agricultural and class of ownership; for example, public, private, etc.

4. All abandoned wells, shafts, etc., where possible, should be located and identified. Pertinent information thereon shall be furnished.

5. Geology.

A. Geologic formation's name and the rock types at the site.

B. Degree of weathering of the bedrock.

C. Character and thickness of the surficial deposits.

D. Local bedrock structure including the presence of faults, fractures and joints.

E. The presence of any solution openings and sinkholes in carbonate terrain.

F. The source of the information above. must be indicated.

6. Hydrology.

A. The depth to seasonal and permanent highwater tables (perched and/or regional) must be given, including an indication of seasonal variations.

B. When there is an indication through the geologic and soil testing that contamination of a drinking water supply is a possibility, the direction of groundwater movement and the point(s) of discharge must be shown on one (1) of the attached maps.

C. When there is an indication through the geologic and soil testing that contamination of a drinking water supply is a possibility, Chemical analyses indicating the quality of groundwater at the site must be included.

D. The following information shall be provided from existing wells and from the test wells as may be necessary, where it is available:

1. Construction details—where available. Depth, well log, pump capacity, static levels, pumping water levels, casing, grout material and the other information as may be pertinent; and

2. Groundwater quality. For example, nitrates, total nitrogen, chlorides, sulfates, pH, alkalinities, total hardness, coliform bacteria and metal ions.

E. A minimum of one (1) groundwater monitoring well, where deemed necessary by the Missouri Geological Survey, must be drilled in each dominant direction of groundwater movement and between the project site and public well(s) and/or high capacity private wells with provision for sampling at the surface of the water table and at five feet (5') (1.5 m) below the water table at each monitoring site. The location and construction of the monitoring well(s) must be approved by the department. These may include one (1) or more of the test wells where appropriate.

7. Evaluation of Effluent to be Applied. Representative samples are essential to properly evaluate the effluent. Where the discharge is from a *[sewage]* wastewater treatment plant, twenty-four (24)-hour composite samples proportioned to the rate of flow will be needed to obtain a representative sample. In cases where the effluent is stored for several days or longer, a single sample of the effluent will suffice. Analyses which will be of major importance will be for total suspended solid (TSS), a volatile suspended solid (VSS), sodium, calcium, magnesium, electrical conductivity (EC), nitrogen, phosphorous, metal ions, boron and fluoride. For systems receiving flows over two hundred thousand gallons per day (200,000 gpd) or receiving industrial wastes, the sodium absorption ratio shall be calculated from the sodium, calcium and magnesium determination.*[The sodium absorption ratio (SAR) should be calculated from sodium, calcium and magnesium determination.]*

8. Soils. All soils investigation should be performed by a qualified soil scientist.

A. A soils map should be furnished of the spray field, indicating the various soil types. This may be included on the large-scale topographic map. Soils information can normally be secured through the *[USDA Soil Conservation Service]* National Resources Conservation Service (NRCS).

B. The soils should be named and their texture described.

C. Slopes and agricultural practice on the spray field are closely related. Slopes on cultivated fields should be limited to four percent (4%) or less. Slopes on sodded fields should be limited to eight percent (8%) or less. Forested slopes should be limited to eight percent (8%) for year-round operation but some seasonal operation slopes up to fifteen percent (15%) may be acceptable. For slopes greater than fifteen percent (15%), justification shall be provided.

D. The thickness of soils should be indicated. Indicate how determined.

E. Data should be furnished on the exchange capacity of the soils. In cases of industrial wastes particularly, this information must be related to special characteristics of the wastes.

F. Information must be furnished on the internal and surface drainage characteristics of the soil materials. Location and depths to impermeable or restricted horizons should be indicated.

G. Proposed application rates should take into consideration the drainage and permeability of the soils, the distance to the water table and for no observable runoff to occur.

9. Agricultural Practice.

A. The present and intended soil-crop management practices, including forestation, shall be stated.

B. Pertinent information shall be furnished on existing drainage systems.

[C. When cultivated crops are anticipated, a cropping and harvesting program by a qualified agronomist shall be included.]

10. Adjacent Land Use.

A. Present and anticipated use of the adjoining lands must be indicated. This information can be provided on one (1) of the maps and may be supplemented with notes.

B. The plan shall show existing and proposed screens, barriers or buffer zones to prevent blowing spray from entering adjacent land areas.

C. If expansion of the facility is anticipated, the lands which are likely to be used must be shown on the map.

(9.) Surface Land Application of Wastewater. The summary of design data and general layout shall contain pertinent information on the proposed site including location, geology, soil conditions, area for expansion, groundwater conditions and any other factors which may affect the feasibility and acceptability of the proposal. The summary of design data shall also include pretreatment and storage requirements, the design application rates and monitoring, application equipment, and operation and maintenance requirements. The source should be given for any information used by the consultant in design.

(A) Site Considerations. The following information concerning the site shall be provided:

1. Legal description of the disposal site;

2. The location of all existing and proposed residences, commercial or industrial developments, roads, ground or surface water supplies and wells within one-half (1/2) mile of the proposed site;

3. Available land area, both gross and net areas (excluding roads, right-of-way encroachments, stream channels and unusable soils);

4. Distance from the pretreatment and the storage facilities to the application site including elevation differential;

5. Proximity of site to industrial, commercial, residential developments, surface water streams, potable water wells, public use areas such as parks, cemeteries and wildlife sanctuaries;

6. Present and future land and groundwater uses;

7. A summary describing the existing vegetation of the area;

8. A description including maps showing elevations and contours of the site and adjacent areas which may be suitable for expansion. Specific information on the maximum and average slopes of the site must be provided; and

9. The department *[may]* requires a geological evaluation of the proposed land application site prepared by Missouri Geological Survey. *[A geologic report is not required for application rates that will not exceed twenty-four inches (24") of applied wastewater per year for typical domestic wastewater lagoon effluent.]*

(B) Wetted Application Area. The wetted application area is the land area which is normally wetted by wastewater application. The wetted application area must conform to the following criteria:

1. Flood-prone areas which flood at a frequency greater than once every ten (10) years should not be the sole source of land application;

2. The wetted application area shall be established at least one hundred fifty feet (150') from existing dwellings or public use areas, excluding roads or highways. In addition the wetted application area shall be at least fifty feet (50') inside the property line. Distances may be reduced depending upon the extent of pretreatment and operational techniques. One-half (1/2) the required distances may be used if the wastewater is disinfected in accordance with section (XX) of this rule;

3. The wetted application area should be at least three hundred feet (300') from any sinkhole, losing stream or other structure or physiographic feature that may provide direct connection between the ground water table and the surface;

4. The wetted application area shall be at least three hundred feet (300') from any existing potable water supply well not located on the property. Adequate protection shall be provided for wells located on the application site; and

5. The application area should be fenced and posted along public roads and public use areas. Fencing is not required if the wastewater is disinfected prior to application or if other suitable barriers are provided or if the wetted application area is located in areas where access is limited. A minimum of one (1) sign should be placed on each side of the application area. The perimeter distance between any two (2) signs should not exceed five hundred feet (500'). Each sign should clearly identify the nature of the facility and advise against trespassing in letters not less than two inches (2") high.

(C) Soils Information. The department may require that the soil types and characteristics for the top five feet (5') of soil be investigated if applied wastewater will exceed twenty-four inches (24") per year. Unless required otherwise by the department, soils information shall include soil series name, soil texture, soil permeability and water-holding capacity. If a county soils map is available, the approximate boundaries of the different soils shall be shown. If a published soil survey is not available, the soils shall be classified by a professional soil scientist. In areas of soluble limestone and dolomite, where there is a potential for groundwater contamination, chert or stone content shall be determined to a depth of five feet (5'). Depth to restrictive layers such as fragipans or claypans shall be determined. Recommendations by the Missouri Geological Survey for further soils investigations shall be complied with.

1. The wetted application area should have a soil mantle of at least five feet (5') overlying any sand or gravel strata.

2. The topography of the site and adjacent land shall be evaluated for areas of potential erosion. The effects of both applied wastewater and storm runoff shall be considered. Special consideration should be given to the period of construction and system startup when vegetative cover may be lacking or not fully developed.

3. Soil permeability. Soil permeability shall be based on the most restrictive layer in the top five feet (5') of soil. Soils having permeability rates of two-tenths to two inches (0.2–2") per hour are most suitable for irrigation. Values below two-tenths inch (0.2") per hour may generally require special application equipment, reduced application rates or overland flow approach. Values above two inches (2") per hour will require reduced application rates to provide adequate residence time within the soil profile or will require additional soils and geologic information for depth to bedrock, depth to water table and recharge areas

(D) Preapplication Treatment. As a minimum, treatment prior to land application shall provide treatment equivalent to that obtained from a primary wastewater pond cell designed and constructed in accordance with section (5) of this rule, except that the lagoon depth may be increased to include wastewater storage on top of the primary volume.

1. The storage basins shall be based on the design wastewater flows and net rainfall minus evaporation expected for a one (1) in ten (10) year return frequency for the storage period selected.

2. The storage volume for wastewater stabilization lagoons shall be calculated based on the useable volume above the two-foot (2') level. These requirements assume that a permanent cover crop is in place and the primary purpose of the system is wastewater treatment. If the system uses row crops, or crop production is the primary goal, storage should be increased to correspond with crop planting and harvesting schedules.

3. For facilities that employ a part-time operator, lease land application fields, have highly variable influent flow, or experienced discharges, consideration should be given for increasing the minimum storage of the basins by at least thirty (30) days to ensure the facility has sufficient storage.

A. The minimum total days' storage required for no discharge facilities located south of Highway 60 is sixty (60) days.

B. The minimum total days' storage required for no discharge facilities located south of Highway 50 and north of Highway 60 is seventy-five (75) days.

C. The minimum total days' storage required for no discharge facilities located south of Highway 36 and north of Highway 50 is ninety (90) days.

D. The minimum total days' storage required for no discharge facilities located north of Highway 36 is one hundred twenty (120) days.

E. An exception to this is a system where flows are generated only during the application period. A storage capacity of forty-five (45) days or the flow generated during the period of operation, whichever is less, must be provided.

(E) Land Application Rates. Application rates shall be determined for each individual site based on topography, soils, geology, hydrology, weather, agricultural practice, adjacent land use and application method. For the range of flows covered by this rule, the maximum application rate for typical domestic wastewater shall be twenty-four inches (24") of applied wastewater per year depending on soil characteristics. For higher application rates than twenty-four inches per year, additional soils and geologic information, detailed site specific design proposals and supporting documentation shall be submitted to justify the proposed design.

1. Crops and vegetation. A description of the crops or vegetation to be grown is required for all systems in which vegetation is to be an integral part of the treatment system. This includes all slow rate and overland flow systems. The use of wastewater for irrigation of truck farms growing vegetables will not be approved. The following information shall be provided:

A. Compatibility of the crop with site characteristics and design hydraulic loading rates;

B. Cultivation and harvesting requirements; and

C. Crop management.

3. Equipment. The following shall be considered in the design of the land application equipment:

A. Any spray application equipment specified shall minimize the formation of aerosols;

B. The pumping system and distribution system shall be sized for the flow and operating pressure requirements of the distribution equipment and the application restrictions of the soils and topography;

C. Provisions shall be made for draining the pipes to prevent freezing if pipes are located above the frost line;

D. A suitable structure shall be provided for either a portable pumping unit or a permanent pump installation. The intake to the pumping system shall provide the capability for varying the withdrawal depth. The intake elevation should be maintained twelve to twenty-four inches (12–24") below the wastewater elevation. The intake shall be screened so as to minimize clogging of the sprinkler nozzle or distribution system orifices. For use of a portable pump, a stable platform and flexible intake line with flotation device to control depth of intake will be acceptable;

E. Thrust blocking of pressure pipes shall be provided. For use of above ground risers for sprinklers, a concrete pad and support bracing should be considered; and

F. Automatic or semi-automatic controls should be considered for shut off of the system after a prescribed wastewater application period. Manual start-up of the application system is recommended.

G. The facility shall have the ability to pump down the lagoon in November without impacting the seal, liner, or berms of the facility to ensure that sufficient storage capacity is available for storing wastewater during the winter season.

4. Slope. Justification shall be provided for a wetted application area greater than fifteen percent (15%). The maximum allowable slope of the wetted application area is thirty percent (30%).

5. Application rate. The application rate consists of an hourly application rate in inches per hour and daily, weekly and annual application rates in inches per acre. Application of wastewater will not be allowed during periods of ground frost, frozen soil or during rainfalls. The following shall apply to design application rates:

A. The hourly application rate should not exceed the design sustained permeability rate except for short periods when initial soil moisture is significantly below field capacity. The hourly rate shall not exceed one-half (½) the design sustained permeability for slopes exceeding ten percent (10%). ***[However, in no case should the application rate be greater than one-half inch (½") per hour. For soil permeability of less than two-tenths inch (0.2") per hour, the designed maximum application rate should be as low as practicable and shall not exceed two-tenths inch (0.2") per hour;]***

B. The daily and weekly application rates should be based on soil moisture holding capacity, antecedent rainfall and depth to the most restrictive soil permeability. For facilities applying at twenty-four inches per year, the application rate shall in no case exceed one inch (1") per day and three inches (3") per week. For facilities applying above twenty-four inches per year, the application rate shall not exceed the values determined in the soils report and loading design.

C. The design maximum annual application rate shall not exceed a range from four percent to ten percent (4%–10%) of the design sustained soil permeability rate for the number of days per year when soils are not frozen.

D. In no case shall the application rate result in the runoff of applied wastewater during or immediately following application.

6. Nitrogen Loading. Nitrogen application rates shall not exceed the amount of nitrogen that can be utilized by the vegetation to be grown. Typical domestic wastewater after lagoon storage can be expected to contain from five to eight milligrams per liter (5–8 mg/l) of ammonia nitrogen as N and less than one milligrams per liter (1mg/L) of nitrate nitrogen as N. Ammonia nitrogen can be adsorbed onto soil particles and retained in the soil for later use by plants and microorganisms. However, nitrate nitrogen is mobile and will readily leach through the soil profile if wastewater is applied faster than the vegetation or soil microbes can utilize the nitrates. If the applied wastewater is expected to provide more than one hundred fifty pounds (150 lbs.) of total nitrogen per acre annually or if the applied wastewater exceeds ten (10) mg/l of nitrate nitrogen as N, then calculations shall be submitted to show the amount of plant-available nitrogen provided and the amount of nitrogen that will be utilized by the vegetation to be grown.

7. Trace element loading. Consideration shall be given to the type and influence of any industrial wastes contributed to the wastewater stabilization pond. Typical domestic wastewater does not contain amounts of trace substances which are of concern for land application of wastewater under this rule. However, introduction of substances, such as excess sodium, chlorides, boron or other constituents, can have an adverse impact on soils and vegetation. Wastewater suitable for general land application shall not exceed the trace element concentrations in Table 4-5 of the *U.S. Environmental Protection Agency Process Design Manual for Land Treatment of Municipal Wastewater* (EPA 625-1/81-013).

8. Grazing and harvesting deferment. Grazing of animals or harvesting of forage crops should be deferred for up to thirty (30) days following wastewater irrigation depending upon ambient air temperature and sunlight conditions. The following deferments shall be considered:

A. During the period from May 1 to October 30 of each year, the minimum deferment from grazing or forage harvesting shall be fourteen (14) days;

B. During the period from November 1 to April 30 of each year, the minimum deferment from grazing or forage harvesting shall be thirty (30) days;

C. Grazing of sewage irrigated land is generally not recommended for lactating dairy animals unless there has been a much longer deferment period. The recommendations of the State Milk Board shall be followed; and

D. Deferment may not be required for irrigation water that has been disinfected so that the water contains less than one hundred twenty-six (126) Escherichia coliform organisms per one hundred milliliters (100 ml).

(F) Operation and Maintenance. An operation and maintenance plan shall be provided to explain the key operating procedures at a level easily understood by the owner and the operator of the facility. An outline and brief summary of operations shall be provided as part of the facility plan. A detailed operation and maintenance plan shall be included as part of the submitted plans and at a minimum shall address maintenance of mechanical equipment and vegetative cover, monitoring, record keeping, operating procedures, application scheduling and winterization of the system.

1. Public Access Areas. The wastewater shall be disinfected prior to land application (not storage) in accordance with section (5) of this rule.

A. The wastewater shall contain as few of the indicator organisms as possible and in no case shall the irrigated wastewater contain more than one hundred twenty-six (126) Escherichia coliform organisms per one hundred milliliters (100 ml);

B. The public shall not be allowed into an area when application is being conducted; and

C. For golf courses utilizing wastewater, all piping and sprinklers associated with the distribution or transmission of wastewater shall be color-coded and labeled or tagged to warn against the consumptive use of contents.

2. Nighttime Irrigation

A. If land applying in evening or nighttime, an automatic notification alarm system shall be installed. The alarm system shall be installed on each pivot and pump system, and be capable of notifying an on-call operator when a fault occurs in the system. The alarm system shall also include pressure monitoring in case of line break or other malfunctions that causes leaks.

B. The operations and maintenance manual shall include provisions on daily operator checks of the system to ensure that the irrigation pumping and pivot systems are working properly and that there is no runoff from any field where the irrigating pivot is currently located. The manual shall include provisions for stress testing the system at least once per season to ensure the alarm system is operating properly and the system components are in good condition.

3. System Monitoring. *[An]* appropriate monitoring *[system]* shall be provided to determine the quality of water leaving the land treatment site based on Missouri Geological Survey's recommendations. *[and entering surface and/or ground water. Analysis of soil and plant tissue samples may be required to monitor the effect of the wastewater on the soil and crop.]*

(10) Facility Plan Supplemental for Subsurface Systems

(A) General

1. Location. A copy of the USGS topographic map of the area (seven and one-half (7 1/2)-minute series where published), similar map or aerial photograph showing the exact boundaries of the spray field.

2. A topographic map of the total area under consideration by the applicant at a scale of approximately one inch to fifty feet (1":50') (2.54:15.2 cm) with appropriate contour interval. It should show all buildings, the waste disposal system, the spray field boundaries and buffer zone. An additional map should show the spray field topography in detail with a contour interval of two feet (2') (61 cm) and include buildings and land use on adjacent lands within one-fourth (1/4) mile of the project boundary.

3. Water supply wells which might be affected shall be located and identified as to uses—for example, potable, industrial, agricultural and class of ownership; for example, public, private, etc.

4. All abandoned wells, shafts, etc., where possible, should be located and identified. Pertinent information thereon shall be furnished.

(B) Geohydrology and Hydrology

1. 2. The supplemental to the Facility Plan shall include the following geological information:

A. A geohydrological evaluation conducted by Missouri Geological Survey

B. Geologic formation's name and the rock types at the site.

C. Degree of weathering of the bedrock.

D. Character and thickness of the surficial deposits.

E. Local bedrock structure including the presence of faults, fractures and joints.

F. The presence of any solution openings and sinkholes in carbonate terrain.

G. The source of the information above. must be indicated.

H. The depth to seasonal and permanent highwater tables (perched and/or regional) must be given, including an indication of seasonal variations.

I. When there is an indication through the geologic and soil testing that contamination of a drinking water supply is a possibility, the direction of groundwater movement and the point(s) of discharge must be shown on one (1) of the attached maps.

J. When there is an indication through the geologic and soil testing that contamination of a drinking water supply is a possibility, Chemical analyses indicating the quality of groundwater at the site must be included.

K. The following information shall be provided from existing wells and from the test wells as may be necessary, where it is available:

1. Construction details—where available. Depth, well log, pump capacity, static levels, pumping water levels, casing, grout material and the other information as may be pertinent; and

2. Groundwater quality. For example, nitrates, total nitrogen, chlorides, sulfates, pH, alkalinities, total hardness, coliform bacteria and metal ions.

L. As determined necessary by Missouri Geological Survey in the Geohydrological Evaluation, a minimum of one (1) groundwater monitoring well shall be drilled in each dominant direction of groundwater movement and between the project site and public well(s) and/or high capacity private wells with provision for sampling at the surface of the water table and at five feet (5') (1.5 m) below the water table at each monitoring site. The location and construction of the monitoring well(s) must be approved by the department's Missouri Geological Survey. These may include one (1) or more of the test wells where appropriate.

(C) Soils Report

Soils. All soils investigation should be performed by a Missouri qualified soil scientist as defined in 701.040(2)(e) RSMo.. The soils report can be generated only after a thorough, systematic investigation of the soil properties and landscapes in the proposed development. Soil observation pits (backhoe or hand dug) dug to a depth to reveal the major soil horizons shall be utilized. The soils report resulting from the investigation shall include the following information as part of the Facility Plan

(1) A site drawing. The site drawing shall be scaled or include sufficient dimensions to identify locations of all soil borings and/or excavations, locations of the representative area for described soil borings and/or excavations and applicable site features as determined by the department. The soil scientist may use previously prepared or otherwise available drawings such as a survey prepared by a Missouri registered professional surveyor, an aerial photograph or digital orthophotograph prepared from a geographical information system, or other similar drawing. The drawing shall include the assessment and documentation of the following:

(a) Any existing dwellings and/or structures and any proposed dwellings and/or structures, if known;

(b) Any site disturbances such as excavated or fill areas, existing driveways and other hardscapes and proposed hardscapes, or related site disturbances, if known;

(c) Location of all private water systems, abandoned wells, or geothermal systems if known, and surface water features on the lot and within three hundred feet of the areas identified for possible system installation;

(d) North orientation arrow;

(e) Identification of all soil borings and/or excavations;

(f) Identification and dimensions of spatial areas for which each soil profile description is representative and where the soil has capacity for the treatment and/or dispersal of effluent. The soil evaluation shall include the entire lot or sufficient area to support a primary system and replacement area on the site;

(g) Identification of areas with conditions that would prohibit or impact the siting of a treatment system, but not limited to: sinkholes, wetland vegetation, bedrock outcrops, areas with a slope greater than fifteen percent (15%), soils prone to slippage on slopes greater than eight percent (8%), and existing or abandoned drainage tiles, if known; and

(h) Identification of known, proposed, and/or observed easements and right-of-ways.

(2) Record of the site and soil characteristics for each soil boring and/or excavation location designated in this paragraph using the nomenclature from the National Resources Conservation Service (NRCS) field book for describing and sampling soils, including but not limited to:

(a) Site descriptions, including but not limited to, landscape position, slope, vegetation, drainage features, rock outcrops, erosion and other natural features;

(b) Detailed soil profile descriptions, including but not limited to, color, texture, grade, shape, structure, consistence, and the depth of each soil horizon or layer including fill or mine spoils where present;

(c) The identification of limiting conditions;

(d) Data should be furnished on the exchange capacity of the soils. In cases of industrial wastes particularly, this information must be related to special characteristics of the wastes.

(e) Proposed application rates should take into consideration the drainage and permeability of the soils and the distance to the water table.

(f)If evident or visible, provide documentation of any relevant surface hydrology, geologic and hydrogeologic risk factors such as bedrock outcrops, sinkholes or karst features on the specific site or in the surrounding area that may indicate vulnerability for surface water and groundwater contamination; and

(g) Provide documentation of any geologic risk factors affecting the soil's ability to treat and/or disperse effluent including dense tills and fragipan.

(3) Soil observation pits (backhoe or hand dug) dug to a depth to reveal the major soil horizons shall be utilized. The minimum number of pits shall be one every five acres. The minimum number of soil observation pits may be greater based upon the complexity of soils and landscapes within the proposed development. These pits may be supplemented by soil borings to help determine the extent of similar soil properties.

(a) Each soil profile description submitted shall include the following: describers name; date described; slope – aspect, gradient, shape and position; horizon – nomenclature, depth (thickness), boundary, matrix color, mottling - quantity, orientation and size, redoximorphic features – kind, quantity and size, texture - percentage clay and sand (if needed), structure - type, size and grade, consistence, rock fragment – size and percentage; water table – depth and kind; drainage class; flooding - frequency and duration; ponding – frequency, depth and duration; vegetative cover; other pertinent features related to the treatment and control of the effluent within the soils.

(b) The soils report shall contain a topographic map delineating the proposed development into the following slope categories: 0-2%, 2-15%, 15-30% and 30% and greater.

(c) The soils reports shall contain a map delineating the depth of acceptable soil into the following categories: less than 18 inches, 18 to 30 inches over bedrock, 18 to 30 inches over a limiting layer, and greater than 30 inches.

(d) The location of all soil observation pits shall be included on the above referenced topographic and acceptable soils maps.

(e) A general discussion describing the soil scientist's findings and conclusions shall be included.

(f) The soils report must be signed and dated by the soil scientist responsible for the documentation contained within it.

(D) Site Restrictions

1. Sites with seasonal high groundwater less than twenty-four (24) inches deep may require drainage improvements before being utilized.

2. Subsurface systems shall not be constructed in unstabilized fill.

3. The vertical separation between the bottom of the trench and a limiting layer, including but not limited to, bedrock; restrictive horizon; or seasonal high water table, shall be no less than twenty-four inches (24") or shall be no less than twelve inches (12") for systems dispersing secondary or higher quality effluent;

4. Vertical separation shall be no less than forty-eight inches (48") where karst features are present unless the site can be reclassified;

5. For dispersal trenches on slopes of land greater than fifteen percent, justification shall be provided. Dispersal trenches shall not be installed on slopes greater than thirty percent (30%).

6. Where slopes are less than two percent (2%), adequate surface drainage shall be provided;

7. Trenches may be required by the department to be sand-lined if the soils have severely diminished treatment capability due to excessive rock content; and

8. When needed, surface water diversion shall be provided. Subsurface lateral groundwater movement shall be intercepted using a curtain or perimeter drain. A perimeter drain is a four sided, completely surrounding the seepage field. A one to three sided curtain drain can also be used with the downhill side of the field left open.

(F) Summary of Design. The summary of design shall include all calculations in determining design flows, pump rates to the absorption fields, sizing of the absorption fields, sizing of the *~~[preliminary]~~* treatment *~~[components and if used secondary treatment]~~* system. The summary of design shall include the dosage rate of each system and zone.

(G) An operation and maintenance plan shall be provided to explain the key operating procedures at a level easily understood by the owner and the operator of the facility. An outline and brief summary of operations shall be provided as part of the facility plan. A detailed operation and maintenance plan shall be included as part of the submitted plans and at a minimum shall address maintenance of mechanical equipment and vegetative cover, monitoring, record keeping, operating procedures, application scheduling and winterization of the system.

(11) Conventional Subsurface Systems

(A) A conventional subsurface system uses a septic tank for preliminary treatment followed by gravity-fed absorption trenches.

(B) Preliminary treatment shall be at a minimum be a septic tank, however secondary treatment technologies should be used. The secondary treatment system shall follow the design guides of 10 CSR 20-8.180 or 8.200(x).

(C) Site restrictions

1. The minimum distance that all treatment system components shall be separated from other site features are listed in section x of this rule.

2. Absorption systems shall not be located under driveways, parts of buildings, or under above-ground swimming pools or other areas subject to heavy loading.

3.Surface waters shall be diverted from the vicinity of the system.

(D) Absorption Trench Systems.

1. Site requirements. A minimum of four feet of useable soil shall exist above bedrock and groundwater with a minimum separation of two feet to the lowest part of any absorption trench system.

2.Design criteria.

A.The required length of absorption trench is determined from the soil evaluation. The maximum trench depth shall be 30 inches below ground surface. The maximum trench width for design purposes shall be 24 inches. Where trenches exceed 24 inches in width, calculations of absorptive area shall be based on a width of 24 inches.

B. Adjacent trenches shall be separated by at least four feet of undisturbed soil. Individual trenches shall be constructed parallel to the ground contours with trench bottoms as near level as possible.

C. Soil with a percolation of less than 1 min/in is unsuitable for a conventional system

D. The required area shall be determined by the flow rate divided by the application rate. Application rates shall not exceed the rate determined in the soils report.

(3) Materials.

- **(i) Perforated distributor pipe shall be used in the trenches. Solid (non-perforated) pipe shall be used between the distribution box and the trenches. Perforated pipe shall be made of rigid or corrugated plastic and be labeled as fully meeting ASTM standards for use in septic systems. Corrugated plastic pipe delivered in coils is not to be used unless provision is made to prevent the recoiling or movement of the pipe after installation.**
- **(ii) Aggregate shall mean washed gravel or crushed stone ¾ - ½ inches in diameter. Larger diameter material or finer substances and run-of-bank gravel are unacceptable.**
- **(iii) The aggregate shall be covered with a material that prevents soil from entering the aggregate after backfilling, yet must permit air and moisture to pass through. The preferred material for covering the aggregate is a permeable geotextile. Untreated building paper or a four inch layer of hay or straw is acceptable. Polyethylene and treated building paper are relatively impervious and shall not be used.**
- **(iv) Alternate aggregate. Materials may be used as a substitute for conventional gravel or stone aggregate when it can be demonstrated that the material provides at least the equivalent soil infiltration area and storage volume as conventional gravel or stone aggregate. Materials shall also maintain structural integrity and be non-degradable by wastewater effluent.**
- **.**

- **(4) Construction.**

- **(i) Trench locations and depths should be marked by stakes before the trenches are excavated. The natural surface shall not be significantly disturbed. If the site is regraded or similarly disturbed, the soil shall be allowed to stabilize and new percolation tests conducted.**
- **(ii) The trench depth shall be as shallow as possible, but not less than 18 inches. At least six inches of aggregate is placed below the distribution line and two inches above the line. The earth cover over the aggregate should not exceed 12 inches in order to enhance natural aeration and nitrogen uptake by plant life. Trenches shall be excavated to design depth with bottoms practically level. Heavy equipment shall be kept away from the field because the weight may permanently alter soil characteristics due to compaction, cause trench cave-ins, and/or misalign and break pipe.**
- **(iii) Trench bottoms are to be raked and immediately covered with at least six inches of aggregate.**
- **(vi) Any smeared surfaces on the trench walls are to be raked. Distributor lines are carefully placed on the aggregate and covered with aggregate to a depth of at least two inches over the top of the pipe. Additional aggregate may be required to bring the top of the aggregate to within six to 12 inches of the surface.**
- **(v) In gravity distribution systems, the pipe shall be carefully sloped at between 1/16 inch and 1/32 inch per foot. Grades shall be determined by an engineer's level, transit or carpenter's level.**
- **(vi) After the upper aggregate is placed, the geotextile, untreated building paper, hay or straw is to be immediately installed and the trench backfilled with native soil. If the trenches cannot be immediately backfilled, they should be temporarily covered with an impervious material such as treated building paper to prevent sidewall collapse and siltation into the aggregate.**
- **(vii) The earth backfill is to be mounded slightly above the original ground level to allow for settling and after settlement the entire area should be graded without the use of heavy equipment and seeded with grass.**

- (c) Gravelless Absorption Systems.
  - **(1) General. Gravelless trench products must be designed to distribute effluent and provide at least the equivalent soil surface area for wastewater treatment as a conventional absorption trench without the use of gravel or stone aggregate. All gravelless systems must also be capable of withstanding typical construction equipment and residential use loads without deformation.**
  - **(2) Site requirements. These products may be used as an alternative to conventional gravel or stone absorption trenches in wastewater treatment systems. All other treatment system design requirements shall apply.**
  - **(3) Design criteria. all absorption trench system designs incorporating gravelless products shall have the same trench length as a conventional (24-inch wide) absorption trench.**
  - **(i) Open-bottom gravelless chambers. Absorption area designs may use a 25% reduction in the total absorption trench length when the product can demonstrate the following features:**
  - ***(a)* minimum soil infiltration bottom area of 1.6-square feet per linear foot, and**
  - ***(b)* a minimum volumetric capacity of 7.5-gallons per linear foot, and**
  - ***(c)* open sidewall area for aeration and infiltration.**
  - **(ii) Gravelless media-wrapped corrugated pipe sand-lined systems. Absorption area designs may use a 25% reduction in the total absorption trench length, when the product can demonstrate the following features and installation criteria:**
  - ***(a)* corrugated pipe with a minimum outside diameter of 12-inches, and**
  - ***(b)* wrapped in a media that allows wastewater distribution and prohibits sand infiltration, and**
  - ***(c)* installed with a minimum of 6-inches of washed concrete sand surrounding the pipe.**
  - **(iii) Gravelless geotextile sand filter. Absorption area designs may use a trench bottom sand criteria of 6-square feet per linear foot of trench when the product demonstrates the following features and installation criteria:**
  - ***(a)* a minimum unit width of 3-feet, and**
  - ***(b)* a mimimum storage capacity of 12-gallons/linear foot of unit, and**

- *(c)* a minimum of 6-square feet per linear foot of geotextile surface area per linear foot of unit, and
- *(d)* installed with 6-inches of washed concrete sand below and on the sides of each unit.
- (5) Construction.
- (i) Gravelless absorption system products shall be installed in conformance with the manufacturer's instructions because of the proprietary design of some products.
- (ii) The gravelless trench sidewalls shall be separated by a minimum of 4-feet of undisturbed soil.
- (iii) All gravelless trenches shall be equal in length. The total trench length shall be increased if necessary.

(d) Deep Absorption Trenches.

- (1) Site Requirements. These are used on sites where an useable layer of soil is overlaid by three to five feet of impermeable soil.
- (2) Design Criteria.
  - (i) There shall be at least four feet of useable soil beneath the impermeable layer.
  - (ii) The required length of absorption trench is determined from Table 4A based upon percolation tests conducted in the underlying soil.
- (3) Construction.
  - (i) Trenches are excavated at least two feet into the useable layer and backfilled with aggregate or coarse sandy material containing a low percentage of fines more permeable than the underlying material to a level 30 inches below the original ground surface.

(e) Shallow Absorption Trenches.

- (1) Site Requirements. These systems are used where there is at least two feet but less than four feet of useable soil and/or separation to boundary conditions.
- (2)Design criteria.
  - (i) A minimum two foot separation must be maintained between the bottom of each trench and all boundary conditions.
  - (ii) The bottom of each trench must not be above the original ground surface.
  - (iii) Material of the same permeability as the underlying original soil shall be used as fill material. The depth of the fill shall not be greater than 30 inches above the original ground elevation.
  - (iv) An absorption trench system as described in Section 75-A.8(b) is designed using the percolation of the underlying original soil.
- (3) Construction.
  - (i) Heavy equipment shall be kept out of the absorption area.
  - (ii) Fill material is carefully placed within the absorption area.
  - (iii) The edge of the fill material shall be tapered at a slope of no greater than one vertical to three horizontal. On sloped sites a diversion ditch shall be placed on the uphill side to prevent runoff from entering the fill.
  - (iv) The absorption trench system is constructed in the fill material, extending into the existing natural soil.

(f) Cut and Fill Systems.

- (1) A cut and fill system is an absorption trench system installed on sites where impermeable soil overlays a permeable soil.
- (2) Site Requirements. Cut and fill systems may be used where all the following conditions are found:
  - (i) A soil with a percolation rate slower than 60 minutes per inch, such as clay or clay loam, overlays a useable soil with a percolation rate faster than 60 minutes per inch;
  - (ii) At least three feet of useable soil is available beneath the tight soil;
  - (iii) All minimum vertical and horizontal separation distances can be maintained
- (3) Design criteria.
  - (i) It shall provide for the removal of the overlaying unusable soil and replacement by soil having a percolation rate comparable with the underlying soil;
  - (ii) An absorption trench system is designed as described in Section 75-A.8(b).
  - (iii) The required length of absorption trench is based upon the percolation of the underlying soil or the fill material, whichever has the slower percolation (lower permeability).
- (4) Construction.

- (i) The area excavated and filled must provide at least a five foot buffer in each direction beyond the trenches.
- (ii) The material placed above the trenches shall have a percolation rate faster than 60 minutes per inch.
- (iii) Original surface material shall not be used as backfill above the trenches.
- (iv) The surface area of the fill system must be mounded and graded to enhance the runoff of rainwater from the system and seeded to grass.

(12) Mound Subsurface Systems
(A)Mound system design has been developed for those site conditions in which adequate vertical separation is not available between the bottom of a subsurface soil absorption system and a restrictive layer, or a water table. Mound systems are used primarily in shallow soils overlying a restrictive layer or elevated groundwater table, including permeable or slowly permeable soils with a high water table, excessively permeable soils over unprotected aquifers or shallow permeable soils overlying excessively permeable soils or creviced or porous bedrock, and slowly permeable soils without a high water table. The shallower the soil the more attention must be paid to transporting the treated effluent away from the point of application.

(B) Site Considerations. Locate the mound in open areas for exposure to sun and wind where evaporation and transpiration will be maximized. Mound systems shall not be constructed in drainage ways, depressions, or areas subject to flooding.
1. Upslope runoff must be diverted around the mound.
2. Good design practice must consider drainage constraints for both upgradient and downgradient area drainage. The department may require additional site evaluations and/or testing to analyze the site before siting the mound system.

(C) Preliminary Treatment. Mound systems shall be preceded by preliminary treatment. Preliminary treatment shall be at a minimum be a septic tank, however secondary treatment technologies should be used. The secondary treatment system shall follow the design guides of 10 CSR 20-8.180 or 8.200(x).

(D) Design.
1. The mound sand fill depth shall be determined based on the depth to the limiting conditions. The sand fill depth shall not be less than four inches for effluent from a pretreatment component approved by the director for meeting the BOD_5 and TSS standard and six inches for septic tank effluent.
2. The loading rate for the sand fill material shall be determined by the soils report and should not exceed 0.8 gallons per day per square-foot.
3. The mound sand fill depth shall be determined based on the depth to the limiting conditions. The sand fill depth shall not be less than six inches for septic tank effluent.
4. The soil placed over the entire mound must be selected and placed to promote aeration of the mound, rainwater movement off and away from the mound, and establishment and maintenance of a vegetative cover. The cap may consist of a material as course textured as the filter media, and the topsoil may be as fine as a medium-to-fine sandy loam.
5. The final settled depth of the cap and topsoil should be no less than 12 inches above the center and 6 inches above the outer edge of the bed. Additional depth of topsoil may be needed during final construction activities to assure that the minimum depths are achieved following natural settling of the soil.
6. The depth and type of topsoil used must not adversely inhibit the free transfer of oxygen to the bed and filter media of the mound.
7. The cap provides frost protection, a barrier to infiltration, retains moisture for vegetation and promotes runoff of precipitation. The topsoil aids in establishing and maintaining a vegetative cover.
8. The cap and topsoil will settle during construction and usage. It is important that the finished settled cap and topsoil promote runoff and contain no depressions. Some soils may settle a great deal so be sure to place adequate depth of soil to allow for settling in achieving the final settled depth of cap and topsoil.
9. The use of a medium to fine sandy loam will enhance moisture retention for plant growth and increased rainwater runoff. Exercise caution, however, so as not to use soils with such fine texture as to severely reduce oxygen transfer through the cap. Coarse textured soils, such as sands, are not recommended, as they drain rapidly and allow more intrusion of precipitation
into the infiltration bed.

(E) Media

1. The media shall have an effective size between 0.15 to 0.3 millimeters, a uniformity coefficient of 5 or less, with not more than five per cent passing the No. 200 (75 µm) sieve and not less than eighty percent passing the No. 8 (2.36mm) sieve.

2. A geotextile fabric or straw covering of the aggregate in the distribution area or other barrier as specified for proprietary components shall be used to prevent introduction of soil fines and allow for free movement of air and water.

3. The length and width of the filter media are dependent upon the length and width of the infiltration bed, filter media depth and side slopes of the filter media.

A. Side slopes must be no steeper than 3:1. Appropriate topsoil may be used to make the slopes gentler (such as 4:1 to facilitate landscaping and lawn mowing) than the required 3:1 slopes, once the 3:1 slope exists with the filter media.

B. The filter media length consists of the end slopes (K) and the bed length (B).

C. The filter media width consists of the upslope width (J), the bed width (A), and the downslope width (I). On sloping sites the downslope width (I) will be greater than on a level site if a 3:1 side slope is maintained. Table 3 gives the slope correction factors (multipliers) for slopes from zero up to 20% assuming a 3:1 side slope.

D. To calculate required filter media length is length of bed plus two times the end slope.

Filter Media Length (**L**) = Length of Bed (**B**) + [2 x End Slope (**K**)]

$$\text{End Slope (K)} = \left[\left(\frac{D+E}{2}\right) + F + H\right] \times \text{Selected Horizontal Gradient of Sideslope (3 if 3:1)}$$

Filter Media Width (**W**) = Upslope Width (**J**) + Downslope Width (**I**) + Width of Bed (**A**)

4. Basal Area. The basal area required is based on the daily design flow and the infiltration rate. For level sites, the total basal area [length of filter media (L) x width of filter media (W)] beneath the filter media is available for effluent absorption into the soil. For sloping sites, the only available basal area is the area beneath the bed (A x B) and the area immediately downslope from the bed [bed length (B) x downslope width (I)]. It includes the area enclosed by [B x (A + I)]. The upslope and end slopes will transmit very little of the effluent on sloping sites, and are therefore disregarded. It is important to compare the required basal area to the available basal area, as the available basal area must equal or exceed the required.

$$\text{Basal Area Required} = \frac{\text{Daily Design Flow}}{\text{Infiltration Rate of Original Soil}}$$

Basal Area Available:

Sloping Sites = B x (A + I)
Level Sites = L x W

Upslope Width (**J**) = Filter Media Depth at Upslope Edge of Bed (D + F + G) x Horizontal Gradient of Side Slope (3 if 3:1) x Slope Correction Factor (See Table 3).

Downslope Width (**I**) = Filter Media Depth at Downslope Edge of Bed (E + F + G) x Horizontal Gradient of Side Slope (3 if 3:1) x Slope Correction Factor (See Table 3).

Table 3. Downslope and Upslope Width Corrections (Multipliers) for Mounds on Sloping Sites (3:1 Side slopes)

Slope as a percentage	*Downslope (I) Correction Factor*	*Upslope (J) Correction Factor*
0	1.00	1.00
2	1.06	0.94
4	1.14	0.89
6	1.22	0.85
8	1.32	0.81
10	1.44	0.77
12	1.58	0.74
14	1.74	0.71
16	1.95	0.68
18	2.21	0.66
20	2.55	0.64

(F) Distribution. Mound distribution media shall consist of one of the following:
1. A minimum of three inches of approved coarse aggregate placed beneath the distribution pipe and at least one inch of approved coarse aggregate placed over top of the pipe;
2. Approved chamber or bundled polystyrene distribution media products having a minimum eight inch height used in accordance with manufacturer specifications for installation; or
3. Other alternative distribution media materials as authorized by the department.

(G) Operations and Maintenance
1.An operations and maintenance manual must be developed for the mound system and provided to the owner. The manual must be available for review. The manual must contain the following as a minimum:
- A. Diagrams of all system components and their location. This should include the location of the reserve area.
- B. As-built drawings of all system components and their location are to be provided. The location of the reserve area also needs to be clearly
- C. Specifications for all electrical and mechanical components.
- D. Names and phone numbers of department's regional office, component manufacturer or management entity to be contacted in the event of an alarm, or other problems or failure.
- E. Information on the periodic maintenance of the mound system, including electrical/mechanical components. Periodic inspections of system performance are required to check:
  - 1. Liquid levels in the standpipes should be checked and examinations made for any seepage around the toe of the mound.
  - 2. Flushing of distribution laterals.
  - 3. Ponding in the distribution area
  - 4. For any surface water infiltration or clear water flows from the dwelling or structures into the system components or around the mound soil absorption area
- F. Review and document event counters, elapsed time meters, flow meters, and alarm conditions, where present.
- G. What activities can or cannot occur on and around the mound and the reserve area.
- H. Information regarding suitable landscaping and vegetation for the mound and surrounding areas.
- I. A thorough description of activities and practices that should be employed or avoided to promote desired treatment levels and long-term service.
- J. Avoid traffic in the initial and replacement mound areas, in particular the area down-slope from the mound and replacement mound. No vehicular or livestock traffic should be permitted. Be careful with lawn care equipment, such as riding lawn mowers or tractor, to not travel on the mound, or the downslope area, when the soil is saturated, such as during the wet winter or snowmelt seasons. Winter traffic on the mound should be avoided to minimize frost penetration in colder.

2. Each mound should have a minimum of two monitoring ports, one placed in the infiltration bed down to the gravel-sand, and one downslope from the bed down to the sand-native soil interface. An additional monitoring port should be installed through the soil interface into the soil several inches.

3. The mound must not be left without a vegetative cover or allowed to go to weed. Mowed turf grass and turf sod are the best vegetative covers for mounds.

(13) Low Pressure Pipe Subsurface Systems

(A) Low Pressure Pipe Systems A low-pressure pipe (LPP) system is a shallow, pressure-dosed soil absorption system with a network of small diameter perforated pipes placed in narrow trenches.

(B) Preliminary Treatment. Low pressure systems shall be preceded by preliminary treatment. Preliminary treatment shall be at a minimum be a septic tank, however secondary treatment technologies should be used. The secondary treatment system shall follow the design guides of 10 CSR 20-8.180 or 8.200(x).

(C) Design

Loading rates shall not exceed the values assigned by the site and soil evaluation. The minimum soil treatment area and total trench length. The system shall be sized in accordance with the following equations:

A = Q / LTAR and

L = A / 5 feet where:

A = Minimum LPP soil treatment area (square feet)
L = Minimum total length of LPP trench (feet)
Q = Maximum daily sewage flow (gallons per day)
LTAR = Long term acceptance rate (gallons per day per square foot). This is the lowest reported LPP soil loading rate between the soil surface and at least twelve inches (12") below the specified LPP trench bottom or as approved by the department.

(D) Distribution Network

The low pressure distribution design shall include the entire network configuration including, but not limited to, pipe lengths and size, exterior control panel and alarm information, and calculations used to determine dose volume, orifice flow rates, dosing tank sizing and pump selection:

1. Supply network piping including the main, sub-mains, and manifold shall be watertight, rigid solid wall pipe, and shall be properly supported to prevent sagging and damage under normal loads and operating conditions. All network piping and low pressure distribution piping and fittings shall be polyvinyl chloride meeting ASTM Standard D 1785 Schedule 40, 80, or 120 or equivalent. All fittings shall be pressure rated meeting or exceeding ASTM D 2466.

2. Manifold designs shall address freeze protection while assuring uniform distribution. The manifold shall be designed to minimize drain down of laterals into other laterals at a lower elevation between dosing events.

3. Lateral pipes shall be three-quarter to two inches in diameter.

4. There shall be no more than a five percent (5%) difference in flow rate between the proximal and distal orifices on each distribution lateral. The system design shall ensure a minimum fluid velocity of two feet per second (2fps) is maintained in the main and manifold piping during dosing.

5. There shall be no more than a five percent (5%) difference in the flowrate between two orifices in different distribution laterals that are to be dosed simultaneously during a single dosing event.

6. Laterals shall include valves to allow adjustment of the operating distal pressure at startup to meet design specifications. Baseline measurements including reconciling the gallons per minute with the design, distal pressures/heights, and dose rates for future operations, maintenance, and monitoring must be measured and recorded.

7. Low pressure distribution networks shall have an accessible means of measuring design pressure or operating head for both initial baseline measurement and future monitoring of orifice clogging and other network operations and shall include a means of scouring or flushing distribution laterals.

(E) Dosage

1. For zoned systems, the dosing frequency shall be determined based on the soils report and the dosing volume. The dosing volume shall be based on the soil loading rate for each zone and shall be designed to maximize treatment by control of the instantaneous loading rate and dose frequency.

A. When a flow restrictive layer is present within twelve inches of the natural ground surface, each dose shall deliver no greater than one-eighth of the daily design flow and at least three times the void volume of the laterals during each twenty-four hour period.

B. For facilities with restrictive layer greater than twelve inches of the natural ground surface, each dose shall deliver to the distribution area no greater than one-fourth of the daily design flow and at least five times the void volume of the laterals during each twenty-four hour period.

2. When time dosing is used, the selected dose volume and frequency shall ensure that dosing events are spaced uniformly throughout a twenty-four hour period to maximize resting between dosing events. Time dosed controls should prevent premature dosing when less than the daily dose volume is present in the dosing tank.

(F) Orifices and Orifice Shielding

1. Orifices shall be uniform, clean, and free of all drill cuttings. Lateral pipes must be stabilized when drilling orifices to prevent the pipes from moving and to ensure orifices are drilled perpendicular to the pipe.

2. Orifice flow may be calculated using the following formula.

$$Q = 11.79 \times D^2 \times \sqrt{h}$$

Where D = orifice diameter in inches; and

H = pressure head in feet

3. Orifices must be sized no less than one-eighth inch and spaced a maximum of six feet apart along the lateral.

4. The orifice number and spacing shall provide distribution of no more than six square feet per orifice with an orifice size of not less than one-eighth inch. Orifices must be spaced a minimum of six inches from the end of the lateral.

5. The direction of orifices and the method of orifice shielding shall be specified in the design and shall allow for uniform pressurization and depressurization of the laterals, and drain-back to prevent freezing.

6. The design must specify how the effluent stream from the orifices will be dispersed for uniform distribution.

A. When orifices are positioned up in the twelve o'clock position, the effluent stream must be sprayed against an orifice shield, gravel-less chambers, or similar device.

B. When orifices are positioned down in the six o'clock position to facilitate draining after each dosing cycle, a mechanism to disperse the effluent stream such as an orifice shield, a pad of gravel, or a splash plate shall be provided.

7. When orifice shields are used, they must be strong enough to withstand the weight of the backfill and large enough to protect the orifice from being plugged by gravel.

8. If effluent is to be sprayed upward against the top of gravel-less chambers, the design shall include and follow manufacturer recommendations.

9. The selected distal pressure to be maintained at the end of each lateral shall be no less than two feet (2 ft) (0.87 psi) when using three-sixteenth inch (3/16") or larger diameter orifices, and no less than five feet (5 ft) (2.18 psi) when using orifices smaller than three-sixteenth inch (3/16").

10. Pressure dosed systems shall use either elapsed time meters, event counters, or flow meters capable of measuring total flow to help determine flow rates and dose volumes.

A. Time dosed systems shall also have control panels with programmable timers, manual pump operation or hand- off- auto switches, test features, and as applicable, adjustable override settings.

B. Adjustable override settings cannot exceed the daily design flow and the override volume cannot exceed the dosing design of the downstream component.

11. The dosing tank size and the pump, exterior control panel, and alarm information shall be included with the design. The design shall indicate the settings or means used to accommodate the dose volume including any drainback to the dosing tank.

(G) Trenches

1. LPP trenches shall follow the contour of the ground

2. Compaction of the trench bottom, such as walking in the trench, shall be minimized

3. LPP trenches shall be constructed as level as possible, but in no case shall the fall in a single trench bottom exceed one-half inch (1/2") in one hundred feet (100');

4. There shall be no soil disturbance to an LPP site except the minimum required for installation.

5. LPP trenches shall be constructed with a minimum of four inches (4") of backfill unless specified by the gravelless product manufacturer or professional engineer and specifically approved by the department;

6. Rock used in LPP trenches shall be clean pea gravel or other approved aggregate and graded or sized between three-eighths inch and one inch (3/8" and 1"). Crushed limestone and dolomite shall not be used. No more than one percent (1%) fines, or materials passing the No. 100 sieve shall be allowed;

A. Other aggregate material may be used in LPP trenches, including but not limited to, tire chips or crushed glass when specified by the designer and specifically approved by the department;
B. When aggregate is used, there shall be a minimum of five inches (5") of gravel below and a minimum of two inches (2") of gravel above the LPP laterals; and
C. When aggregate is used, a durable geotextile fabric shall be used as a barrier to permit passage of water and prevent passage of soil into the aggregate; and
D. When gravelless dispersal trench products are used, LPP trench construction shall be in accordance with the manufacturer's requirements

(H) Operations and Maintenance

1. The following considerations should be made to ensure proper operation and maintenance of the facility:
A. Inspection ports should be installed to have at least one port placed in each leaching trench for observation of distribution and any ponding at the infiltrative surface. The ports shall be anchored and be accessible with at least a four inch opening and a removable cap;
B. Accessible turn-ups shall be provided at the end of each lateral for the purpose of flushing the laterals and testing distal operating head.
C. Shutoff mechanisms with a durable and stable access port shall be provided to isolate portions of the distribution network.
D. Baseline measurements including reconciling the gallons per minute with the design, distal pressures/heights, and dose rates for future operations, maintenance, and monitoring must be measured and recorded.
E. The distribution networks shall have an accessible means of measuring design pressure or operating head for both initial baseline measurement and future monitoring of orifice clogging and other network operations and include a means of scouring or flushing distribution laterals.
F. An elapsed time meter shall be installed on the pumps.
G. To prevent clogging, a disc filter or other manufacturer approved filter should be used.

2. The operations and maintenance manual of the treatment system shall include at a minimum, procedures for:
A. Checking for ponding in the distribution area;
B. Checking for surface water infiltration or clear water flows from the dwelling or structures into the system components and around or onto the soil absorption area;
C. Checking the vegetative cover for erosion or settling and any evidence of settling or seepage in the area of the soil absorption component;
D. Monitoring for proper operation of mechanical devices;
E. Monitoring the dose volume and operating pressure head of the distribution system and compare to baseline measurements;
F. Flushing of distribution laterals; and
G. Review and document event counters, elapsed time meters, flow meters, and alarm conditions where present.

(14) Drip Dispersal Subsurface Systems

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

(B) Preliminary Treatment. Drip Dispersal systems shall be preceded by secondary. The secondary treatment system shall follow the design guides of 10 CSR 20-8.180 or 8.200(x).

1. When using septic tank effluent there shall be a minimum of two feet (2') of sand fill material and two feet (2') of naturally occurring soils between the bottom of the trench rock and the highest elevation of the seasonal high groundwater level, bedrock, or other limiting layer; or
2. When using secondary treatment there shall be a minimum of one foot (1') of material and two feet (2') of naturally occurring soils between the bottom of the trench rock and the highest elevation of the seasonal high groundwater level, bedrock, or other limiting layer.

(C) Design.

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

as old road beds, foundations, etc., must be excluded when evaluating suitable areas for drip dispersal systems.

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

3. The design wastewater loading is a function of precipitation, evapotranspiration, design hydraulic conductivity rate, nitrogen loading limitations, other constituent loading limitations, groundwater and drainage conditions, average and peak design wastewater flows, soil denitrification rates, and the rate of nitrogen uptake in site vegetation .

4. The design application rate in gallons per day per square foot (GPD/SF) shall be derived from either the hydraulic (water) loading rate (Lwh) based upon the most restrictive of

A. The NRCS hydraulic conductivity data and the texture and structure

B. The nutrient (nitrogen) loading rate (Lwn). The amount of wastewater that can be applied to a site may be limited by the amount of nitrogen in the wastewater. A particular site may be limited by the nitrogen content of the wastewater during certain months of the year and limited by the infiltration rate during the remainder of the year. The equation below shall be used to calculate, on a monthly basis, the allowable hydraulic loading rate based on nitrogen limits:

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

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

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

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

PET = potential evapotranspiration, inches/month

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

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

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

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

C. The Lwh value is determined by a detailed site evaluation and will be dependent upon the soil characteristics. The values of Lwh and Lwn are compared for each month. The lesser of the two values will be used to determine the amount of acreage needed.

5. Drip field area requirements. The minimum soil treatment area and total length. The system shall be sized in accordance with the following equations:

$$A = \frac{Q}{LTAR} \text{ and } L = \frac{A}{5\,feet}$$

Where:

A = Minimum LPP soil treatment area (square feet)

Q = Maximum daily sewage flow (gallons per day)

L = Minimum total length (feet)

LTAR = Long term acceptance rate (gallons per day per square foot). LTAR = Long term acceptance rate (gallons per day per square foot). This is the lowest reported conventional soil loading rate between the soil surface and at least twelve inches (12") below the fill.

(D) Soils.

1. The use of any soil is should meet the following four (4) criteria:

A. The applied effluent loading rate does not exceed the applicable hydraulic loading rate in the table below. The applicable hydraulic loading rate is determined by a detailed site evaluation in which the site is mapped utilizing soil borings and pits to determine the physical properties of soil horizons and soil map units.

B. The applied effluent maximum loading rate does not exceed 10% of the minimum NRCS saturated vertical hydraulic conductivity (K_{SAT}) for the soil series, the results of the nutrient loading rate, or 0.20 gallons per day per square foot whichever is least.

C. The soil does not have a restrictive horizon within its top twenty (20) inches.

D. The soil is well drained, or capable of being drained.

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

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

(E) Lines and Trenches.

1. **Drip dispersal lines should be placed at depths of six (6) to ten (10) inches below the surface. The drip lines should be laid level and should run with the contour.**
2. **The emitter line spacing and emitter spacing shall be at 2-foot spacing to achieve even distribution of the wastewater and maximum utilization of the soil.**
3. **The vertical separation between the bottom of the trench and a limiting layer, including but not limited to, bedrock; restrictive horizon; or seasonal high water table, shall be no less than twenty-four inches (24") or shall be no less than twelve inches (12") for systems dispersing secondary or higher quality effluent.**
4. **Vertical separation shall be no less than forty-eight inches (48") where karst features are present unless the site can be reclassified;**
5. **Trenches shall be spaced at least five feet (5') apart on centers. When trench spacing is greater than five feet (5'), a maximum effective area of up to five square feet (5 sq.ft.) of soil treatment area per foot of trench may be allowed.**
6. **Rock used in trenches shall be clean pea gravel and graded or sized between three-eighths inch and one inch (3/8" and 1"). Crushed limestone and dolomite shall not be used. No more than one percent (1%) fines, or materials passing the No. 100 sieve shall be allowed;**
7. **Other aggregate material may be used in trenches, including but not limited to, tire chips or crushed glass when specified by the designer and specifically approved in the facility plan by the department.**

(F) Operations and Maintenance

(1) The following considerations should be made to ensure proper operation and maintenance of the facility:

A. Inspection ports should be installed to have at least one port placed in each leaching trench for observation of distribution and any ponding at the infiltrative surface. The ports shall be anchored and be accessible with at least a four inch opening and a removable cap;

B. Accessible turn-ups shall be provided at the end of each lateral for the purpose of flushing the laterals and testing distal operating head.

C. Shutoff mechanisms with a durable and stable access port shall be provided to isolate portions of the distribution network.

D. Baseline measurements including reconciling the gallons per minute with the design, distal pressures/heights, and dose rates for future operations, maintenance, and monitoring must be measured and recorded.

E. The distribution networks shall have an accessible means of measuring design pressure or operating head for both initial baseline measurement and future monitoring of orifice clogging and other network operations and include a means of scouring or flushing distribution laterals.

(2) The operations and maintenance manual of the treatment system shall include at a minimum, procedures for:

A. Checking for ponding in the distribution area;

B. Checking for surface water infiltration or clear water flows from the dwelling or structures into the system components and around or onto the soil absorption area;

C. Checking the vegetative cover for erosion or settling and any evidence of settling or seepage in the area of the soil absorption component;

D. Monitoring for proper operation of mechanical devices;

E. Monitoring the dose volume and operating pressure head of the distribution system and compare to baseline measurements;

F. Flushing of distribution laterals; and

G. Review and document event counters, elapsed time meters, flow meters, and alarm conditions where present.