

Chapter NR 504

LANDFILL LOCATION, PERFORMANCE, DESIGN AND CONSTRUCTION CRITERIA

NR 504.01	Purpose.		
NR 504.02	Applicability.		
NR 504.03	Definitions.		
NR 504.04	Landfill locational criteria and performance standards.		
NR 504.05	General design and construction criteria.		
NR 504.06	Minimum design and construction criteria for landfill liners and leachate collection systems.		
NR 504.07	Minimum design and construction criteria for final cover systems.		
NR 504.075	Soil borrow sources.		
NR 504.08	Minimum design and construction criteria for landfill gas extraction systems.		
		NR 504.09	Storm water management and miscellaneous design and construction criteria for landfills.
		NR 504.095	Design criteria for landfills that recirculate leachate.
		NR 504.10	Alternative design criteria for landfills accepting high volume industrial wastes.
		NR 504.11	Minimum design and construction criteria for landfills accepting residue produced by burning municipal solid waste.
		NR 504.12	Minimum design and construction criteria for CCR landfills.

Note: Corrections made under s. 13.93 (2m) (b) 7., Register, August, 1997, No. 500.

NR 504.01 Purpose. The purpose of this chapter is to help ensure that efficient, nuisance-free and environmentally acceptable solid waste management procedures are practiced in this state and to provide information on locational criteria, performance standards and the minimum design and construction requirements for landfills. This chapter is adopted under ch. 289, Stats., and s. 227.11, Stats.

History: Cr. Register, January, 1988, No. 385, eff. 2-6-88; am., Register, June, 1996, No. 486, eff. 7-1-96.

NR 504.02 Applicability. (1) (a) Except as provided in par. (b) and except as otherwise provided, this chapter governs all landfills as defined under s. 289.01 (20), Stats., including all CCR landfills and expansions.

(b) This chapter does not govern any of the following:

1. Landspreading facilities regulated under ch. NR 518, small demolition waste landfills regulated under ch. NR 503, hazardous waste facilities as defined under s. 291.01 (8), Stats., and regulated under chs. NR 660 to 679.

2. Metallic mining operations for nonferrous minerals as defined under s. 293.01 (9), Stats., and regulated under ch. NR 182.

3. Metallic mining operations for ferrous minerals as defined under s. 295.41 (26), Stats., including mining wastes and mining waste sites as defined under s. 295.41 (30) and (31), Stats., and regulated under subch. III of ch. 295, Stats.

(2) This chapter does not apply to the design, construction or operation of industrial wastewater facilities, sewerage systems and waterworks treating liquid wastes approved under s. 281.41, Stats., or permitted under ch. 283, Stats., nor to facilities used solely for the disposal of liquid municipal or industrial wastes which have been approved under s. 281.41, Stats., or permitted under ch. 283, Stats., except for facilities used for the disposal of solid waste.

Note: Owners or operators proposing to site a new or expand an existing municipal solid waste landfill within a 5 mile radius of any airport runway end used by turbojet or piston type aircraft must notify the owner or operator of the affected airport and the federal aviation administration (FAA).

History: Cr. Register, January, 1988, No. 385, eff. 2-6-88; correction in (1) made under s. 13.93 (2m) (b) 7., Stats., Register, May, 1995, No. 473; am. (1), Register, June, 1996, No. 486, eff. 7-1-96; am. (1), Register, August, 1997, No. 500, eff. 9-1-97; correction in (2) made under s. 13.93 (2m) (b) 7., Stats., Register March 2003 No. 567; correction in (1) made under s. 13.93 (2m) (b) 7., Stats., Register December 2006 No. 612; CR 13-057: am. (1) Register July 2015 No. 715, eff. 8-1-15; **CR 21-076: renum. (1) to (1) (a) and (b) 1. to 3. and am., cr. (b) (intro.) Register July 2022 No. 799, eff. 8-1-22.**

NR 504.03 Definitions. The terms in this chapter are defined in s. NR 500.03.

History: Cr. Register, January, 1988, No. 385, eff. 2-6-88.

NR 504.04 Landfill locational criteria and performance standards. (1) GENERAL. As part of the feasibility report required under ch. NR 512 an applicant shall demonstrate to the department that the proposed landfill will comply with all of the locational criteria and performance standards of this section unless an exemption is granted.

(2) EXEMPTIONS. (a) Exemptions from compliance with subs. (3) (a), (b), (d), (e), (f), (g), (h), (i) and (4) (b), (e) and (f) may be granted by the department only upon demonstration by the applicant of circumstances which warrant an exemption. Compliance with sub. (4) (a) shall be evaluated in accordance with the standards in ch. NR 103. For the purpose of determining whether there is a practicable alternative to a proposed landfill expansion under s. NR 103.08, the department may allow an applicant to limit its analysis of alternatives to alternatives within the boundaries of the property where the existing landfill is located and on property immediately adjacent to the existing landfill. Exemptions from compliance with subs. (3) (c) and (4) (c) may not be granted. Exemptions from compliance with sub. (4) (d) may be granted only according to the procedures set forth in chs. NR 507 and 140. Exemptions from compliance with sub. (3) (f) will be based on an evaluation of the information contained in par. (b). However, no exemptions from sub. (3) (f) may be granted unless information on the well location, current and immediate past well owners, well driller, well log and construction details, the general hydrogeologic setting and a completed s. NR 812.43 variance request is submitted to the department. Exemptions from sub. (3) (f) shall be requested by the applicant and re-evaluated for each subsequent expansion proposal. Exemptions from sub. (3) (i) may be granted only if the applicant demonstrates that engineering measures have been incorporated into the landfill's design to ensure that the integrity of the structural components of the landfill will not be disrupted.

Note: Contact the groundwater expert or water supply specialist in the local DNR office to obtain a list of the current requirements for a completed s. NR 812.43 variance request. To determine who is the appropriate contact in a particular part of the state either call (608) 266-0821 or e-mail the Drinking Water and Groundwater program at DG.Mail@dnr.state.wi.us.

(b) Additional factors which may be considered by the department in determining whether or not to grant exemptions under this section include waste types, characteristics and quantities; the geology and hydrogeology of the landfill; the proposed landfill design and operation; the availability of other environmentally suitable alternatives; status of the s. NR 812.43 variance application; compliance with other state and federal regulations and the health, safety and welfare of the public. Requests for exemptions and information needed to demonstrate the circumstances that warrant exemptions shall be addressed by the applicant in the feasibility report.

(3) LOCATIONAL CRITERIA. No person may establish, construct, operate, maintain or permit the use of property for a landfill

where the limits of filling are or would be within the following areas:

(a) Within 1,000 feet of any navigable lake, pond or flowage not including landfill drainage or sedimentation control structures.

(b) Within 300 feet of any navigable river or stream.

(c) Within a floodplain.

(d) Within 1,000 feet of the nearest edge of the right-of-way of any state trunk highway, interstate or federal aid primary highway or the boundary of any public park or state natural area, unless the landfill is screened by natural objects, plantings, fences or other appropriate means so that it is not visible from the highway, park or natural area.

(e) Within an area where the design or operation of the landfill would pose a significant bird hazard to aircraft.

1. A landfill which is proposed to be located within 10,000 feet of any airport runway end designed or planned to be designed and used by turbojet aircraft or within 5,000 feet of any airport runway end designed for and used only by piston type aircraft and which is proposed to be used for the disposal of putrescible waste shall be presumed to pose a significant bird hazard to aircraft unless the applicant can demonstrate to the satisfaction of the department that the landfill will not pose a significant bird hazard to aircraft.

2. A landfill used for the disposal of putrescible waste which is in existence on July 1, 1996, and which is located within 10,000 feet of any airport runway end used or planned to be used by turbojet aircraft or within 5,000 feet of any runway end used by only piston-type aircraft shall be closed by October 9, 1996 unless the owner or operator of the landfill demonstrates to the satisfaction of the department that the landfill will not pose a significant hazard to aircraft. The deadline for closure may be extended by the department by up to 2 years if the owner or operator demonstrates that there is no available alternative disposal capacity and there is no immediate threat to human health and the environment.

Note: Owners or operators proposing to site a new or expand an existing municipal solid waste landfill within a 5 mile radius of any airport runway end used by turbojet or piston type aircraft must notify the owner or operator of the affected airport and the federal aviation administration (FAA).

(f) Within 1,200 feet of any public or private water supply well.

(g) Within 200 feet of a fault that has had displacement in Holocene time.

(h) Within seismic impact zones.

(i) Within unstable areas.

(4) **PERFORMANCE STANDARDS.** No person may establish, construct, operate, maintain or permit the use of property for a landfill if there is a reasonable probability that the landfill will cause:

(a) A significant adverse impact on wetlands as provided in ch. NR 103.

(b) A take of an endangered or threatened species in accordance with s. 29.604, Stats.

(c) A detrimental effect on any surface water.

(d) A detrimental effect on groundwater quality or will cause or exacerbate an attainment or exceedance of any preventive action limit or enforcement standard at a point of standards application as defined in ch. NR 140. For the purposes of design the point of standards application is defined by s. NR 140.22 (1).

(e) The migration and concentration of explosive gases in any landfill structures excluding the leachate collection system or gas control or recovery system components in excess of 25% of the lower explosive limit for such gases at any time. The migration and concentration of explosive gases in the soils outside of the limits of filling within 200 feet of the landfill property boundary or beyond the landfill property boundary in excess of the lower explosive limit for such gases at any time. The migration and concentration of explosive gases in the air outside of the limits of filling within 200 feet of the landfill boundary or beyond the landfill

property boundary in excess of the lower explosive limit for such gases at any time.

(f) The emission of any hazardous air contaminant exceeding the limitations for those substances contained in s. NR 445.07.

History: Cr. January, 1988, No. 385, eff. 2-6-88; am. (1), (2) (a), (b), (3) (intro.), (a), (d), (4) (intro.), (a) (e), r. and recr. (3) (e), cr. (3) (g) to (i), Register, June, 1996, No. 486, eff. 7-1-96; am. (2) (a), Register, May, 1998, No. 509, eff. 6-1-98; CR 05-020: am. (2) (a), (b), (3) (d), (4) (b) and (f) Register January 2006 No. 601, eff. 2-1-06; correction in (4) (f) made under s. 13.92 (4) (b) 7., Stats., Register April 2017 No. 736.

NR 504.05 General design and construction criteria.

(1) Unless otherwise specified in this chapter, the minimum design criteria in ss. NR 504.06 to 504.09 apply to all new landfills and to the expansion of existing landfills for which the plan of operation was approved after July 1, 1996, as well as to proposed design changes for all landfills which are submitted after July 1, 1996. Landfills designed in substantial conformance with these design criteria are presumed to be capable of meeting the performance standards of s. NR 504.04 (4) (d) regarding groundwater quality.

(2) If the proposed design differs from the requirements in ss. NR 504.06 to 504.09, the applicant shall provide supporting justification for any differences.

(3) The design capacity of all proposed landfills, except landfills that are exempted in s. 289.28 (2), Stats., shall be determined such that the projected operating life of the landfill is not less than 10 years nor more than 15 years. Expansions of existing landfills are not subject to the 10-year minimum design capacity requirement. Waste approved for use in construction of landfill components is not considered part of the design capacity.

History: Cr. Register, January, 1988, No. 385, eff. 2-6-88; r. and recr., Register, June, 1996, No. 486, eff. 7-1-96.

NR 504.06 Minimum design and construction criteria for landfill liners and leachate collection systems.

(1) **GENERAL.** (a) All major phases of landfills initially accepting municipal solid waste after July 1, 1996, shall be designed with a composite liner and a leachate collection system capable of limiting the average leachate head level on the composite liner to one foot or less during operation and after closure of the landfill, except as provided in s. NR 504.10 (1) (c). The composite liner shall consist of 2 components; the upper component shall consist of a nominal 60-mil or thicker geomembrane liner with no thickness measurements falling below the minimum industry accepted manufacturing tolerances, and the lower component shall consist of a minimum 4 foot thick layer of compacted clay meeting the specifications of s. NR 504.06 (2) (a). The geomembrane component shall be installed in direct and uniform contact with the compacted clay soil component, and the landfill shall meet or exceed the standards in the applicable portions of subs. (2), (3) and (4). All other landfills shall be designed to contain and collect leachate to the maximum practical extent. This shall be accomplished by designing the landfill to meet the standards contained in the applicable portions of subs. (2), (3) and (4), unless the department approves the applicant's alternative design as per s. NR 504.10, which provides an equivalent or better level of performance than the standards contained in this chapter.

(b) If the applicant does not complete construction of the first major phase of the landfill within 2 years from the date of the plan of operation approval, the applicant shall reapply to the department for approval to construct the landfill. This application does not constitute a feasibility report as defined in s. 289.24, Stats. The department may require additional conditions of approval and require redesign of the landfill in accordance with state-of-the-art design criteria.

(2) **COMPOSITE OR CLAY LINED LANDFILLS.** All landfills designed with a composite liner or a clay liner shall meet the following requirements:

(a) All clay used in liner construction shall meet the following specifications:

1. A minimum of 50% by weight which passes the 200 sieve.
2. A saturated hydraulic conductivity of 1×10^{-7} cm/sec or less, when compacted to required moisture contents and densities based on the modified Proctor method, standard Proctor method, or a line of optimums method approved by the department.

3. An average liquid limit of 25 or greater with no values less than 20.

4. An average plasticity index of 12 or greater with no values less than 10.

(b) The separation distance between the seasonal high groundwater table and the bottom of the clay component of a composite liner or a clay liner shall be at least 10 feet except for zone-of-saturation landfills.

(c) The separation distance between the top of the bedrock surface and the bottom of the clay component of a composite liner or a clay liner shall be at least 10 feet.

(d) The slope of the liner surface toward the leachate collection lines shall be at least 2%.

(e) The minimum thickness of the clay component of a composite liner at all locations shall be at least 4 feet. The minimum thickness of a clay liner at all locations shall be at least 5 feet.

(f) The clay component of a composite liner or a clay liner shall be constructed in the following manner:

1. All clay layers in the liner shall be constructed in lift heights no greater than 6 inches after compaction using footed compaction equipment having feet at least as long as the loose lift height. As needed, clay shall be disked or otherwise mechanically processed prior to compaction to break up clods and allow for moisture content adjustment. Clod size shall be no greater than 4 inches. All compaction equipment utilized shall have a minimum static weight of 30,000 pounds. Lighter equipment may be used in small areas where it is not possible to use full size equipment. Alternative procedures or equipment may be proposed for approval by the department.

2. A sufficient number of passes of the compaction equipment shall be made over each lift of clay to ensure complete remolding of the clay.

3. All clay shall be compacted to 90% modified or 95% standard Proctor density at a moisture content at least 2% wet of optimum if using the modified Proctor method and wet of optimum if using the standard Proctor method, based on the characteristics of the appropriate Proctor curve for the clay being placed. As clay placement proceeds, the minimum density and moisture content targets shall be adjusted as necessary. The department recommends use of an alternate method of determining adequate density and moisture content based on a line of optimums method. However, this method may not be used unless it has been previously detailed in a landfill's plan of operation or a proposed plan modification and approved in writing by the department. At a minimum, any such proposal shall address how the line of optimums would be defined, as well as how the minimum dry unit weight needed to ensure adequate shear strength of the clay soils proposed would be determined.

(g) The slope of the interior sidewalls of a landfill may not exceed 3 horizontal to one vertical nor be less than 5 horizontal to one vertical.

(h) The clay component of a liner in adjacent phases shall be keyed together to form a continuous clay seal. This shall be accomplished by excavating steps along the edge of the existing lined phase and overlapping them with the lifts of clay being placed for the liner of the new phase. A minimum of 4 steps shall be included, with the total width of the spliced area measuring a minimum of 15 feet.

(3) COMPOSITE-LINED LANDFILLS. All landfills designed with a composite liner shall meet the following additional requirements for the geomembrane component of the liner:

(a) All geomembranes shall be fabricated from resins specifically formulated for waste containment purposes. Nominal geomembrane thickness shall be 60 mils or greater with no thickness measurements falling below the minimum industry accepted manufacturing tolerances.

(b) Additional protection shall be provided for the geomembrane component of the composite liner along areas subject to traffic or other concentrated activity during construction or operation. This shall include sumps, sideslope risers and entry ramps.

(c) For slopes in excess of 10%, geomembrane panels shall be installed such that all seams run perpendicular to the contour lines of the slope to the extent possible.

(d) Prior to geomembrane placement, the clay surface shall be rolled and graded so it is free of irregularities, protrusions, loose soil and abrupt changes in grade. The surface shall also be free of stones, grade stakes and construction debris which may be damaging to the geomembrane and shall contain no areas excessively softened by high water content. The clay surface shall be sufficiently dry and dense such that the construction equipment used to place the geomembrane panels do not rut the clay surface. All depressions and large cracks shall be filled in with tamped clay.

(e) Geomembrane panels made of polyethylene resins shall be welded by double-tracked, fusion welding machines for all linear seams. Corners, butt seams and long repairs shall be fusion welded where possible. Extrusion or fusion welding shall be used for all other repairs, detail work and patches. Department approval shall be obtained prior to use of any other welding method for either panel seaming, repairs or construction of details.

(f) The geomembrane component of a composite liner constructed in phases adjacent to each other shall be welded together to form a continuous membrane surface. The liner extending beyond the proposed edge of waste at a phase junction shall be protected from traffic and weather.

(g) Wrinkles in the geomembrane component which are higher than they are wide, shall be smoothed or cut out and repaired prior to covering with soil. Guidance to machine operators placing soil on the geomembrane component shall be provided by the use of an observer with an unobstructed view of the advancing lift of soil.

(h) The minimum thickness of soil which must be present over the geomembrane component before vehicular traffic may occur shall be one foot for vehicles with ground pressure less than 5 pounds per square inch and 2 feet for all other tracked vehicles and flotation tire equipped vehicles. Trucks and other wheeled hauling equipment shall be confined to corridors or locations with a soil thickness of 3 or more feet over the geomembrane component.

(i) In order to lessen desiccation effects, the base of the landfill and the lower 10 vertical feet of the sideslope shall be covered with a drainage blanket within 30 days after completing quality control and quality assurance testing of the installation. The remaining sideslope shall be covered with either drainage material or a geotextile to prevent damage to the geomembrane.

(j) To prevent movement and folding of wrinkles, placement of soil over the membrane shall be performed during cooler temperature periods to the extent possible using methods of placement which minimize wrinkling.

(k) Anchor trenches shall be designed and constructed around the perimeter of the landfill to secure the permanent edges of the geomembrane. The geomembrane shall be seamed completely to the ends of all panels to minimize the potential of tear propagation along the seam.

(4) ZONE-OF-SATURATION LANDFILLS. All landfills proposed with base grades beneath the groundwater table shall meet the following requirements:

(a) The landfill shall be located in a fine-grained soil environment.

Note: Fine-grained soil environment is defined in s. NR 500.03 (86).

(b) The landfill shall meet the requirements in sub. (2) (a), (d), (e), (f), (g) and (h), and if the landfill will accept municipal solid waste, sub. (3).

(c) An analysis shall be performed of the effect which groundwater flow may have on uplift of the liner and the short and long-term stability of the geomembrane component of the composite liner. The analysis shall evaluate the effect of an underdrain or other dewatering system.

(d) Borings, backhoe pits or other means of exposing subsoils shall be performed on a 100-foot grid to a minimum depth of 5 feet below the gradient control layer, if part of the design, or a minimum depth of 5 feet below the subbase grades of the liner. All detected granular or silty soils within this 5 foot depth shall be removed and replaced with compacted, fine-grained soils.

(5) LEACHATE COLLECTION SYSTEMS. All leachate collection systems shall incorporate the following design features:

(a) A leachate collection system shall be included in each horizontal phase of the landfill. This system shall be designed to route leachate to the perimeter of the landfill in the most direct manner possible and limit the average leachate head level on the liner to one foot or less. The piping layout shall be such that leachate flows no more than 130 feet across the base of the liner before encountering a perforated leachate collection pipe. The department will consider greater flow distances for well designed composite landfills.

(b) The minimum slope on all leachate collection pipes at the base of the landfill shall be a constant 0.5%. The department recommends that greater pipe slopes be utilized whenever possible.

(c) The minimum diameter of all leachate collection or transfer pipes shall be 6 inches. Schedule 80 PVC pipe or an approved substitute shall be used.

(cm) Pipe fittings selected for use with PVC and HDPE pipe shall be secured to the leachate collection pipe. PVC fittings and pipe shall be solvent-welded. HDPE fittings and pipe shall be fusion welded.

(d) Leachate collection trenches for clay liners shall be designed as rectangular trenches. Leachate collection trenches for composite liners shall be designed as vee-trenches, with a minimum depth of 18 inches and with sideslopes no steeper than 3 horizontal to one vertical. The clay component of vee-trenches shall be smooth-drum rolled such that the clay in the trenches is smooth prior to placement of the membrane.

(dm) A geotextile shall be used to line the base and sidewalls of all leachate collection trenches and shall be placed directly over the geomembrane component of a composite liner or the clay component of a clay liner. The geotextile shall have a minimum weight of 12 oz/yd², and may not be overlapped over the top of the trench. The geotextile specifications, including manufacturer's data for grab and puncture strength, shall be used to demonstrate that the geotextile can resist damage due to impact and puncture when aggregate is placed over the geotextile.

(e) The bedding material utilized in backfilling the leachate collection pipe trenches shall have a uniformity coefficient of less than 4, a maximum particle diameter of 1½ inches, a maximum of 5% of the material which passes the number 4 sieve and consist of rounded to subangular gravel. A minimum depth of 4 inches of gravel shall be placed in the trenches prior to installation of the leachate pipes. The backfill shall also be placed such that a minimum of 6 inches of material exists above the top of the pipe and within the trenches. An additional 12 inches of material shall be mounded above the trench. In cases where the particle size of the drainage blanket is significantly less than the collection trench bedding, a properly designed graded soil filter or geotextile shall be utilized to minimize the migration of the drainage blanket material into the collection trenches. Limestone and dolomite may not be used in the leachate collection system unless no other suitable material is reasonably available.

(f) The sizing of sand, gravel, geotextiles and pipe openings shall be analyzed for control of piping of soil materials. The gradation of sand and gravel, the apparent opening size of geotextiles, and the pipe opening sizes shall be selected to achieve a stable and self-filtering structure under all conditions of leachate flow.

(g) All leachate collection lines shall have cleanout access points installed on both ends of each line and may not exceed 1,200 feet from the end of one cleanout to the toe of the opposite slope.

(h) Leachate lines, manholes and other engineering structures may not penetrate the liner in the vertical direction. For clay lined landfills, leachate transfer lines may penetrate the liner in the horizontal direction only. The number of liner penetrations shall be kept to a minimum. Composite lined landfills shall be designed without any perforations in the liner and in accordance with par. (j).

(i) Any leachate line that penetrates a clay liner shall have a 4 foot by 4 foot anti-seep collar placed around it. A minimum of 5 feet of compacted clay, as measured from the pipe, shall be placed around the collar in all directions.

(j) All composite lined landfills shall be designed and constructed with sumps and sideslope risers as part of their leachate removal system rather than utilizing systems which penetrate the composite liner sidewall. The leachate removal system shall meet the following requirements:

1. The volume of the sump and the capacity of the pump shall be sized so that accumulation of leachate outside the sump does not occur based on an assumed annual leachate collection rate of 6 inches. The volume of the sump shall take into account the potential buildup of solids over time.

2. The base of the leachate collection sumps shall be protected by the use of a thick polyethylene plate or other means acceptable to the department which is placed prior to the installation of the sideslope riser and backfill.

3. The leachate discharge pipes between the sideslope risers and collection tank shall be equipped with valves to prevent backflow into the waste disposal area.

4. The minimum diameter of the sideslope riser shall be 18 inches. The geometry of the sideslope riser at the junction of the sump and sidewall shall be selected to assure passage of the pump and associated hardware and to assure correct positioning of the intake of the pump.

5. The area of the sump and depth of gravel fill shall be sized to allow remedial installation of access and hardware for removal of leachate in the event of failure of the sideslope riser and pump system. The base of the sump shall be protected by polyethylene plate.

(k) All leachate lines transporting leachate out of the landfill by gravity shall be constructed with valves so the flow of leachate can be controlled. The valves shall be compatible with the leachate and be capable of being operated from the ground surface.

(L) All leachate transfer lines located outside of the composite lined or clay lined area shall be designed to assure groundwater protection through the use of double-cased pipe or by using another approved secondary containment method. All leachate transfer line piping shall be pressure tested prior to use. Unless otherwise approved by the department, the upslope end of the secondary pipe shall be sealed and the downslope end shall be open to allow any collected liquid to flow into the manhole.

(m) All leachate transfer lines, manholes, lift stations and other structures which transfer or store leachate outside the limits of waste shall be designed as shallow as practical and located far enough from the limits of filling so that excavations associated with repair of these devices would not infringe on the landfill cover system or sidewall liner. Each of these devices shall be constructed above the seasonal high groundwater table unless it is not technically feasible to do so and the design meets the requirements of par. (L).

(n) Leachate collection tanks and manholes shall be designed with a secondary containment system to prevent the discharge of leachate to ground and surface waters in the event of a leak or spill. Means shall be provided to monitor the tank and manholes within the secondary containment system unless other means for leak detection are approved by the department.

(o) All leachate collection tanks shall be designed to contain the volume of leachate which is generated by the landfill over a 4 day period and to withstand the soil and liquid loads that will be encountered during installation and use. The installation of the tanks shall follow the recommendations of the consultant and manufacturer.

(p) Measures shall be proposed to prevent accidental discharges at the leachate loadout station from entering groundwater or surface water. Unless an alternate method is approved by the department, the leachate loading station shall be paved with a concrete or asphalt pad and sloped to a catch basin to direct all spills back into the leachate holding tank.

(q) All manholes and enclosed structures for leachate and gas control systems shall be designed to allow for proper venting and access control. For landfills designed with active gas recovery systems, these devices shall be designed to minimize air intrusion into the landfill.

(r) All control systems such as pumps, valves and meters shall be designed to be operated from the ground surface.

(s) All leachate and groundwater collection systems shall be designed to accurately monitor the volume of liquid removed by the system.

(t) A minimum one foot thick granular drainage blanket shall be placed on top of the geomembrane component of a composite liner and on top of the clay component of a clay liner. For composite lined landfills, if the drainage blanket contains gravel greater than 1/4 inch, then a nonwoven geotextile shall be installed below the drainage blanket. The geotextile shall have a minimum weight of 12 oz/yd² and shall be certified to be needle-free. The granular drainage blanket shall contain no more than 5% material by weight which passes the number 200 sieve.

(tm) Leachate collection blankets shall have a minimum hydraulic conductivity of 1 cm/sec for any site that accepts any amount of municipal solid waste and 1×10^{-2} cm/sec for landfills which do not accept municipal solid waste. The gradation of the granular drainage blanket and associated hydraulic conductivity shall be selected to maintain the maximum head in the drain within the drain thickness.

(u) All major horizontal clay lined phases above the saturated zone shall be designed with a collection basin lysimeter to monitor the unsaturated zone except for composite lined landfills.

(6) ADDITIONAL REQUIREMENTS FOR LANDFILLS WITH EXTENDED COLLECTION LINES. (a) Landfills shall meet the requirements of pars. (b) to (f) where they will accept municipal solid waste and contain leachate collection lines that exceed 1,200 feet from the end of each cleanout to the toe of the opposite slope. Where the requirements of this subsection differ from other requirements of this chapter, these requirements shall take precedence.

(b) The maximum length of leachate collection lines from the access point at one end to the toe of the opposite slope may not exceed 2,000 feet.

(c) The minimum slope on all leachate collection pipes and associated pipe trenches at the base of the landfill shall be designed and constructed to be 0.5% after accounting for primary and secondary settlement of the subgrade. The minimum design slope shall be selected following computation of 100% of the primary consolidation settlement and the secondary consolidation settlement of the compressible materials beneath the facility, which includes, as applicable, in-situ soil, added geologic material, structural fill material, and compacted clay liner. Secondary settlement shall be calculated using a 100-year time frame.

(d) Pipe bedding material shall be composed of coarse, uniform gravel with a hydraulic conductivity that is greater than or equal to the hydraulic conductivity of the leachate collection blanket specified in s. NR 504.06 (5) (tm), in addition to meeting the other requirements of s. NR 504.06 (5) (e).

(e) The maximum anticipated construction, operation and post-closure overburden loads over the leachate collection piping shall be calculated and utilized in selecting the pipe material and wall thickness, based on 6-inch pipe diameter and an appropriate in-field consolidated density.

(f) All components of the leachate collection system shall incorporate all of the following design features:

1. Sweep bends at all changes of alignment, using a minimum radius of 10 pipe diameters, consisting of prefabricated PVC sweep bends or smooth pipe bends or prefabricated sweep bends for HDPE or other pipe materials.

2. Pipe alignments that minimize horizontal and vertical alignment changes for the entire leachate collection pipe length.

3. Elimination or minimization of obstructions or artifacts of construction which impose drag on pipe cleaning jetter hose or nozzles.

(7) COMPOSITE-LINED LANDFILLS USING GCLS. Use of GCLs in construction of a composite liner may not be used except in landfills which do not accept municipal solid waste, unless the GCL is used as a pad for the upper surface of the 4 foot clay component of a composite liner for a municipal solid waste landfill. The GCL and soil barrier layer components of a barrier system shall meet all of the following requirements:

(a) The hydraulic performance of the GCL shall be assessed by the use of compatibility testing. The testing protocol shall be provided to the department for review and concurrence prior to the initiation of compatibility testing. The compatibility testing shall utilize percolation fluids that simulate the leachate that will be produced by the landfill.

(b) The GCL shall meet the specifications of s. NR 504.07 (4) (a) 1. to 11.

(c) The GCL shall be underlain by a soil barrier layer that is a minimum of 2 feet thick and that meets the specifications of s. NR 504.07 (4) (a) 12. to 17.

History: Cr. Register, January, 1988, No. 385, eff. 2-6-88; r. and recr., Register, June, 1996, No. 486, eff. 7-1-96; am. (5) (e) and (t), Register, August, 1997, No. 500; CR 04-077: cr. (5) (cm), (dm), (j) 4., 5., (tm) and (6), am. (5) (d), (e), and (t) Register November 2005 No. 599, eff. 12-1-05; CR 05-020: cr. (7) Register January 2006 No. 601, eff. 2-1-06; correction made under s. 13.93 (2m) (b) 1., Stats., Register January 2006 No. 601; CR 06-026: am. (5) (dm) and (e), Register December 2006 No. 612, eff. 1-1-07.

NR 504.07 Minimum design and construction criteria for final cover systems.

(1) GENERAL. (a) All final cover systems shall be designed to minimize leachate generation by limiting the amount of percolation through the cap system, reduce landfill maintenance by stabilizing the final surface through design of compatible slopes and establishment of vegetation, account for differential settlement and other stresses on the capping layer, minimize the climatic effects of freeze-thaw and desiccation on the clay capping layer of the final cover system, and provide removal of leachate and venting of gas from those landfills which accept wastes with a high moisture content or which readily biodegrade.

(b) All new landfills and expansions of existing landfills shall be designed with a final cover system meeting the requirements in subs. (2) to (9) unless it is established to the satisfaction of the department that portions of the final cover system are not needed based on the proposed waste types and the proposed design. The geomembrane component in sub. (5) does not apply to landfills designed exclusively for the disposal of high volume industrial waste, or to other landfills which are not designed to accept municipal solid waste unless the landfill is composite lined.

(c) Any phases of an existing landfill which have been designed and constructed with a composite liner shall be designed

and constructed with a final cover system meeting the requirements in subs. (2) to (9), except that the requirement for the geomembrane layer in sub. (5) does not apply to composite lined phases of existing landfills which have completed final cover placement by July 1, 1996.

(d) Landfills which accept papermill sludges or other industrial solid wastes with high water contents and low strength may propose alternate final cover systems if the strength of the waste mass will not allow for the construction of the cover system required in this section.

(2) **GRADING LAYER.** A minimum 6 inch thick grading layer shall be designed over the final waste elevation of landfills proposing to accept municipal solid waste to attain the required slope and provide for a stable base for subsequent system components. Daily and intermediate cover may be used for this purpose.

(3) **SUPPORT LAYER FOR LOW-STRENGTH WASTES.** A support layer shall be designed for stabilization, reinforcement and removal of leachate and gas over the final waste elevations for landfills which accept industrial solid wastes with high water contents and low strength.

(4) **CLAY CAPPING LAYER.** A minimum 2 foot thick clay cap shall be designed to provide a low hydraulic conductivity barrier to percolation. Clay used for this layer shall meet the specifications in s. NR 504.06 (2) (a). The clay capping layer shall be constructed according to s. NR 504.06 (2) (f). Final cover systems that are required to include a geomembrane layer may be designed with the following alternatives to the clay component of the composite capping layer:

(a) The clay component of the capping layer may be replaced by a GCL overlying a minimum of 2 feet of soil barrier layer. This GCL layer and the soil barrier layer shall meet the following material and construction specifications:

1. The GCL shall consist of a layer of sodium bentonite clay encapsulated between 2 geotextiles.

2. The GCL shall be covered with a geomembrane the same day that it is unpacked and placed in position. The GCL may not be installed in standing water or during rain. The GCL shall be dry when installed and covered. A GCL exhibiting unconfined swelling shall be removed and replaced.

3. The GCL shall be installed in a relaxed condition and shall be free of tension or stress upon completion of the installation. The GCL may not be stretched to fit.

4. Adjoining panels of a GCL shall be laid with a minimum of 6 inches of overlap on the longitudinal seams and a minimum 20 inches of overlap on the panel end seams.

5. Irregular shapes, cuts or tears in the installed GCL shall be covered with a GCL patch that provides a minimum 12 inch overlap onto adjacent GCL surfaces.

6. A seal of loose bentonite granules shall be placed in seam overlaps at a minimum rate of one quarter pound per linear foot of seam for all panel end seams and longitudinal seams. The seal of loose bentonite may be deleted, with concurrence by the department, for longitudinal seams where the manufacturer has processed the overlap area to enhance sealing. The seal may not be deleted for any longitudinal seams that are transitions between construction phases.

7. Loose bentonite or bentonite amended soil shall be placed at all patches and penetrations.

8. GCL panels shall be certified needle-free through magnetic and metal detection tests.

9. The GCL shall be placed in direct contact with a soil barrier layer.

10. Vehicle traffic on the subgrade of the GCL and on the GCL shall be restricted to the minimum weight and number of machines needed to deploy the GCL and geomembrane. Vehicles shall be operated to minimize the formation of ruts and surface

deformations and to prevent damage to the GCL and geomembrane. Deployment methods shall be selected to prevent any tearing or combing out of fibers of the GCL.

11. Soil cover placement over the geosynthetics shall be completed in the same construction season as the geosynthetic construction.

12. The soil barrier layer shall consist of fine-grained soil or a well graded sandy soil with fines, meeting the USCS soil types ML, CL, CH, SM, or SC or dual-symbol classifications of these soils, with at least 25% by weight passing the P200 sieve size. The upper one foot shall have a maximum particle size of 2 inches or less. The lower one foot shall have a maximum particle size of 4 inches or less.

13. The soil barrier layer shall be compacted in lift heights of no greater than 12 inches after compaction using footed compaction equipment with feet at least 6 inches long. Each lift shall be disked or otherwise mechanically processed prior to compaction to break up clods and allow for moisture content adjustment. Clod size shall be no greater than 4 inches.

14. A sufficient number of passes of the compaction equipment shall be made over each lift to ensure complete remolding of the soil. All compaction equipment utilized shall have a minimum static weight of 30,000 pounds. Compaction equipment with static weight that exceeds 15,000 pounds may be utilized where it utilizes vibration to achieve dynamic compaction that exceeds 30,000 pounds of compaction energy. Lighter equipment may be used in small areas where it is not possible to use full size equipment. Alternative procedures or equipment may be proposed for approval by the department.

15. All soil shall be compacted to 90% modified or 95% standard Proctor density or greater at a moisture content at or wet of optimum. As soil placement proceeds, the minimum density and moisture content targets shall be adjusted as necessary.

16. Each lift shall be keyed into clay or soil barrier layer soils in adjacent phases to form a continuous seal. This shall be accomplished by excavating steps with a minimum width of 2 feet along the edge of the existing phase and overlapping them with lifts being placed for the new phase. A minimum of 2 steps shall be included.

17. The surface of the top lift shall be graded or compacted to be smooth and firm and shall be inspected for removal of coarse gravel, cobbles and debris prior to placement of a GCL.

(b) For industrial solid waste landfills that predominantly accept compressible wastes or wastes with high water contents and low strength, the clay layer may be replaced by a GCL overlying a minimum of a one foot sand layer. The gradation of the sand layer shall be a uniform sand selected to vent gas, drain leachate and provide hydration water to the GCL.

(c) For industrial solid waste landfills that predominantly accept ash, the clay layer may be replaced by a GCL overlying a minimum of 2 feet of soil barrier layer. The soil barrier layer shall meet the requirements of par. (a) 13. to 17. The upper foot of soil barrier layer shall also meet the requirements of par. (a) 12. The lower foot shall be designed to provide a capillary break between the ash and the upper one foot of soil barrier layer.

(d) The lower one foot of the clay layer may be replaced with a minimum of one foot of foundry green sand system sand with a bentonite content of greater than 6%, a liquid limit of greater than 20, a plasticity index of greater than 6, and a hydraulic conductivity of less than 1×10^{-7} cm/sec. The green sand system sand shall be compacted to 90% modified or 95% standard Proctor density or greater at a moisture content at or wet of optimum.

(5) **GEOMEMBRANE LAYER.** A geomembrane layer shall be designed to provide a low hydraulic conductivity barrier to percolation. The design and construction of the geomembrane component of the final cover system shall meet the requirements of s. NR 504.06 (3) (c) to (j) and the following:

(a) The nominal geomembrane thickness shall be 40 mils or greater, with no thickness measurements falling below industry accepted manufacturing tolerances.

(b) The geomembrane shall be installed in direct contact with the clay capping layer.

(c) Penetrations of the geomembrane, such as gas extraction wells, shall be fitted with prefabricated collars of pipe and membrane or plate and welded at the same angles which the penetrations make with the final cover slope. Methods of fixing membrane boots to vertical pipes extending above the geomembrane shall allow for differential settlement of the waste with respect to the piping without damage to the membrane seal.

(6) DRAINAGE AND ROOTING ZONE LAYER. A minimum 2.5 foot thick drainage and rooting zone layer shall be designed above the geomembrane layer or clay capping layer. This layer shall include a rooting zone to provide additional rooting depth for vegetation and to protect the geomembrane layer or the clay capping layer from freeze-thaw damage and other environmental effects. It shall also include a drainage layer to allow for the drainage of liquid infiltrating through the cap. Soils available on or near the proposed landfill property may be proposed for the rooting zone portion of this layer. This layer may not be densely compacted.

(a) For all landfills, a drainage layer shall be designed immediately above the capping layer. The drainage layer shall consist of a minimum of one foot of sand with a minimum hydraulic conductivity of 1×10^{-3} cm/sec or a geosynthetic drain layer of equivalent or greater flow capacity. The design shall include an analysis which demonstrates whether the maximum head in the drain layer will be confined within the thickness of the drain. Drain calculations shall include infiltration rates based on saturated characteristics of the topsoil and rooting zone and a hydraulic gradient of one through the topsoil and rooting zone.

(b) A perimeter drain pipe shall be placed at the low end of all final cover sideslopes. The drain pipe shall be surrounded by a minimum of 6 inches of gravel or sand with a minimum hydraulic conductivity of 1×10^{-2} cm/sec. The drain pipe shall be sloped to a series of outlets at spacings no further than every 200 feet. Modeling may be submitted to the department which supports the proposal of a different spacing.

(7) TOPSOIL. A minimum of 6 inches of topsoil shall be designed over the cover layer to support the proposed vegetation. Fertilizer and lime shall be added in accordance with section 630, Wisconsin department of transportation standard specifications for road and bridge construction or other appropriate specifications in order to establish a thick vegetative growth.

(8) REVEGETATION. The seed type and amount of fertilizer applied shall be proposed depending on the type and quality of topsoil and compatibility with both native vegetation and the final use. Unless otherwise approved by the department in writing, seed mixtures and sowing rates shall be those specified for right-of-ways according to section 630, 2003 edition of the Wisconsin department of transportation standard specifications for highway and structure construction and the 2004 supplemental specifications. Application rates for fertilizer and mulch shall also be specified.

Note: The 2003 edition of the Wisconsin department of transportation standard specifications for highway and structure construction and any annual supplemental specifications are available at <http://www.dot.wisconsin.gov/business/engserv/procedures.htm> or can be obtained from the department of natural resources, bureau of waste management, 101 S. Webster Street, P.O. Box 7921, Madison, WI 53707-7921, (608) 266-2111, waste.management@dnr.state.wi.us. Copies are also available for inspection at the offices of the legislative reference bureau and the secretary of state.

(9) FINAL USE. The proposed final use shall be compatible with the final cover system. The following activities are prohibited at solid waste disposal landfills which are no longer in operation unless specifically approved by the department in writing.

(a) Use of the waste disposal area for agricultural purposes.

(b) Establishment or construction of any buildings over the waste disposal area.

(c) Excavation of the final cover or any waste materials.

History: Cr. Register, January, 1988, No. 385, eff. 2-6-88; am. (1) (a), (b), (2), cr. (1) (c), (d), (5), (6) (a), (b), r. and recr. (3), (4), r. (5) (a) to (c), renum. (5) to (6) to (9) and am. (6) (intro.), (7), (9) (intro.), (a), (b), Register, June, 1996, No. 486, eff. 7-1-96; CR 04-077: am. (6) (a) Register November 2005 No. 599, eff. 12-1-05; CR 05-020: r. and recr. (4), am. (8) Register January 2006 No. 601, eff. 2-1-06.

NR 504.075 Soil borrow sources. (1) GENERAL. This section applies to all soil borrow sources developed for the purpose of constructing, operating or closing landfills. Written approval from the department shall be obtained prior to initiating soil borrow activities at any borrow source subject to these requirements.

(2) EXEMPTIONS. (a) The following activities are exempt from the requirements of this section:

1. Production of processed aggregate products.

2. Excavation of soils from construction projects off of the landfill property, provided the soils will be used for purposes other than a compacted clay liner or capping layer, soil barrier layer, leachate collection layer or final cover drain layer.

(b) Soil borrow sources which are exclusively within the proposed or approved limits of filling for a landfill or areas where soils are obtained from excavation projects developed primarily for purposes other than construction, operation or closure of a landfill are not subject to the requirements of subs. (3) and (4) (b).

(3) INITIAL SITE INSPECTION. An initial site inspection shall be conducted in accordance with s. NR 509.04 for each proposed soil borrow source.

(4) LOCATIONAL INFORMATION. (a) Submittals for soil borrow sources shall include a description of total acreage, ownership, location by quarter - quarter section and by parcel corner using a coordinate system and datum acceptable to the department, present land uses, transportation routes, any access restrictions and travel distance to and from the landfill.

(b) Submittals for soil borrow sources shall include site-specific surface water drainage patterns and significant hydrologic features such as surface waters, springs, drainage divides and wetlands; areas of special natural resource interest; and historical or archaeological areas within and adjacent to the proposed limits of excavation.

(5) FIELD AND LABORATORY INVESTIGATIONS FOR CLAY BORROW SOURCES AND SOIL BARRIER LAYER SOURCES. Submittals for soil borrow sources shall include field and laboratory investigations to define the physical characteristics of any clay borrow source or soil barrier layer source designated to be used for a liner or final cover for the landfill. An alternative geotechnical investigation program may be used if it is approved by the department in writing prior to performing the field and laboratory investigations. An alternative geotechnical investigation program may be submitted in cases where previous information exists regarding the proposed soil borrow source. Submittals for soil borrow sources shall include justification for any reduction in sampling or testing frequency required by this section or by an approved alternative geotechnical investigation.

(a) A minimum of 10 test pits or borings for the first 5 or less acres and one test pit or boring for each additional 3 or less acres shall be excavated or drilled on a uniform grid pattern across each proposed borrow source to document the depth, lateral extent and uniformity of the clay or soil barrier layer. The department recommends using test pits as the method of borrow source investigation. Logs identifying the geologic origin, testing results, USCS classification and a visual description of each major soil unit encountered shall be included with the submittals for soil borrow sources.

(b) A minimum of 2 representative samples from each test pit or boring shall be analyzed by a soils laboratory for Atterberg limits and grain size distribution to the 0.002 millimeter particle size using mechanical and hydrometer methods. Each sample shall be classified according to the USCS.

(c) A minimum of one representative sample from each major soil unit shall be tested for the relationship of water content to dry density using either the modified or standard Proctor method. For uniform clay deposits or uniform soil barrier layer source deposits, no fewer than 3 samples shall be tested. Each Proctor curve shall be developed with a minimum of 5 points. If the line of optimums method is anticipated to be used in construction, both the standard and modified Proctor curves shall be developed for each representative sample.

(d) A minimum of one laboratory hydraulic conductivity test shall be conducted on each sample used to develop the Proctor curves. The samples tested shall be at or above the optimum moisture content. This requirement does not apply if the soil borrow source is contiguous with a previously approved borrow source for clay or soil barrier layer soils and all field observations and laboratory test results support an interpretation that the soil borrow source occupies the same soil horizon and has the same genesis as the previously approved borrow source. Support for such a conclusion shall be provided in the submittals for soil borrow sources.

(6) **STOCKPILING.** Stockpiling of soils obtained from clay borrow sources and soil barrier layer sources for landfill liner or final cover construction shall be conducted in an organized manner that minimizes mixing of dissimilar soil types. Soils shall be segregated into stockpiles based on similar USCS soil type, soil gradation, Atterberg limits and compaction specifications. Soils from differing sources may not be commingled unless soil properties are similar.

(7) **DATA PRESENTATION FOR ALL CLAY BORROW SOURCES AND SOIL BARRIER LAYER SOURCES.** Submittals for soil borrow sources for clay and soil barrier layers shall include all of the following:

- (a) The calculated volume of soil needed and the volume of acceptable soil available.
- (b) Property boundaries and any test pit or boring locations, shown on a topographic map with a scale of 1 inch = 500 feet and provided in a digital format acceptable to the department. The mapped area shall extend a minimum of 500 feet beyond the proposed borrow source.
- (c) An isopach map showing the thickness of acceptable soil.
- (d) A description of the methods to be used for separating the acceptable soil from any unacceptable soil.
- (e) A proposal for maintaining drainage and sedimentation control.
- (f) All data obtained from the testing program.

(8) **DATA PRESENTATION FOR OTHER BORROW SOURCES.** Submittals for soil borrow sources other than those used for clay and soil barrier layers shall include all of the following:

- (a) Property boundaries shown on a topographic map with a scale of 1 inch = 500 feet and provided in a digital format acceptable to the department. The mapped area shall extend a minimum of 500 feet beyond the proposed borrow source.
- (b) A proposal for maintaining drainage and sedimentation control.

(9) **STORMWATER MANAGEMENT.** Submittals for soil borrow sources shall include a stormwater management plan that complies with the requirements of s. NR 504.09 (1) (a) to (f) and (h) to (j), unless the borrow source is subject to other permits with equivalent authority and requirements, such as a stormwater discharge permit or non-metallic mining reclamation permit.

(10) **RECLAMATION OF BORROW SITES.** Submittals for soil borrow sources shall include a reclamation plan detailing the actions to be taken to achieve successful reclamation of the borrow source.

(a) Reclamation plans for borrow sources on the property where the landfill is located shall specify a post-mining land use that is integrated with the existing and proposed drainage, surface water discharge requirements, grades and final use of the landfill. The reclamation plan shall be prepared consistent with the applicable standards in ss. NR 135.06 to 135.12.

(b) Soil borrow areas that are not on the landfill property are subject to the provisions of ch. NR 135 and, if required, shall submit a reclamation plan and obtain a nonmetallic mining reclamation permit from the appropriate regulatory authority.

(11) **OTHER REQUIREMENTS.** (a) Clay borrow sources and soil barrier layer sources proposed for a liner or final cover that have less than a 5 foot but greater than 2 foot uniform thickness may be approved if the applicant demonstrates an excavation methodology and a documentation procedure to ensure that all soil used meets soil index properties required by this chapter.

(b) Submittals for soil borrow sources shall include a description of any necessary measures to be taken to comply with wetlands protection requirements, runoff and sediment controls and surface water discharge permit requirements and to minimize effects on areas of special natural resource interest and historical or archaeological areas within and adjacent to the proposed limits of excavation.

Note: It may be necessary to obtain federal, state or local permits prior to excavating soil from a borrow source near surface waters or wetlands. For example, s. 30.19 (1g) (c), Stats., requires a permit for grading or removing top soil from the bank of any navigable stream, lake or body of navigable water where the area exposed by such grading or removal will exceed 10,000 square feet. It is the responsibility of the applicant or property owner to obtain any federal, state or local permits that are required and to provide reference to those other permit applications in the submittals for soil borrow sources.

History: CR 05-020: cr. Register January 2006 No. 601, eff. 2-1-06.

NR 504.08 Minimum design and construction criteria for landfill gas extraction systems. (1) **GENERAL.** All landfills accepting wastes with the potential to generate gas shall be designed to prevent the migration of explosive gases generated by the waste fill.

(2) **ACTIVE GAS EXTRACTION AND TREATMENT.** In order to efficiently collect and combust hazardous air contaminants, all landfills which accept municipal solid waste shall be designed with an active gas recovery system. All gas recovery systems shall include the following design features, unless otherwise approved by the department:

- (a) Vertical gas extraction wells shall be proposed throughout the entire landfill with a maximum radius of influence of 150 feet per well and lesser radii proposed for wells located near the perimeter of the landfill. The radii of influence of adjacent wells shall overlap. Alternate well spacings may be proposed if site specific data is obtained through performance of pump tests.
- (b) All vertical gas extraction wells shall extend to 10 feet above the leachate collection system and shall be placed in 36 inch diameter boreholes. An exemption may be proposed to allow for placement of gas extraction wells closer to the leachate collection system.
- (c) The pipe in the borehole shall be a minimum 6 inch diameter, Schedule 80 polyvinylchloride or an approved alternate.
- (d) The lower 2/3 to 3/4 of the pipe in the borehole shall be slotted or perforated pipe.
- (e) The backfill around the slotted or perforated pipe in the borehole shall be one to one and 1/2 inch washed stone. The top 10 feet of the borehole shall be sealed.
- (f) Each gas extraction well shall have a flow control valve and sampling access port.
- (g) The gas header system shall be looped to allow alternative flow paths for the gas.
- (h) The minimum slope on the header pipe shall be 2% for pipes over the waste mass.
- (i) Polyethylene pipe shall be used for header and lateral pipes.

(j) The sizing of the blower, header and laterals shall ensure that a minimum vacuum of 10 inches water column is available in the header adjacent to those wells located furthest from the blower.

(k) A drip leg or equivalent shall be installed immediately before the blower to separate condensate from gas while preserving the suction at the wells while under maximum operating vacuum.

(L) All condensate transfer piping and gas transfer piping located outside of the limits of waste shall be designed to be fully encased in at least 2 feet of clay, double-cased pipe or by using another approved secondary containment method except for systems with multiple drip legs within the landfill where the bulk of the condensate has been removed.

(m) The system shall be designed to have the ability to collect and treat all condensate, measure volumes and collect samples.

(n) A flare shall be designed to meet the requirements of ch. NR 445.

(3) GAS MONITORING WELLS. A minimum of one gas monitoring well shall be located on each side of the landfill. The wells shall be constructed according to s. NR 507.11.

(4) PASSIVE GAS EXTRACTION SYSTEMS. Landfills which accept only industrial waste or other nonmunicipal solid waste with the potential to generate gas and which do not utilize an active gas extraction system shall be designed with a system which allows gas venting from the entire landfill surface. An analysis shall be performed to determine the spacing needed between gas venting trenches for an effective system and also to ensure that ch. NR 445 limits for hazardous air contaminants will not be exceeded. The system shall be designed with a continuous layer below the capping layer which allows surficial venting from the waste final surface. This layer may be part of the support layer required in s. NR 504.07 (3). This layer shall consist of a minimum of one foot of granular soil with a minimum hydraulic conductivity of 1×10^{-3} cm/sec and a series of flexible, perforated pipes connected to a series of outlets.

History: Cr. Register, May, 1992, No. 437, eff. 6-1-92, r. and recr., Register, June, 1996, No. 486, eff. 7-1-96; CR 05-020: r. (2) (e) Register January 2006 No. 601, eff. 2-1-06.

NR 504.09 Storm water management and miscellaneous design and construction criteria for landfills.

(1) STORM WATER MANAGEMENT. (a) Storm water drainage ditches, structures and sedimentation basins shall be designed such that the construction of these items shall occur during the initial stage of construction to control rainfall runoff and limit entrained sediment from reaching surface water bodies.

(b) All landfills shall incorporate the following concepts in the design of both temporary and permanent erosion and sediment control measures:

1. Grading and construction shall be scheduled to minimize soil exposure.
2. Existing vegetation shall be retained whenever feasible.
3. Disturbed areas shall be vegetated and mulched.
4. Runoff shall be diverted away from disturbed areas and active fill areas.
5. Runoff velocities shall be minimized.
6. Drainageways and outlets shall be prepared to handle concentrated or increased runoff.
7. Sediment shall be trapped on site.
8. Runoff control structures shall be inspected and maintained.

(c) The design calculations required in pars. (d), (e) and (f) shall each be performed for the period in the landfill's development where the combination of surface conditions and contributing acreage would result in the greatest runoff volume.

(d) All temporary and permanent storm water drainage ditches, swales, conveyance channels, channel linings, outlet protection, culverts and other storm water control structures handling flow onto or off the landfill shall be designed to accommodate peak flow rates from a 25 year, time of concentration storm event.

(e) Temporary and permanent sediment control measures shall be designed to settle 0.015 mm size particles for all storms up to and including the 25 year, 6-hour storm. The surface area for sediment basins shall be calculated using the rainfall intensity over the 25 year, 6-hour storm event for the landfill. Principal spillways, and outlet protection for sediment basins shall be designed to pass a 25 year, time of concentration storm event. Emergency spillways for sedimentation basins shall be designed to pass a 100 year, time of concentration storm event. The design of the dewatering structures for sediment basins shall be selected such that the basin is dewatered in no less than 3 days. An analysis shall be performed to document compliance with this requirement.

(f) Storm water shall be diverted away from the active fill area of the landfill and any borrow areas to a sedimentation control structure.

(g) Containment berms placed around active fill areas shall be designed to control and collect the liquid volume resulting from the 25 year, 24-hour storm event. The design shall consider the volume of liquid generated from active fill areas which shall include areas with exposed solid waste or areas with waste covered by daily cover. Storm water in contact with active fill areas shall be handled and treated as leachate in accordance with ch. NR 506.

(h) Storm water drainage ditches, structures and sedimentation basins shall discharge along existing drainage patterns capable of accepting the anticipated flow volume. An analysis shall be performed to determine the amount and velocity of runoff prior to landfill development and to document compliance with this requirement.

(i) Storm water diversion and construction at a landfill shall be designed to minimize impacts on adjacent property, such as erosion, sedimentation and flooding.

(j) Design of all storm water management features shall comply with other applicable requirements of the department. Such requirements include, but are not limited to, ch. NR 103, and permits required by ch. 30, Stats.

(2) MISCELLANEOUS. All landfills shall be designed to meet the following requirements:

(a) A method of controlling any dust or windblown debris shall be included in the landfill design. The factors which will be considered by the department when evaluating alternative provisions for controlling dust and windblown debris includes the remoteness of the landfill, natural screening, windbreaks and waste types.

(b) Access to the landfill shall be restricted through the use of fencing, natural barriers or other methods approved in writing by the department.

(c) All access roads for the landfill, including those leading to the active area, shall be designed for all weather operation.

(d) All access roads which are used by over the highway vehicles shall be designed with a maximum grade no greater than 10%. The intersection of the landfill access road with an existing highway shall be designed to provide sufficient sight distance and minimum interference with traffic on the highway.

(f) A minimum separation distance of 100 feet shall be maintained between the limits of filling and adjacent property line. A minimum distance of 50 feet shall be maintained between any permanent berms or excavations associated with the landfill, excluding storm water diversion structures and the adjacent property line.

(g) The landfill shall be designed so that final grades in each phase are reached as soon as possible, and the open area used for refuse filling is minimized.

(h) The final slopes of all landfills shall be equal to or greater than 5%, but may not exceed 4 horizontal to one vertical. Landfills primarily designed for the acceptance of papermill or wastewater treatment plant sludge shall have final slopes no greater than 6 horizontal to one vertical.

(i) A minimum of 2 leachate head wells shall be proposed for each major horizontal phase of the landfill unless otherwise approved by the department.

(j) All landfills which accept municipal solid waste shall be supplied with a weight scale.

(k) All landfills shall be designed with properly protected permanent benchmarks for horizontal and vertical control. Elevations shall be tied to USGS datum and horizontal control shall be referenced to the property boundary.

History: Cr. Register, June, 1996, No. 486, eff. 7-1-96; am. (1) (e), Register, September, 1998, No. 513, eff. 10-1-98; CR 05-020: r. (2) (e) Register January 2006 No. 601, eff. 2-1-06.

NR 504.095 Design criteria for landfills that recirculate leachate. (1) **GENERAL.** Leachate recirculation systems shall be designed to meet the following requirements:

(a) Leachate recirculation shall be limited to municipal solid waste landfills that are designed with a composite liner and leachate collection system meeting the minimum requirements of s. NR 504.06.

(b) Leachate recirculation shall be limited to areas of the landfill where the leachate collection drainage blanket has a hydraulic conductivity of 1 cm/sec or greater. The department may approve leachate recirculation in existing cells with lower permeability leachate collection blankets, provided that the operator can demonstrate that the maximum leachate head on the liner can be maintained at less than 12 inches and that the recorded leachate head has not exceeded 12 inches in the past.

(c) Leachate shall be recirculated only in areas of the landfill which are connected to the active gas extraction systems and are capable of collecting the additional gas expected to be generated. Active gas extraction shall commence in those areas no later than the initiation of leachate recirculation.

(d) Leachate recirculation distribution systems may not discharge leachate within 100 lateral feet of the exterior sideslope final grades unless otherwise approved by the department in writing.

(e) A minimum depth of 20 feet of waste shall be maintained between the landfill base and lowest point of leachate distribution.

(f) Operating controls and instructions for leachate recirculation distribution systems shall be prepared to apply to operations expected to be encountered in all weather and seasons. Instructions shall include cessation of leachate recirculation upon discovery of seeps and other surface expressions of recirculated leachate, excessive pressures within the waste mass, saturated conditions in the waste mass, inadequate shear strength of the waste mass or other conditions indicative of instability.

(2) **SURFACE APPLICATION.** In addition to the general requirements, surface application systems for leachate recirculation shall meet the following requirements:

(a) The leachate distribution system shall be designed so that leachate is not introduced into the waste in a manner that causes ponding or surface runoff of leachate. Open surface trenches or ponds shall not be utilized.

(b) The leachate distribution system shall be designed to minimize evaporation of the leachate and volatilization of compounds in leachate. The leachate distribution system shall be designed to distribute the leachate in a manner that results in its absorption into the waste mass after application. Spray irrigation systems that are designed to promote evaporation may not be utilized.

(3) **VERTICAL DISTRIBUTION SYSTEMS.** Vertical distribution systems for leachate recirculation shall meet the following requirements:

(a) Wells designed solely for the gas extraction system shall not be used for leachate recirculation.

(b) Vertical distribution systems shall utilize vertical wells placed into the waste mass. Distribution well design need not comply with the requirements of s. NR 504.08 (1) or ch. NR 141 or 812. Well spacing shall be determined based on leachate flow rates, pumping characteristics, permeability of the waste mass, and ability of the waste to accept liquid without being pressurized.

(c) Leachate distribution wells shall be designed with a surface seal to control odors and landfill gas.

(d) Pumping pressures and pumping intervals for distribution wells shall be designed to prevent surface emergence of leachate. Pumping pressures and hydrostatic pressures shall be limited to prevent excessive pressures to prevent separation of waste layers or short-circuiting of leachate to the leachate collection system.

(e) The leachate distribution system shall be designed to achieve a uniform distribution of leachate throughout the zone of influence of the wells.

(f) Leachate distribution wells may be designed to also extract landfill gas.

(4) **HORIZONTAL DISTRIBUTION SYSTEMS.** Horizontal distribution systems shall meet the following requirements:

(a) The leachate distribution piping shall be designed to distribute the leachate consistently along its length.

(b) Distribution systems shall be designed with a permeable bedding material that is capable of rapidly dissipating recirculated leachate into the waste mass.

(c) Distributions systems shall be designed with bedding material which is capable of maintaining its structure and characteristics during the expected operational life of the system.

(d) Distribution systems shall be designed to operate with specific distribution periods with landfill gas extracted in the interval between those distribution periods, unless otherwise approved by the department in writing. The length of the leachate distribution periods and the intervals of gas extraction shall be determined in a manner that minimizes uncontrolled landfill gas emissions.

(e) Pumping pressures and pumping intervals shall be designed to prevent surface emergence of leachate. Pumping pressures shall be limited to prevent excessive pressures to prevent separation of waste layers or seeps or other leachate discharges.

History: CR 04-077: cr. Register November 2005 No. 599, eff. 12-1-05; CR 06-026: am. (1) (d) and (2) (b), Register December 2006 No. 612, eff. 1-1-07.

NR 504.10 Alternative design criteria for landfills accepting high volume industrial wastes. This section applies to landfills designed principally for high volume industrial waste, wood residue and minor amounts of other wastes as approved by the department. This section applies to all new landfills and to the expansion of existing landfills for which the plan of operation was approved after February 1, 1988. This section also applies to new and existing CCR landfills and lateral expansions of a CCR landfill.

(1) **GENERAL.** (a) An applicant may design a high volume industrial waste landfill to meet the standards contained in ss. NR 504.05 to 504.09 or may propose an alternative design in accordance with the provisions of this section.

(b) If the applicant does not complete construction of the first major phase of the landfill within 2 years from the date of the plan of operation approval, the applicant shall reapply to the department for approval to construct the landfill. This application does not constitute a feasibility report as defined in s. 289.24, Stats. The department may require additional conditions of approval

and require redesign of the landfill in accordance with state-of-the-art design criteria.

(c) An owner or operator of a landfill which is designed primarily for disposal of high volume industrial waste may accept up to 10% by weight of municipal waste such as packaging which is generated in conjunction with the manufacturing process, and not be subject to the design requirements of s. NR 504.05 (1). Household and plant waste not generated as a direct result of the manufacturing process such as office and cafeteria waste, may not be disposed of in a landfill which does not meet the requirements of s. NR 504.05 (1).

(2) **DESIGN CAPACITY.** Design capacity shall be in accordance with s. NR 504.05 (3).

(3) **DESIGN CRITERIA.** An applicant seeking approval of an alternative design under this section shall demonstrate in the feasibility report required in ch. NR 512 that the alternative design adequately protects public health, welfare and the environment and meets or exceeds the location and performance standards of s. NR 504.04. The applicant may include the following types of information as a part of such a demonstration:

(a) Landfill characteristics including regional and specific information on land use, geology, hydrology, hydrogeology and soils.

(b) Waste characteristics including quantity and physical and chemical analyses of the waste and its leachate.

(c) An analysis of any design to control geologic or hydrogeologic conditions of the site.

(d) Field demonstration data.

(e) Design and performance data for other similarly designed and constructed landfills.

(f) Accepted scientific or engineering analyses or field studies, field plots, research, manufacturer's data or demonstrations.

(g) For new and existing CCR landfills and any lateral expansion of a CCR landfill, a demonstration that the alternative design meets the federal requirements located under 40 CFR part 257, Subpart D dated April 17, 2015 (80 FR 21468), as amended at 83 FR 36451, July 30, 2018.

Note: The code of federal regulations may be obtained at www.ecfr.gov. Copies of 40 CFR part 257, Subpart D dated April 17, 2015 (80 FR 21468), as amended at 83 FR 36451, July 30, 2018 are available for inspection at the legislative reference bureau.

(4) **APPROVAL CRITERIA.** The department shall approve the alternative design proposed by the applicant if the department determines to a reasonable degree of certainty that the alternative design adequately protects public health, welfare and the environment and meets or exceeds the location and performance standards of s. NR 504.04.

History: Cr. Register, June, 1996, No. 486, eff. 7-1-96; CR 21-076: am. (intro.), cr. (3) (g) Register July 2022 No. 799, eff. 8-1-22.

NR 504.11 Minimum design and construction criteria for landfills accepting residue produced by burning municipal solid waste. (1) **APPLICABILITY.** This section applies to landfills designed for residue produced by the burning of municipal solid waste as approved by the department. This section applies to all new and existing landfills.

(2) **LANDFILL DESIGN CRITERIA FOR RESIDUE PRODUCED BY BURNING MUNICIPAL SOLID WASTE.** (a) All landfills that accept municipal solid waste combustor residue that tests below the limits specified in s. NR 502.13 (6) (g) shall be designed as composite lined monofill cells according to the following criteria:

1. The composite liner shall consist of a minimum 60 mil geomembrane overlying a minimum thickness of 4 feet of compacted clay meeting the specifications of s. NR 504.06.

2. The leachate collection system shall be designed such that the leachate from the residue monofill cell can be sampled and collected separately from non-residue disposal areas.

3. The department may approve alternate designs such as double liners if it finds that the design provides equivalent protection.

(b) All landfills that accept municipal solid waste combustor residue that exceeds the limits specified in s. NR 502.13 (6) (g) shall be designed as a double composite lined monofill cell according to the following criteria. The department may approve alternate designs if it finds that the design provides equivalent protection.

1. The double composite liner shall be designed with 2 separate composite liners with each liner consisting of a minimum 60 mil geomembrane overlying a minimum thickness of 4 feet of compacted clay meeting the specifications of s. NR 504.06.

2. The composite liners shall be separated by a leachate detection layer consisting of a minimum one foot layer of granular material.

3. Separate leachate collection systems shall be designed above and between the composite liners. The leachate collection system shall be designed such that the leachate from the leachate detection layer can be sampled and collected separately from the upper leachate collection system and from the non-residue disposal areas.

(c) All landfills which accept municipal solid waste combustor residue shall be approved by the department in accordance with s. NR 514.07 (5) prior to accepting each specific residue waste stream.

History: Cr. Register, June, 1996, No. 486, eff. 7-1-96.

NR 504.12 Minimum design and construction criteria for CCR landfills. (1) **APPLICABILITY.** In addition to ss. NR 504.04 to 504.10, applicable to all landfills or landfills accepting high volume industrial waste, this section includes design criteria that are applicable to the construction of a new or existing CCR landfill or a lateral expansion of a CCR landfill.

(2) **RUN-ON AND RUN-OFF CONTROLS.** An existing or new CCR landfill or any lateral expansion of a CCR landfill shall be designed, constructed, operated, and maintained with a run-off and run-on control system in accordance with the requirements under s. NR 504.09 (1) (f) and (g) and all of the following:

(a) A run-on control system shall prevent flow onto the active portion of the CCR landfill during the peak discharge from a 24-hour, 25-year storm.

(b) A run-off control system from the active portion of the CCR landfill shall collect and control, at a minimum, the water volume resulting from a 24-hour, 25-year storm.

(3) **LINER DESIGN.** (a) A new CCR landfill or a lateral expansion of a CCR landfill shall be designed, constructed, operated, and maintained with a composite liner that meets the requirements under s. NR 504.06 (2) and (3) and a leachate collection and removal system that meets the requirements under s. NR 504.06 (5). The composite liner shall consist of 2 components; the upper component shall consist of a nominal 60-mil or thicker geomembrane liner, and the lower component shall consist of a minimum 4-foot-thick layer of compacted clay. A GCL and soil barrier may be used in place of the clay layer of a composite liner in accordance with s. NR 504.06 (7). In addition to the minimum design and construction criteria for landfill liners and leachate collection systems under s. NR 504.06, the liner and leachate collection system shall meet all of the following:

1. The leachate collection and removal system shall be designed, constructed, operated, and maintained to limit the leachate head level on the liner to one foot or less.

2. The leachate collection and removal system shall be constructed of materials that exhibit all of the following properties:

a. Chemically resistant to the CCR and any non-CCR waste managed in the CCR landfill and the leachate expected to be generated.

b. Of sufficient strength and thickness to prevent collapse under the pressures exerted by overlying waste, waste cover materials, and equipment used at the CCR landfill.

3. The leachate collection and removal system shall be designed and operated to minimize clogging during the active life and during the long-term care of the landfill.

4. The geomembrane component of the liner shall be installed in direct and uniform contact with the compacted clay soil component.

5. A liner that utilizes a GCL and soil barrier layer in accordance with s. NR 504.06 (7) shall be designed to have a liquid flow rate no greater than the liquid flow rate through 2 feet of compacted soil with a hydraulic conductivity of 1×10^{-7} cm/sec. The liquid flow rate comparison shall be made using the following equation, which is derived from Darcy's Law for gravity flow through porous media:

$$Q/A = q = k (h/t + 1)$$

Where:

Q = flow rate (cubic centimeters / second).

A = surface area of the liner (squared centimeters).

q = flow rate per unit area (cubic centimeters / second / squared centimeter).

k = hydraulic conductivity of the liner (centimeters / second).

h = hydraulic head above the liner (centimeters).

t = thickness of the liner (centimeters).

(b) A new CCR landfill or a lateral expansion of a CCR landfill shall be designed and constructed with a subbase grade that is located no less than 5 feet above the upper limit of the uppermost

aquifer, or shall demonstrate that there will not be an intermittent recurring or sustained hydraulic connection between any portion of the base of the CCR landfill and the uppermost aquifer due to normal fluctuations in groundwater elevations, including the seasonal high water table.

Note: A new CCR landfill or lateral expansion of a CCR landfill is also required to comply with s. NR 504.06 (2) (b) or (4) for zone-of-saturation landfills. The definition of an uppermost aquifer can be found under s. NR 500.03 (246m).

(c) A new CCR landfill or a lateral expansion of a CCR landfill may not be constructed over a closed CCR surface impoundment.

(4) FINAL COVER SYSTEM. (a) A new or existing CCR landfill or a lateral expansion of a CCR landfill shall be designed and constructed with a final cover system that meets the requirements under s. NR 504.07.

(b) The owner or operator of a new or existing CCR landfill or a lateral expansion of a CCR landfill may propose an alternative final cover system design within a written closure plan in accordance with s. NR 504.10 and all of the following:

1. The permeability of the final cover system shall be less than or equal to the permeability of any bottom liner system or natural subsoils present or shall be no greater than 1×10^{-5} cm/sec, whichever is less.

2. The design of the final cover system shall include an infiltration layer that achieves an equivalent reduction in infiltration as the layers specified under s. NR 504.07 (4).

3. The design of the final cover system shall include an erosion layer that provides equivalent protection from wind or water erosion as the topsoil layer specified under s. NR 504.07 (7).

4. The disruption of the integrity of the final cover system shall be minimized through a design that accommodates settling and subsidence.

History: CR 21-076: cr. Register July 2022 No. 799, eff. 8-1-22.