SCS ENGINEERS

Initial Closure Plan
Phase 3 Module 1
Phase 3 Module 2
Phase 4 Module 1

Edgewater I-43 Ash Disposal Facility

Prepared for:

Wisconsin Power and Light Company
Edgewater Generating Station
3739 Lakeshore Drive
Sheboygan, Wisconsin 53081-7233

Prepared by:

SCS ENGINEERS
2830 Dairy Drive
Madison, Wisconsin 53718-6751
(608) 224-2830

September 2016
File No. 25216111.00

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PE CERTIFICATION

WISCONSIN
ERIC J.
NELSON
E-37855-006
STITZER,
WIS.
PROFESSIONAL ENGINEER
9/29/16

I, Eric J. Nelson, hereby certify the following:

- This Initial Closure Plan meets the requirements of 40 CFR 257.102(b)
- The final cover system described in this Initial Closure Plan meets the design requirements in 40 CFR 257.102(d)(3)

The Initial Closure Plan was prepared by me or under my direct supervision, and that I am a duly licensed Professional Engineer under the laws of the State of Wisconsin.

[signature] 9/29/16
(signature) (date)

ERIC J. NELSON
(printed or typed name)

License number E-37855-6

My license renewal date is 7/31/18.

Pages or sheets covered by this seal:
SEPTEMBER 2016 INITIAL CLOSURE PLAN -
I-43 ASH DISPOSAL FACILITY

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1.0 INTRODUCTION AND PROJECT SUMMARY

On behalf of Wisconsin Power and Light (WPL), SCS Engineers (SCS) has prepared this Initial Closure Plan for the I-43 Ash Disposal Facility (I-43) Phase 3 Modules 1 and 2 and Phase 4 Module 1 as required by 40 CFR 257.102(b).

40 CFR 257.102(b) *"Written closure plan—(1) Content of the plan. The owner or operator of a CCR unit must prepare a written closure plan that describes the steps necessary to close the CCR unit at any point during the active life of the CCR unit consistent with recognized and generally accepted good engineering practices. The written closure plan must include, at a minimum, the information specified in paragraphs (b)(1)(i) through (vi) of this section."*

The I-43 facility includes a closed coal combustion residual (CCR) landfill, which consists of disposal Phase 1 and Phase 2, and an active CCR landfill. The active CCR landfill currently consists of three existing CCR units in disposal Phase 3 and Phase 4. The two landfills are located on the same property, but are not contiguous. The U.S. Environmental Protection Agency (USEPA) CCR rule does not apply to Phase 1 and Phase 2, because they were closed before the effective date of the CCR rule.

The active CCR landfill at I-43 is comprised of three existing CCR units, which are the subject of this closure plan. These CCR units are listed below along with their current status as it relates to the closure plan:

- Phase 3, Module 1 – this unit has received some final cover over completed outer sideslope areas that will no longer receive additional CCR. The final cover placed complies with the CCR Rule.
- Phase 3, Module 2 – this unit is currently being filled.
- Phase 4, Module 1 – this unit has received some final cover over completed outer sideslope areas that will no longer receive additional CCR. This final cover placed complies with the CCR Rule.

Two future CCR units (Phase 4 Module 2 and Phase 4 Module 3) are permitted with the Wisconsin Department of Natural Resources (WDNR), but have not been developed. When developed, the units will be new CCR landfills, as defined in 40 CFR 257.53.

Figure 1 shows the site location. **Figure 2** shows the closure areas. A detail of the final cover system is also included on **Figure 2**.

2.0 PROPOSED CLOSURE PLAN NARRATIVE

40 CFR 257.102(b)(1)(i) *"A narrative description of how the CCR unit will be closed in accordance with this section."*

When CCR placement is completed in a CCR unit, or if early closure is required, the unit will be closed by covering the CCR with the final cover system described in **Section 3.0**. Prior to final cover system construction, the CCR surfaces will be graded and compacted to establish a firm subgrade for final cover construction.

The timing for completion of CCR placement in the units that are addressed with this closure plan will depend on CCR generation and disposal rates. Future CCR unit development will also impact the timing of closure. Each of the existing CCR units is designed to receive additional CCR once adjacent units are constructed and overlay airspace is available for filling. Based on the current CCR units alone, if early closure of all units were required, final cover will be placed in the active landfill areas shown on **Figure 2**. A closure schedule is discussed in **Section 6.0** and presented in **Appendix B**.

The initiation of closure activities will commence no later than 30 days after the final receipt of CCR as required by 40 CFR 257.102(e)(1), or in accordance with 40 CFR 257.102(e)(2).

3.0 FINAL COVER SYSTEM AND PERFORMANCE

40 CFR 257.102(b)(1)(iii). *"If closure of the CCR unit will be accomplished by leaving CCR in place, a description of the final cover system, designed in accordance with paragraph (d) of this section, and the methods and procedures to be used to install the final cover. The closure plan must also discuss how the final cover system will achieve the performance standards specified in paragraph (d) of this section."*

"(d) Closure performance standard when leaving CCR in place.
(1) The owner or operator of a CCR unit must ensure that, at a minimum, the CCR unit is closed in a manner that will:

(i) Control, minimize, or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere;

The final cover system design will minimize or eliminate infiltration, as further described below.

(ii) Preclude the probability of future impoundment of water, sediment, or slurry;

The final cover system will meet these criteria, as further described below.

(iii) Include measures that provide for major slope stability to prevent the sloughing or movement of the final cover system during the closure and post-closure care period;

The final cover system is designed to provide slope stability and to prevent sloughing or movement during the closure and post-closure care period. Stability of the final cover system was assessed as part of the WDNR landfill permitting process and is further addressed below.

(iv) Minimize the need for further maintenance of the CCR unit; and

Maintenance of the final cover will be minimized by the establishment of vegetative cover and the erosion control systems, which are further described below.

(v) *Be completed in the shortest amount of time consistent with recognized and generally accepted good engineering practices."*

All closure activities for the CCR units will be completed within 6 months, as stated in **Section 7.0** below.

"(2) Drainage and stabilization of CCR surface impoundments."

This does not apply to the I-43 CCR landfill units.

"(3) Final cover system"

The final cover system (see **Figure 2**) on portions of Phase 3 Module 1 and Phase 4 Module 1 will also be installed in the remaining areas of these CCR units. This final cover system will also be installed in Phase 3 Module 2. The final cover system is as follows from the bottom up:

- Two feet of clay, compacted to a permeability of $1x10^{-7}$ cm/sec
- Forty-mil low density polyethylene geomembrane
- Geonet geocomposite drainage layer
- Twelve inches of rooting zone soils
- Six inches of topsoil

This final cover meets and exceeds the minimum requirements of 40 CFR 257.102(d)(3)(i)(A) through (D) as follows:

- Per 257.102(d)(3)(i)(A), the permeability of the final cover system is less than or equal to the permeability of the bottom liner system and is less than $1x10^{-5}$ cm/sec required by the Rule. The final cover system 2-foot thick clay cap is compacted to $1x10^{-7}$ cm/sec permeability. The geomembrane above the 2-foot clay cap makes the cover system even less permeable.

  The bottom liner system for the CCR Units is as follows:

  - Phase 3 Module 1:
    - Five feet of clay, compacted to a permeability of $1x10^{-7}$ cm/sec. The liner system does not include a geomembrane and therefore is not as impermeable as the final cover system.
  - Phase 3 Module 2:
    - Two feet of clay, compacted to a permeability of $1x10^{-7}$ cm/sec
    - Sixty-mil High Density Polyethylene (HDPE) geomembrane

Based on the design slopes and drainage system components in the liner system and final cover system, the final cover system is less permeable than the liner system in Phase 3 Module 2.

- Phase 4 Module 1:
  - Five feet of clay, compacted to a permeability of $1x10^{-7}$ cm/sec. The liner system does not include a geomembrane and therefore is not as impermeable as the final cover system.

- Per 257.102(d)(3)(i)(B), the final cover system includes 3.5 feet of soil, which is greater than the 18 inches of earthen material required to minimize infiltration.

- Per 257.102(d)(3)(i)(C), the erosion of the final cover system is minimized with a vegetative support layer consisting of 12 inches of uncompacted rooting zone material and 6 inches of topsoil. This provides more than the required 6-inch thickness for plant growth.

  Also, this final cover system limits infiltration while promoting surface water runoff in a controlled manner to minimize erosion and promote stability. The surface layer of 18 inches of soil supports vegetation that assists with erosion control. Water that infiltrates through the vegetative support layers is collected by the lateral drainage layer (geonet geocomposite) and routed to the perimeter drainage system.

  In addition, the surface has intermediate drainage swales to reduce the flow lengths down the final cover slope, also aiding in erosion control. Where needed, the intermediate drainage swales are connected to downslope flumes and energy dissipaters to control storm water runoff and prevent erosion of the final cover.

- Per 257.102(d)(3)(i)(D), the design of the final cover system minimizes disruptions to the final cover system. Stability of the final cover system was assessed as part of the WDNR landfill permitting process. The stability calculations are included in **Attachment A**.

  The design of the final cover system accommodates settling and subsidence of the CCR fill below the cover. The CCR at I-43 is placed dry and is compacted in place. CCR continues to consolidate and gain strength as filling progresses prior to final cover placement. The final cover system is designed with a maximum slope of 25 percent (4 horizontal to 1 vertical). Because the final cover has a relatively large positive slope and the CCR has been gaining strength over time, the final cover is expected to easily accommodate the remaining relatively minor settlement potential of the CCR fill when fill placement ends and the landfill is closed.

All final cover materials will be tested to confirm they meet specifications and construction will be overseen and documented by a licensed engineer. Clay material placement will be tested for compaction, permeability, and thickness. Rooting zone and topsoil layers will be checked for thickness. All areas will be restored after final cover is placed. Vegetation will be monitored and maintained.

4.0 MAXIMUM INVENTORY OF CCR

40 CFR 257.102(b)(1)(iv). *"An estimate of the maximum inventory of CCR ever on-site over the active life of the CCR unit."*

The following table reflects the estimated maximum volumes of CCR in each CCR Unit at the I-43 facility.

Area	Capacity (cy)
Phase 3 Module 1	193,523
Phase 3 Module 2	312,984
Phase 4 Module 1	87,291
Total Maximum CCR Quantity	**593,798**

The estimated maximum inventory of CCR ever on-site over the active life of the CCR Units is based on the design capacity of each unit. The design capacity of each unit is defined in the WDNR approved 2008 Plan of Operation and as revised by the March 2015 Plan of Operation Modification.

5.0 LARGEST AREA OF CCR UNIT REQUIRING FINAL COVER

40 CFR 257.102(b)(1)(v). *"An estimate of the largest area of the CCR unit ever requiring a final cover as required by paragraph (d) of this section at any time during the CCR unit's active life."*

The largest area of each CCR unit requiring final cover is the open area shown on **Figure 2**, with areas as follows:

Area	Acres
Phase 3 Module 1	2.4
Phase 3 Module 2	5.6
Phase 4 Module 1	0.74
Total	**8.74**

6.0 SCHEDULE OF SEQUENTIAL CLOSURE ACTIVITIES

40 CFR 257.102(b)(1)(vi). *"A schedule for completing all activities necessary to satisfy the closure criteria in this section, including an estimate of the year in which all closure activities for the CCR unit will be completed."*

CCR placement is estimated to be complete in each of the existing CCR units as follows:

Unit	Filling Completed
Phase 3 Module 1	December 2036
Phase 3 Module 2	December 2036
Phase 4 Module 1	December 2026

These estimated dates are based on the site life calculated from the design capacity of each unit and currently anticipated disposal rates. These dates also assume that the adjacent, future CCR units that are currently permitted with the WDNR will be constructed as planned allowing for the overlay of additional CCR onto the existing units. The preliminary schedule for closure of the existing CCR units is provided in **Appendix B**.

7.0 COMPLETION OF CLOSURE ACTIVITIES

40 CFR 257.102(f)(1)(i). *"For existing and new CCR landfills and any lateral expansion of a CCR landfill, within six months of commencing closure activities."*

As shown on the enclosed schedule, closure of each CCR unit will be completed within 6 months of commencement of closure activities.

40 CFR 257.102(f)(3). *"Upon completion, the owner or operator of the CCR unit must obtain a certification from a qualified professional engineer verifying that closure has been completed in accordance with the closure plan specified in paragraph (b) of this section and the requirements of this section."*

A qualified licensed engineer will oversee final cover construction. The engineer will verify final cover materials and methods and oversee material testing. At the end of construction, the engineer will provide a report summarizing and documenting construction and will certify compliance with the requirements.

8.0 CERTIFICATION

40 CFR 257.102(b)(4) *"The owner or operator of the CCR unit must obtain a written certification from a qualified professional engineer that the initial and any amendment of the written closure plan meets the requirement of this section."*

Eric Nelson, PE, a licensed professional engineer in the State of Wisconsin, has overseen the preparation of this Initial Closure Plan. A certification statement is provided on **page iii** of this plan.

40 CFR 257.102(d)(3)(iii). *"The owner or operator of the CCR unit must obtain a written certification from a qualified professional engineer that the design of the final cover system meets the requirement of this section."*

Eric Nelson, PE, a licensed professional engineer in the State of Wisconsin has reviewed the final cover design and certifies that the design meets the requirements of 40 CFR 257.102(d). The certification statement is provided on **page iii** of this plan.

9.0 RECORDKEEPING AND REPORTING

<u>40 CFR 257.102(b)(2)(iii).</u> *"The owner or operator has completed the written closure plan when the plan including the certification required by paragraph (b)(4) of this section, has been placed in the facility's operating record as required by Section 257.105(i)(4)."*

The Closure Plan will be placed in the facility's operating record and on Alliant Energy's CCR Rule Compliance Data and Information website.

Amendments to the written closure plan will be done when there is a change in the operation of the CCR unit that affects the plan or when unanticipated events warrant revision to the written closure plan, as required by 40 CFR 257.102(b)(3).

WPL will provide notification as follows:

- Intent to initiate closure
- Closure completion
- Availability of the written closure plan and any amendments.

All notifications will be placed in the facility's operating record and on the website per 40 CFR 257.105(i), 257.106(i), 257.107(i).

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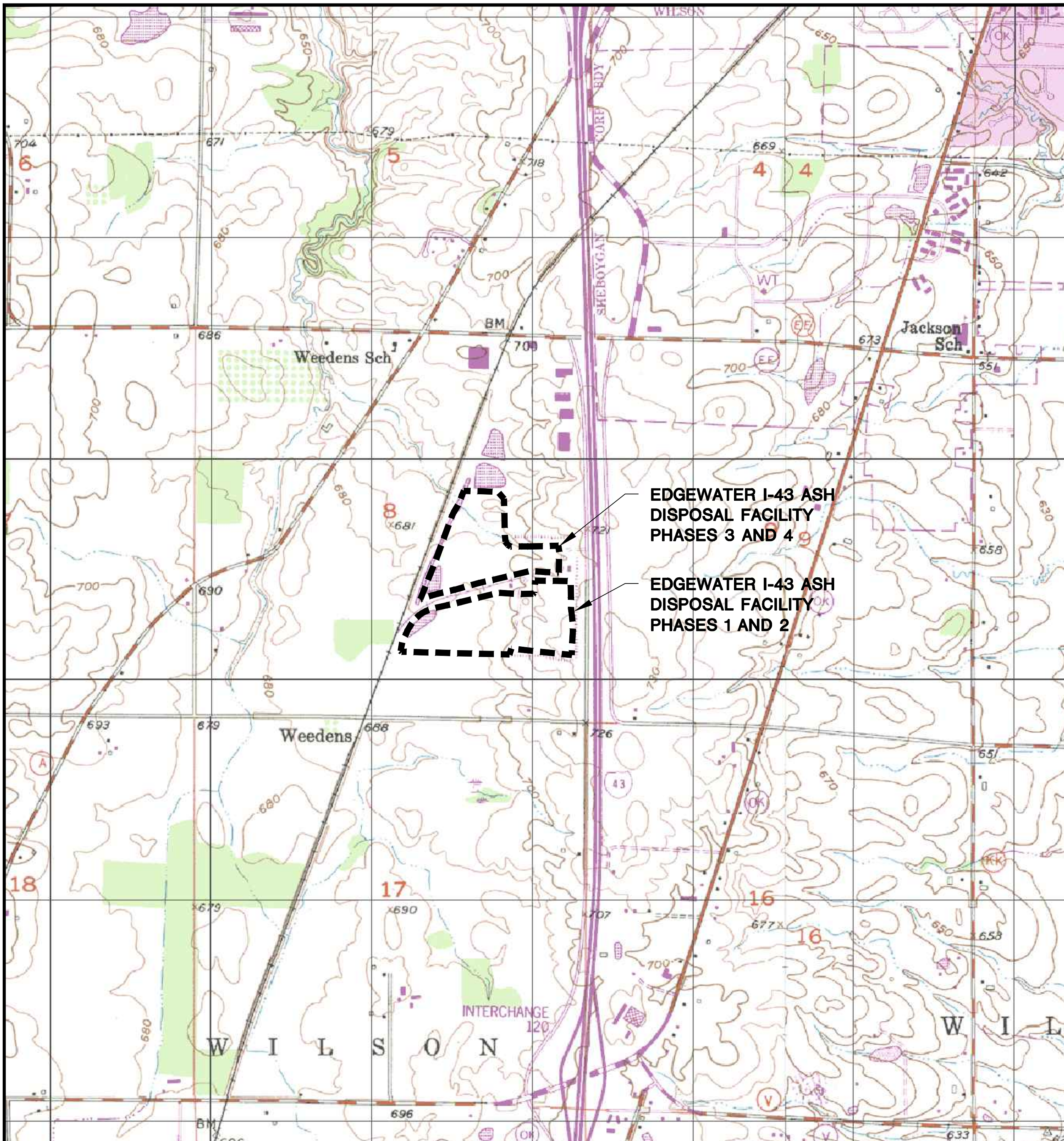
FIGURES



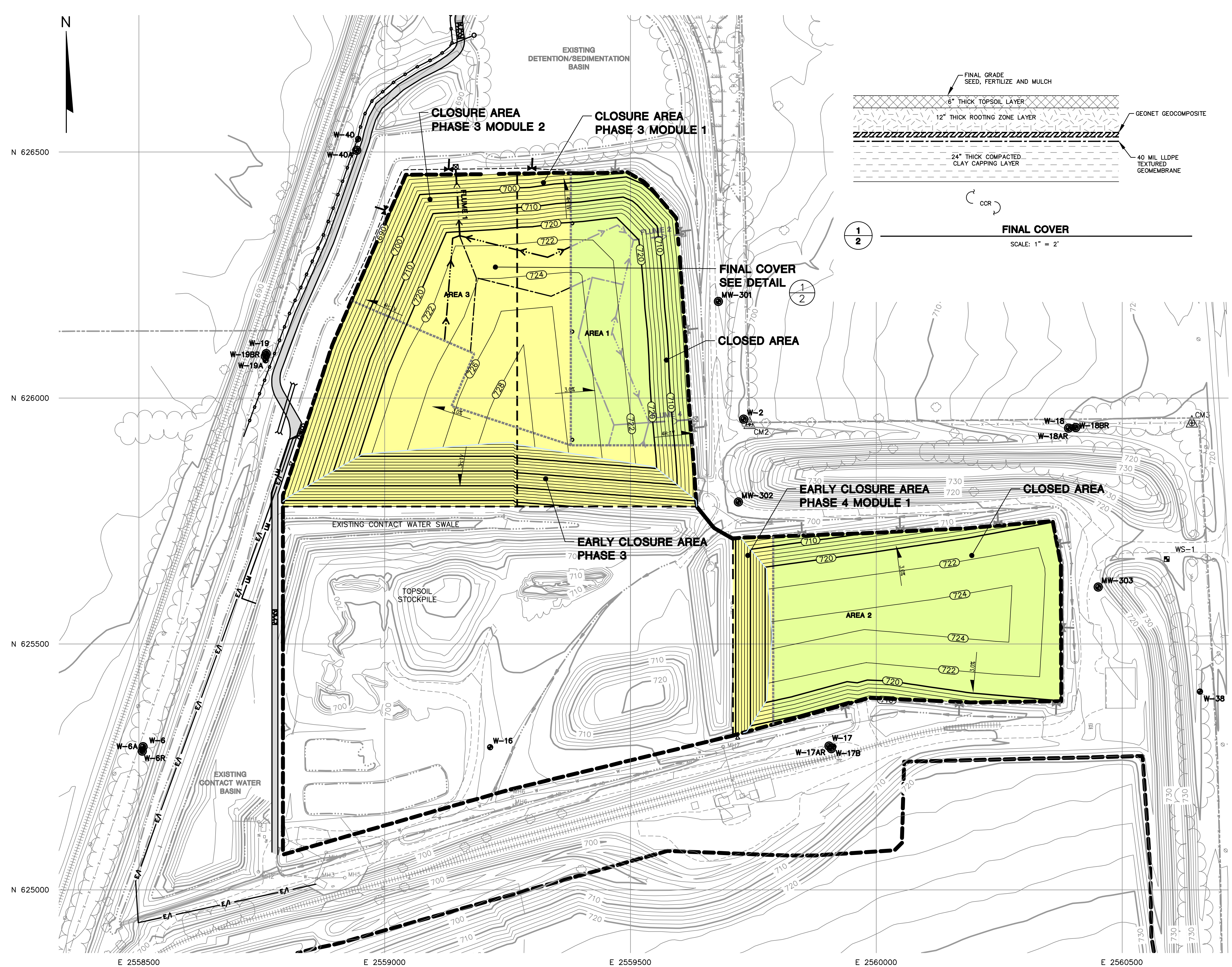
N

SHEBOYGAN HILLS QUADRANGLE
WISCONSIN–SHEBOYGAN CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
SCALE: 1" = 2,000'

CLIENT: WISCONSIN POWER AND LIGHT COMPANY EDGEWATER GENERATING STATION 3739 LAKESHORE DRIVE SHEBOYGAN, WI 53081	SITE: INITIAL CLOSURE PLAN EDGEWATER I–43 ASH DISPOSAL FACILITY TOWN OF WILSON, WISCONSIN	SITE LOCATION MAP

PROJECT NO.	25216111.00	DRAWN BY:	AHB	ENGINEER: SCS ENGINEERS 2830 DAIRY DRIVE MADISON, WI 53718–6751 PHONE: (608) 224–2830	FIGURE
DRAWN:	08/09/16	CHECKED BY:	LB		1
REVISED:	08/09/16	APPROVED BY:	EN 09/28/16		

I:\25216111.00\Drawings\Initial Site Closure\Site Location Map.dwg, 9/28/2016 3:56:16 PM



LEGEND

- APPROXIMATE PROPERTY LINE
- LIMITS OF WASTE
- MODULE LIMITS
- EXISTING GRADE (2' CONTOUR)
- EXISTING GRADE (10' CONTOUR)
- EDGE OF WATER
- SWALE
- WETLAND
- CULVERT
- MANHOLE
- CONTACT WATER TRANSFER PIPE
- TREELINE/TREES
- PAVED ROAD
- ACCESS ROAD
- RAILROAD TRACKS
- FENCE
- UTILITY/LIGHT POLE
- CONTROL MONUMENT
- MONITORING WELL
- PIEZOMETER
- LEACHATE HEADWELL
- PRIVATE WATER SUPPLY WELL
- PROPOSED FINAL GRADE (10' CONTOUR)
- SLOPE AND DIRECTION
- PROPOSED 6" DIA. LEACHATE FORCEMAIN
- PROPOSED LEACHATE VAULT
- PROPOSED ELECTRIC AND INSTRUMENT CONDUITS
- PROPOSED ACCESS ROAD
- PROPOSED FINAL COVER DRAINAGE SYSTEM PIPE
- PROPOSED FINAL COVER DIVERSION BERM
- PROPOSED DOWNSLOPE FLUME
- PROPOSED ENERGY DISSIPATOR
- PROPOSED TOE DRAIN AND DISCHARGE PIPE
- CONCEPTUAL FINAL COVER SEQUENCE LIMITS
- AREA 1 — CONCEPTUAL FINAL COVER AREA
- PROPOSED INITIAL WASTE PLACEMENT LIMIT
- AREAS TO BE CLOSED
- CLOSED AREAS

NOTES:

1. BASE MAP PREPARED BY KBM, INC. BASED ON AERIAL TOPOGRAPHIC SURVEY FLOWN DECEMBER 1, 2014. BASE MAP PREPARED USING WISCONSIN STATE PLANE COORDINATES. ELEVATIONS BASED ON USGS NATIONAL GEODETIC VERTICAL DATUM, 1929.
2. CONTOUR INTERVAL IS 2 FEET.
3. MONITORING WELL LOCATIONS BASED ON WELL INFORMATION FORM COORDINATES AND EXISTING CONDITIONS MAP F11 PREPARED BY WARZYN, INC. USING LOCAL COORDINATES.

FINAL COVER PLACEMENT

1. DOCUMENT FINAL ASH ELEVATIONS AND SURFACE IN PREPARATION OF COMPOSITE COVER PLACEMENT.
2. INSTALL COMPACTED SELECT CLAY FILL.
3. INSTALL GEOMEMBRANE, GEOCOMPOSITE, GEOCOMPOSITE DRAINS, AND GEOCOMPOSITE TOE DRAINS.
4. INSTALL ROOTING ZONE MATERIAL.
5. INSTALL FINAL GRADE SWALES, DOWNSLOPE FLUMES, AND ENERGY DISSIPATORS.
6. INSTALL TOPSOIL.
7. SEED, FERTILIZE, AND MULCH TOPSOIL AND DISTURBED AREAS.

200 0 200

SCALE: 1" = 200'

FIGURE 2

INITIAL CLOSURE PLAN

SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

ENGINEER

SITE: INITIAL SITE CLOSURE PLAN
EDGEWATER I-43 ASH DISPOSAL FACILITY
TOWN OF WILSON, WISCONSIN

CLIENT: WISCONSIN POWER AND LIGHT COMPANY
EDGEWATER GENERATING STATION
3739 LAKESHORE DRIVE
SHEBOYGAN, WI 53081

PROJECT NO.	25216111.00	DRAWN BY:	KP
DRAWN:	08/09/16	CHECKED BY:	LB
REVISED:	08/09/16	APPROVED BY:	EN 09/28/16

APPENDIX A

Stability Calculations

SCS ENGINEERS

		Calc. No.	
		Rev. No.	
Job No. 25214060	Job: Edgewater	By: BJM	Date: 1/22/15
Client: Wisconsin Power & Light Company	Subject: Unit Gradient Calculation (3%)	Chk'd ZB	Date: 01/27/15

Purpose: To determine the maximum length of 3% slope that the final cover plateau drainage geocomposite can carry infiltrating water and maintain the flow within the geocomposite.

Approach: Use the unit gradient method to determine the maximum slope length.

References:

Landfill Design.com

"GRI-GC8, Determination of the Allowable Flow Rate of a Drainage Geocomposite". Geosynthetics Research Institute, 2001.

"Beyond a factor-of-safety value, i.e., the probability of failure". GRI Newsletter/Report, Vol. 15, no.3.

"Designing with Geosynthetics". R.M. Koerner, Prentice Hall Publishing Co., Englewood Cliffs, NJ, 1998.

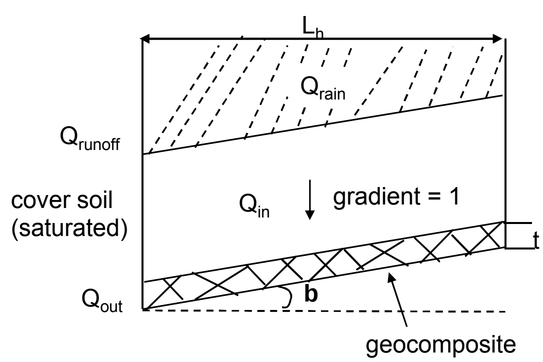
"Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers". J.P. Giroud, J.G. Zornberg and A. Zhao, *Geosynthetics International*, Vol. 7, Nos 4-5.

"Lateral Drainage Design update - part 2". G.N. Richardson, J.P. Giroud and A. Zhao, *Geotechnical Fabrics Report*, March, 2002

Giroud, Zornberg, and Zhao, 2000, "Hydraulic Design of Liquid Collection Layers", Geosynthetics International

HELP Model "User's Guide" Table 4 - Default Soil, Waste, and Geosynthetic Characteristics

Soong, T.Y. and Koerner, R.M. (1997), "The Design of Drainage Systems over Geosynthetically Lined Slopes", Geosynthetics Research Institute, Report #19.



With Darcy's Law:
$Q = k * i * A$

Inflow of water in the geocomposite
$Q_{in} = k_{veg} * i * A = k_{veg} * 1 * L_h * 1$

Outflow of water from the geocomposite at the toe of the slope
$Q_{out} = k_{comp} * i * A = k_{comp} * i * t * 1 = \theta_{required} * \sin\mathbf{b}$

Inflow equals outflow (Factor of Safety = 1)
$Q_{in} = Q_{out} = \theta * i * 1$ where $\theta = k_{comp} * t$ (minimum allowable outflow to keep head within geocomposite)

This results in a required transmissivity of the geocomposite of:

$$\theta_{required} = \frac{k_{veg} * Lh}{\sin\mathbf{b}}$$

Which results in the ultimate transmissivity after multiplying by the Total Servicability Factor (TSF)
$\theta_{ultimate} = \theta_{required} * FS_d * RF_{in} * RF_{cr} * RF_{cc} * RF_{bc}$

Job No. 25214060	Job: Edgewater	By: BJM	Date: 1/22/15
Client: Wisconsin Power & Light Company	Subject: Unit Gradient Calculation (3%)	Chk'd ZB	Date: 01/27/15

Calculation:

L_h= Drainage pipe spacing or length of slope measured horizontally	=	See Below	
k_{veg} = Permeability of the vegetative supporting soil	=	1.9E-05 cm/sec	
S = The liner's slope, S = tan**b**	=	3%	**b** (degrees) = 1.7 °

FSd = Overall factor of safety for drainage	=	2
RF_{in} = Intrusion Reduction Factor	=	1.1
RF_{cr} = Creep Reduction Factor	=	1.2
RF_{cc} = Chemical Clogging Reduction Factor	=	1.1
RF_{bc} = Biological Clogging Reduction Factor	=	1.4

Determine the maximum slope length for transmissivities of example products currently available

L_h (feet)	L_h (meter)	Θ_{ult} (m^2/sec)	
319	97	2.5E-03	GSE FabriNet TRx Geocomposite (Double-Sided), 300 mil
115	35	9.0E-04	GSE FabriNet Geocomposite (Double-Sided), 300 mil
64	19	5.0E-04	GSE FabriNet Geocomposite (Double-Sided), 250 mil
13	4	1.0E-04	GSE FabriNet Geocomposite (Double-Sided), 200 mil

Determine the ultimate transmissivity based on a given slope length

L_h (feet)	L_h (meter)	Θ_{ult} (m^2/sec)	
335	102	2.6E-03	~ Total slope length (3% slope only)

Assumptions:

1. Soil hydraulic gradient į = 1.

2.Typical topsoil in the site area is classified as silty clay based on the Preliminary Site Feasibility Report. Prepared by Meand and Hunt, inc. in December 1977. Estimated permeability of 1.9E-05 cm/sec is from the HELP Model User's Guide.

3. Geocomposite hydraulic gradient = sinβ where β=2° (3% final cover slope).

4. Factor of safety and transmissivity reduction factors are from recommended values in GRI report #19 (Leachate collection system example) and HELP model "Users Guide".

5. Maximum horizontal final cover slope length at 3% is 335 feet as shown on the expansion final grades plan sheet.

6. Geocomposite transmissivities for GSE products were tested at a gradient of 0.1 and normal load of 10,000 psf.

Conclusions: For the proposed design with a toe-of-slope drainage outlet and the assumed vegetative layer hydraulic conductivity, a minimum transmissivity of 2.63E-03 m^2/sec is required. Since this transmissivity is not achieved by the GSE FabriNet TRx Geocomposite (Double-Sided), 300 mil, a pipe system has been designed to provide the necessary drainage for the final cover plateau. The drainage pipe system layout will maintain the flow within the geocomposite when the flow length to the drainage outlet is a maximum of 319 feet and the geocomposite minimum transmissivity is 2.5E-03 m^2/sec.

Job No. 25214060	Job: Edgewater	By: BJM		Date: 01/22/15
Client: Wisconsin Power & Light Company	Subject: Unit Gradient Calculation (4:1)	Chk'd	ZB	Date: 01/27/15

Purpose: To determine the maximum length of 4H:1V slope that the final cover side slope drainage geocomposite can carry infiltrating water and remain stable, and the recommended minimum interface friction angle for final cover side-slope stability.

Approach: Use the unit gradient method to determine the maximum slope length.

References:

Landfill Design.com

"GRI-GC8, Determination of the Allowable Flow Rate of a Drainage Geocomposite". Geosynthetics Research Institute, 2001.

"Beyond a factor-of-safety value, i.e., the probability of failure". GRI Newsletter/Report, Vol. 15, no.3.

"Designing with Geosynthetics". R.M. Koerner, Prentice Hall Publishing Co., Englewood Cliffs, NJ, 1998.

"Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers". J.P. Giroud, J.G. Zornberg and A. Zhao, *Geosynthetics International* , Vol. 7, Nos 4-5.

"Lateral Drainage Design update - part 2". G.N. Richardson, J.P. Giroud and A. Zhao, *Geotechnical Fabrics Report* , March, 2002

Giroud, Zornberg, and Zhao, 2000, "Hydraulic Design of Liquid Collection Layers", Geosynthetics International

HELP Model "User's Guide" Table 4 - Default Soil, Waste, and Geosynthetic Characteristics

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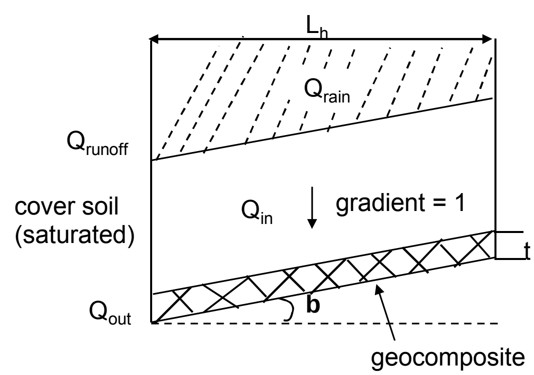


With Darcy's Law:

$Q = k * i * A$

Inflow of water in the geocomposite

$Qin = k_{veg} * i * A = k_{veg} * 1 * L_h * 1$

Outflow of water from the geocomposite at the toe of the slope

$Q_{out} = k_{comp} * i * A = k_{comp} * i * t * 1 = \theta_{required} * \sin\mathbf{b}$

Inflow equals outflow (Factor of Safety = 1)

$Q_{in} = Q_{out} = \theta * i * 1$ where $\theta = k_{comp} * t$ (minimum allowable outflow to keep head within geocomposite)

This results in a required transmissivity of the geocomposite of:

$$\theta_{required} = \frac{k_{veg} *Lh}{\sin\mathbf{b}}$$

Which results in the ultimate transmissivity after multiplying by the Total Servicability Factor (TSF)

$\theta_{ultimate} = \theta_{required} * FS_d * RF_{in} * RF_{cr} * RF_{cc} * RF_{bc}$

Calculation:

L_h= Drainage pipe spacing or length of slope measured horizontally	=	See Below	
k_{veg} = Permeability of the vegetative supporting soil	=	1.9E-05	cm/sec
S = The liner's slope, S = tan**b**	=	25%	**b** (degrees) = 14 °
FS_{slope} = Minimum factor of safety against sliding, for soil/geocomposite or geocomposite/geomembrane interfaces	=	1.5	

$\delta_{req'd}$ = Minimum interface friction angle = $\tan^{-1}$(FS*tan(**b**))	=	20.6	degrees

FSd = Overall factor of safety for drainage	=	2
RF_{in} = Intrusion Reduction Factor	=	1.1
RF_{cr} = Creep Reduction Factor	=	1.2
RF_{cc} = Chemical Clogging Reduction Factor	=	1.1
RF_{bc} = Biological Clogging Reduction Factor	=	1.4

Determine the maximum slope length for transmissivities of example products currently available

L_h (feet)	L_h (meter)	Θ_{ult} (m^2/sec)	
2655	809	2.5E-03	GSE FabriNet TRx Geocomposite (Double-Sided), 300 mil
956	291	9.0E-04	GSE FabriNet Geocomposite (Double-Sided), 300 mil
531	162	5.0E-04	GSE FabriNet Geocomposite (Double-Sided), 250 mil
106	32	1.0E-04	GSE FabriNet Geocomposite (Double-Sided), 200 mil

Determine the ultimate transmissivity based on a given slope length

L_h (feet)	L_h (meter)	Θ_{ult} (m^2/sec)	
128	39	1.2E-04	~ Total slope length (4H:1V slope only)

Assumptions:
1. Soil hydraulic gradient i = 1.
2. Typical topsoil in the site area is assumed to be silty clay based on the Preliminary Site Feasibility Report prepared by Mead and Hunt, Inc. in December 1977. Estimated permeability of 1.9E-05 cm/sec is from the HELP Model User's Guide.
3. Geocomposite hydraulic gradient = sinβ where β= 14 ° (25% final cover slope).
4. Factor of safety and transmissivity reduction factors are from recommended values in GRI report #19 (Leachate collection system example) and HELP model "Users Guide".
5. Maximum horizontal final cover slope length at 25% is 128 feet as shown on the expansion final grades plan sheet.
6. Geocomposite transmissivities for GSE products were tested at a gradient of 0.1 and normal load of 10,000 psf.

Conclusions: For the proposed design with a toe-of-slope drainage outlet and the assumed vegetative layer hydraulic conductivity, a minimum transmissivity of 1.21E-04 m^2/sec is required for the final cover sideslopes. For ease of construction, the same drainage geocomposite required for the 3% final cover plateau could also be used on the final cover sideslopes.

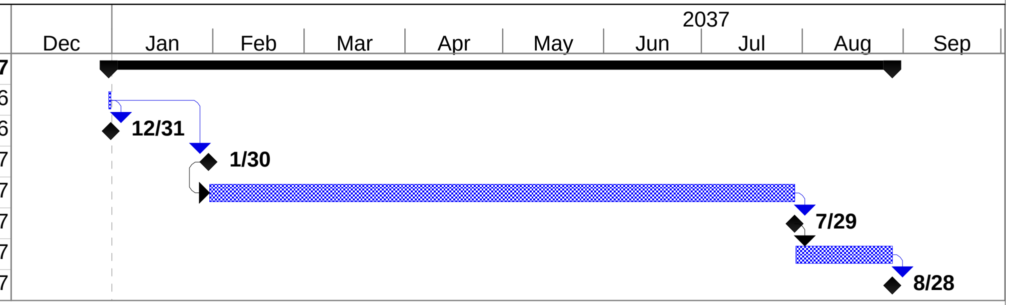
A minimum interface friction angle of 20.6 degrees is required to achieve a minimum recommended final cover slope stability safety factor of 1.5.

APPENDIX B

Closure Schedule

Initial Closure Plan Schedule

ID	Task Name	Duration	Start	Finish
1	**Closure of Phase 3 Module 1 and 2**	**241 days**	**Wed 12/31/36**	**Fri 8/28/37**
2	Ash filling ceases	1 day	Wed 12/31/36	Wed 12/31/36
3	Other regulatory permits - none	0 days	Wed 12/31/36	Wed 12/31/36
4	Notification of Intent to Close	0 days	Fri 1/30/37	Fri 1/30/37
5	Construction Activities	180 days	Sat 1/31/37	Wed 7/29/37
6	Notification of Closure Completion	0 days	Wed 7/29/37	Wed 7/29/37
7	Documentation	30 days	Thu 7/30/37	Fri 8/28/37
8	State Submittal:Documentation Report	0 days	Fri 8/28/37	Fri 8/28/37

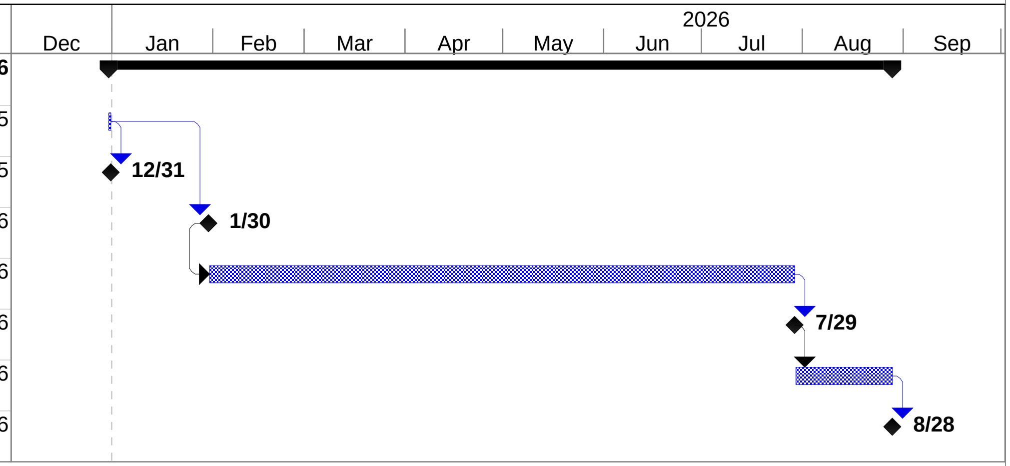


Project: Closure Plan

Task		Inactive Milestone		Finish-only	
Split		Inactive Summary		External Tasks	
Milestone		Manual Task		External Milestone	
Summary		Duration-only		Progress	
Project Summary		Manual Summary Rollup		Deadline	
External Tasks		Manual Summary			
External Milestone		Start-only			

Initial Closure Plan Schedule

ID	Task Name	Duration	Start	Finish
1	**Closure of Phase 4 Module 1**	**241 days**	**Wed 12/31/25**	**Fri 8/28/26**
2	Ash filling ceases	1 day	Wed 12/31/25	Wed 12/31/25
3	Other regulatory permits - none	0 days	Wed 12/31/25	Wed 12/31/25
4	Notification of Intent to Close	0 days	Fri 1/30/26	Fri 1/30/26
5	Construction Activities	180 days	Sat 1/31/26	Wed 7/29/26
6	Notification of Closure Completion	0 days	Wed 7/29/26	Wed 7/29/26
7	Documentation	30 days	Thu 7/30/26	Fri 8/28/26
8	State Submittal:Documentation Report	0 days	Fri 8/28/26	Fri 8/28/26



Project: Closure Plan

Task	Inactive Milestone	Finish-only
Split	Inactive Summary	External Tasks
Milestone	Manual Task	External Milestone
Summary	Duration-only	Progress
Project Summary	Manual Summary Rollup	Deadline
External Tasks	Manual Summary	
External Milestone	Start-only	