Coal Combustion Residuals Landfill Composite Liner Design Certification

Leland Olds Station Landfill

Prepared for
Basin Electric Power Cooperative

Prepared by
Barr Engineering Co.

September 2026

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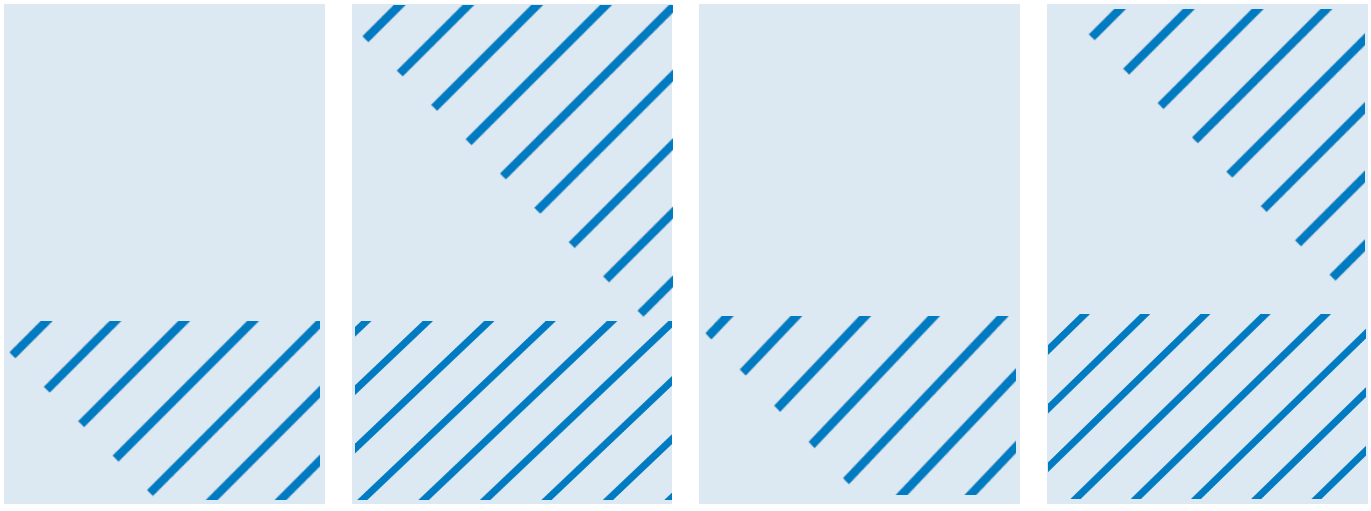
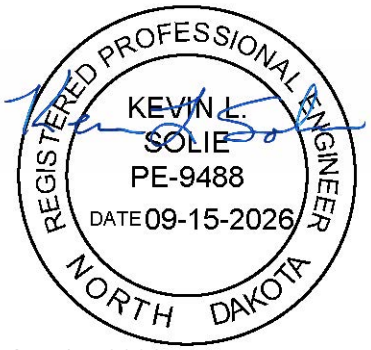


Certification

I hereby certify that I have examined the facility and, being familiar with the provisions of 40 CFR Part 257 Subpart D and North Dakota Administrative Code 33.1 Article 20, attest that this Liner Design Certification has been prepared in accordance with good engineering practice, including consideration of relevant industry standards and the requirements of the applicable rules. I further certify that I am a duly Licensed Professional Engineer under the laws of the State of North Dakota and that I have professional experience with landfill design, operation, monitoring and closure.

The services performed by Barr for this Project have been conducted in a manner consistent with the level of skill and care ordinarily exercised by other members of the profession currently practicing in this area. No other warranty, expressed or implied, is made.



Kevin L. Solie
North Dakota PE #: 9488

September 15, 2026
Date

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1 Introduction

Basin Electric Power Cooperative (Basin Electric) owns and operates Leland Olds Station (LOS), a coal-fired power plant located southeast of Stanton in Mercer County, North Dakota. The Glenharold Mine Landfill (Landfill) is located approximately three miles southwest of the generating station and office complex. The Landfill is used to dispose of coal combustion residuals (CCRs) including fly ash, bottom ash, and flue gas desulfurization (FGD) waste. The CCR Landfill is required to comply with the provisions of the US Environmental Protection Agency (EPA) CCR Rule (40 CFR Parts 257 and 261, Disposal of Coal Combustion Residuals from Electric Utilities), North Dakota Department of Environmental Quality (NDDEQ) solid waste management rules, and NDDEQ Division of Waste Management Permit 0143.

The CCR Landfill, as defined by 40 CFR § 257.53 and North Dakota Administrative Code (NDAC) 33.1-20-08-01, was permitted and began accepting CCR in 1992. Permit 0143 was modified in 2017 to facilitate the lateral expansion of the Landfill in compliance with the CCR Rule. In 2020, NDDEQ promulgated new rules affecting landfills and surface impoundments that dispose of CCRs. North Dakota Administrative Code (NDAC) Chapter 33.1-20-08 (Chapter 8) is essentially equivalent to the federal CCR Rule (40 CFR Part 257).

As Basin Electric constructs additional cells at the Landfill, the design for the leachate collection system (LCS) has been updated to omit a geotextile (filter fabric) above the sand/bottom ash granular drainage layer. The purpose of this report is to document the liner and leachate collection and removal system design for the lateral expansion at LOS meets the minimum requirements as set forth in § 270.70(a), § 257.70(b) and 270.70(d). This minor change is the only modification that is being proposed as part of this certification.

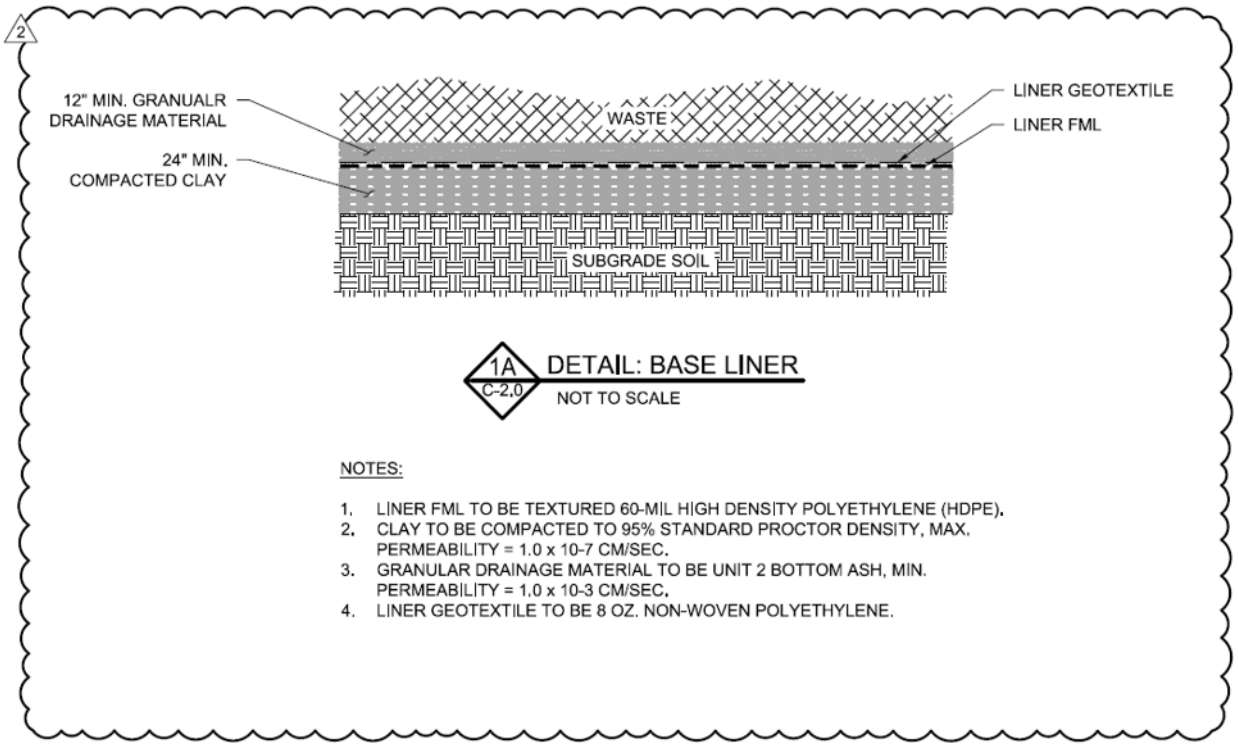
This updated composite liner and leachate collection system certification supersedes the previously issued certification dated November 20, 2017 by AECOM and certified by John Cannon. PE. This Design Certification applies to liners installed beginning in 2026.

2 Liner System Design

The Landfill composite liner system is configured as follows (from the top down for each component):

- 12-inch drainage layer
- Protective geotextile
- 60-mil high density polyethylene (HDPE) geomembrane barrier layer (Liner FML)
- 24-inch compacted soil barrier layer
- Prepared subgrade

A detail of the Landfill composite liner system is illustrated below:



3 Liner and Leachate Collection System Performance

The requirements for CCR landfill liners and leachate collection systems are provided for in § 257.70(a):

§ 257.70(a) New CCR landfills and any lateral expansion of a CCR landfill must be designed, constructed, operated, and maintained with either a composite liner that meets the requirements of paragraph (b) of this section or an alternative composite liner that meets the requirements in paragraph (c) of this section, and a leachate collection and removal system that meets the requirements of paragraph (d) of this section.

Based on the citation above, the composite liner and leachate collection and removal system design must meet the requirements 40 CFR § 257.70(b) and 40 CFR § 257.70(d); 40 CFR 257.70(c) does not apply, because no alternative composite liner is being proposed.

§ 257.70(b) - A composite liner must consist of two components; the upper component consisting of, at a minimum, a 30-mil geomembrane liner (GM), and the lower component consisting of at least two-foot layer of compacted soil with a hydraulic conductivity of no more than 1 x 10^{-7} centimeters per second (cm/sec). GM components consisting of high-density polyethylene (HDPE) must be at least 60-mil thick. The GM or upper liner component must be installed in direct and uniform contact with the compacted soil or lower liner.

The lateral expansion composite liner system includes a 60-mil HDPE geomembrane layer overlying and in direct and uniform contact with a 2-foot (minimum) compacted clay barrier layer. The clay barrier layer will be compacted and will achieve a hydraulic conductivity of no more than 1 x 10^{-7} cm/sec. The prepared subgrade will be moisture conditioned, compacted, and smooth rolled to provide a stable surface of soil

barrier layer construction. Construction quality testing will be performed in accordance with the Construction Quality Assurance Manual and documented in a construction documentation report.

Additionally, the composite liner must be:

§ 257.70(b)(1) – Constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure due to pressure gradients (including static head and external hydrogeologic forces), physical contact with the CCR or leachate to which they are exposed, climatic conditions, the stress of installation, and the stress of daily operation.

The 60-mil HDPE geomembrane component of the composite liner system meets the geomembrane liner requirements prescribed in the rule. The literature and manufacturer's data on chemical compatibility demonstrate acceptability of HDPE geomembranes for lining of CCR landfills. No geocomposite clay liner (GCL) is proposed to be used for construction, so chemical compatibility testing is not necessary.

§ 257.70(b)(2) - Constructed of materials that provide appropriate shear resistance of the upper and lower component interface to prevent sliding of the upper component including on the slopes;

The geomembrane barrier layer will be installed above stable 3 horizontal to 1 vertical side slopes (maximum). A dual-sided textured geomembrane will be utilized on the side slopes to improve stability of the geomembrane/clay interface and geomembrane/drainage layer interface. The geomembrane liner is designed to be a tensionless member with the overlying drainage materials as the interface friction angle of the geomembrane/drainage layer is smaller than the geomembrane/clay liner interface strength.

§ 257.70(b)(3) - Placed upon a foundation or base capable of providing support to the liner and resistance to pressure gradients above and below the liner to prevent failure of the liner due to settlement, compression, or uplift; and

A subsurface investigation included the drilling 10 geotechnical soil borings within and near the Landfill expansion footprint. After completion of drilling activities, a laboratory testing program that included direct shear, triaxial shear, and consolidation testing was completed on select recovered samples. Results from geotechnical drilling and laboratory testing were used to analyze the subsurface foundation soils for settlement and overall stability of base grades for the landfill. Based on the geotechnical analyses, the base for the composite liner system was determined to be capable of providing support to the liner and resistance to pressure gradients above and below the liner to prevent failure of the liner due to settlement, compression, or uplift (AECOM, 2017a). In addition, an unstable areas demonstration was prepared for the landfill expansion area in 2017 and the CCR landfill was determined to not be located in an unstable area (AECOM, 2017b).

§ 257.70(b)(4) - Installed to cover all the surrounding earth likely to be in contact with the CCR or leachate.

The composite liner system will be constructed to the top of the perimeter embankments. All ash and ash-contact surface water will be contained within the lined areas of the landfill. Each new cell will be constructed with a separation berm at the leading edge. The cell separation berm is designed to allow for attachment of new construction composite liner system to the previous phase while maintaining CCR and leachate containment in the existing cell.

Similarly, for compliance the leachate collection and removal system must be:

§ 257.70 (d)(1) Designed and operated to maintain less than a 30-centimeter depth of leachate over the composite liner or alternative composite liner;

The leachate collection system in combination with the base composite liner has been designed to collect and convey leachate from each landfill expansion cell to the collection sumps; leachate is subsequently pumped to the leachate pond. The system has been designed to limit hydraulic head on the liner system to not more than 1 foot by limiting the leachate flow distances along the base of the landfill expansion cells to a maximum of 140 feet in combination with a 2-percent minimum liner slope to the leachate collection trenches. The Hydrologic Evaluation of Landfill Performance (HELP) model was used to calculate the estimated leachate head levels for various landfill conditions (AECOM, 2017c).

§ 257.70 (d)(2) Constructed of materials that are chemically resistant to the CCR and any non-CCR waste managed in the CCR unit and the leachate expected to be generated, and of sufficient strength and thickness to prevent collapse under the pressures exerted by overlying waste, waste cover materials, and equipment used at the CCR unit;

The granular drainage layer drains leachate to the perforated leachate collection pipes installed in the leachate collection trenches. To protect the pipes from damage, to prevent migration of fine particles into the drain pipes, and to provide increased flow performance, the pipes are embedded in drainage aggregate above a geotextile or geocomposite cushion layer and covered with a fine filter aggregate or geosynthetic filter layer. The granular drainage layer also functions as a protective layer to prevent equipment from damaging the geomembrane liner. The sumps incorporate a side-slope riser pumping system to eliminate piping penetrations of the landfill liner at the base.

The leachate collection pipes on the bottom of the landfill expansion consist of 6-inch-diameter, perforated, SDR 11 HDPE pipe. The literature and manufacturer's data on chemical compatibility demonstrate acceptability of HDPE piping for CCR landfills. The leachate collection system was determined to have sufficient strength and thickness to prevent collapse under the pressures exerted by overlying waste, waste cover materials, and equipment used at the CCR unit (AECOM, 2017d).

§ 257.70 **(d)(3) Designed and operated to minimize clogging during the active life and post-closure care period.**

The leachate collection system in combination with the base composite liner has been designed to collect and convey leachate from each landfill expansion cell to the collection sumps, which is then pumped to the leachate pond. The granular drainage layer or geocomposite drains leachate to the perforated leachate collection pipes installed in the leachate collection trenches. To protect the pipes from damage, to prevent migration of fine particles into the drain pipes, and to provide increased flow performance, the pipes are embedded in drainage aggregate above a geotextile or geocomposite cushion layer and covered with a fine filter aggregate. Geotextile or geocomposite will be placed in the leachate collection pipe trenches. A layer of drainage aggregate, 3 inches thick minimum, will be placed above the geotextile or geocomposite in the trench and the pipe then placed and aligned. The remaining drainage aggregate will be placed after the pipe is fully installed. A fine filter material or geosynthetic filter layer will be placed between the drainage aggregate and overlying drainage layer material or waste to provide a filter to limit migration of particles that might otherwise clog the collection pipe. The design without the geotextile meets the second Terzaghi criteria, i.e. prevents the removal of fine fractions from the protected (waste) layer into the (LCS) filter layer. Accordingly, the geotextile is not a design component necessary to prevent clogging of the LCS drainage layer.

4 Summary and Conclusion

The purpose of this report is to document the liner and leachate collection and removal system design for the lateral expansion at LOS meets the applicable requirements as set forth in the CCR Rule for liner installed beginning in 2026. Based on a review of plans, specifications, and engineering calculations, the design for the CCR landfill liner and leachate collection system meets the requirements set forth in § 257.70(a), § 257.70(b) and 270.70(d).

5 References

AECOM, 2017a. Supplemental Site Characterization Report, Basin Electric Power Cooperative Ash Landfill Expansion, Leland Olds Station, Stanton, Mercer County, North Dakota, March 2017.

AECOM, 2017b. Location Restrictions Report, Basin Electric Power Cooperative Ash Landfill Expansion, Leland Olds Station, Stanton, Mercer County, North Dakota, March 2017.

AECOM, 2017c. Engineering Report, Basin Electric Power Cooperative Ash Landfill Expansion, Leland Olds Station, Stanton, Mercer County, North Dakota, March 2017.

AECOM, 2017d. Design Criteria for the Lateral Expansion of the Leland Olds Station Coal Combustion Residual (CCR) Landfill, November 20, 2017