CLOSURE PLAN

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ASH LANDFILL 1

Oak Grove Steam Electric Station

Submitted To: Luminant
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October 2016

Project No. 1648164

Golder Associates

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1.0 INTRODUCTION

1.1 Purpose

The "Standards for Disposal of Coal Combustion Residuals (CCR) in Landfills and Surface Impoundments" (40 Code of Federal Regulations (40 CFR) Part 257, Subpart D), effective October 19, 2015, requires that existing CCR units have a written Closure Plan prepared in accordance with §257.102(b). This Closure Plan provides the following information for the Oak Grove Steam Electric Station's (OGSES's) CCR landfill identified as Ash Landfill 1.

- A description of steps necessary to close CCR unit and any point during the active life, including:
  - A description of how CCR unit will be closed;
  - A description of how the final cover will meet the performance standards§257.102(d), and the methods used to install the final cover;
  - An estimate of maximum inventory of CCR ever on-site during the active life of the CCR unit;
  - An estimate of largest area requiring final cover at any time during the CCR unit's active life; and
  - A schedule, including steps, major milestones, durations.

1.2 Site Background

The OGSES generates bottom ash, fly ash, boiler slag and flue gas desulfurization (FGD) sludge (gypsum) during electricity generation. Flyash and bottom ash generated at the facility (other than that amount that is sold/beneficially used in accordance with the CCR regulation), is handled in a dry manner and deposited in Ash Landfill 1.

This Closure Plan addresses the existing CCR landfill, Ash Landfill 1, at the OGSES. A separate Closure Plan addresses the existing CCR surface impoundments (FGD-A, FGD-B, and FGD-C Ponds).

The location of the existing CCR units at the OGSES are shown on Figure 1.

2.0 DESCRIPTION OF CLOSURE [§257.102(b)(1)(i)]

Ash Landfill 1 will be closed in-place and capped with a final cover system. Cell 1 of Ash Landfill 1 received final closure in 2015.

2.1 Final Cover System [§257.102(b)(1)(iii)]

Ash Landfill 1 is lined with a 3-foot thick compacted clay with a hydraulic conductivity less than 1 x 10^{-7} cm/sec and the remainder of the cells will be closed with an alternate final cover meeting the requirements of §257.102(d)(3)(ii)(A) through (C)[1]. Specifically, the final cover system over Ash Landfill 1 will:

- Achieve an equivalent reduction in infiltration as §257.102(d)(3)(i)(A) and (B); i.e.
  - Have a permeability less than or equal to the permeability of bottom liner system or natural subsoils or no greater than 1 x 10^{-5} cm/sec, whichever is less;
  - Include an infiltration layer with a minimum 18 inches of earthen material;
- Include an erosion layer providing equivalent protection from wind or water erosion as specified in §257.102(d)(3)(i)(C); i.e.
  - Include an erosion layer containing a minimum 6 inches of earthen material and capable of sustaining native plant growth; and
- Accommodate settling and subsidence.

The final cover system for Ash Landfill 1 will be comprised of (from the top to bottom):

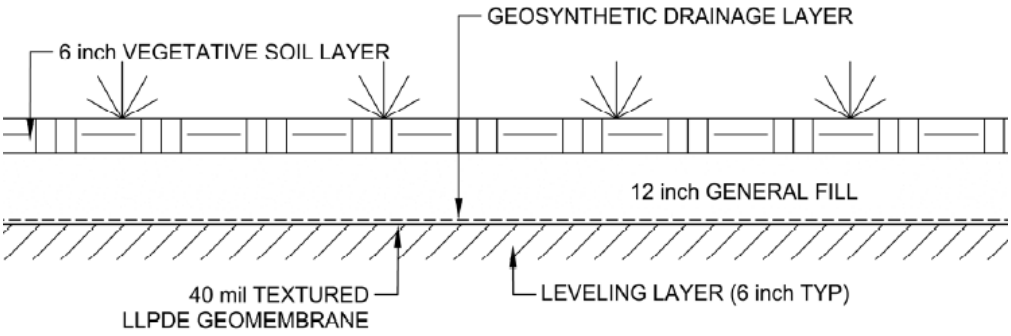
- 18-inch erosion layer consisting of 12 inches of general fill overlain with 6 inches of soil capable of supporting native vegetation;
- Geosynthetic drainage layer; and
- 40-mil linear low-density polyethylene (LLDPE) textured geomembrane.

The proposed alternate final cover replaces the soil infiltration layer with a geomembrane. Since infiltration is limited to potential defects in the geomembrane, the infiltration through the proposed cover will be lower than through a soil infiltration layer. A comparison of infiltration rates to demonstrate that an equivalent reduction in infiltration is included in Appendix A.

The final cover system for Ash Landfill 1 is illustrated below.

[1] The CCR Rule references (f)(3)(ii)(A) through (D), but this appears to be a typo.

Ash Landfill 1 Final Cover System



2.1.1 Final Cover Design and Performance

Table 1 describes how the final cover system meet the performance standards in §257.102(d).

Table 1 - Performance Standards

Standard	Discussion
Control, minimize or eliminate post-closure infiltration, releases of CCR, leachate, or contaminated run-off	Geomembranes are very effective barriers to infiltration and contact with CCR. Liquid will be removed from the CCR prior to final cover construction.
Preclude future impoundment of water sediment, or slurry	Any pipes leading to the landfill will be removed or abandoned and the final cover will be sloped to drain surface water.
Include measures for major slope stability	The textured geomembrane will improve interface shear strength and the geosynthetic drainage layer will prevent development of hydrostatic forces in the overlying erosion layer.
Minimize maintenance	Routine maintenance will consist of mowing the vegetative cover. Other anticipated maintenance activities are limited to repair of erosion rills, and placement of fill in depressions.
Complete in time consistent with good practice	The proposed final cover systems is routinely used at waste containment facilities. Well-developed industry experiences in installing such final cover systems will ensure most efficient construction time.

2.1.2 Methods and Procedures

The final cover system design, particularly the final cover grades, will be re-evaluated prior to initiation of final closure, based on the actual CCR grades at the time of closure. The final cover will be installed in accordance with a construction quality assurance (CQA) plan, which will be developed prior to commencing the work. The CQA plan will require monitoring of final cover construction to ensure that the final cover system will meet the design intent and conforms to the performance standards.

As described in Section 4.3 of the Closure Plan, a certification that the final cover system meets the requirements of §257.102(d)(3)(iii) will be provided by a qualified professional engineer, prior to initiation of final closure.

3.0 CCR QUANTITY [§257.102(b)(1)(iv-v)]

The approximate capacity of Ash Landfill 1 is 15.6 million cubic yards.

Final cover was placed over Cell 1 of Ash Landfill 1 in 2015. It is anticipated that Cell 2 will be closed in 2017. The remaining cells, Cells 3 and 4, are anticipated to reach capacity in approximately 2023. The final cover for these two cells cover an area of approximately 68 acres, which represents the largest area of the CCR unit ever requiring final cover.

4.0 CLOSURE COMPLETION SCHEDULE [§257.102(b)(1)(vi)]

As mentioned above, Ash Landfill 1 is anticipated to reach capacity in 2023 and completion all closure activities are anticipated to occur in 2023-2024. Note that these estimates may vary depending on the future CCR volumes and the other operational factors.

4.1 Commencement of the Closure Plan [§257.102(e)]

In accordance with §257.102(e), commencement of the Closure Plan will occur as specified in either timeframe defined below:

- No later than 30 days after the date on which either:
  - The CCR unit receives the known final receipt of waste; or
  - The last known CCR is removed for beneficial use.

- Within 2 years of either:
  - The CCR unit last receives waste; or
  - The last CCR is removed for beneficial use.

Initiation of closure work may be extended two years with documentation in accordance with §257.102(e)(2)(ii) that there is reasonable likelihood that the CCR unit will accept wastes in the foreseeable future or CCR will be removed from the unit for beneficial use.

Closure of a CCR unit has commenced if waste placement has ceased and any of the following are completed (§257.102(e)(3)):

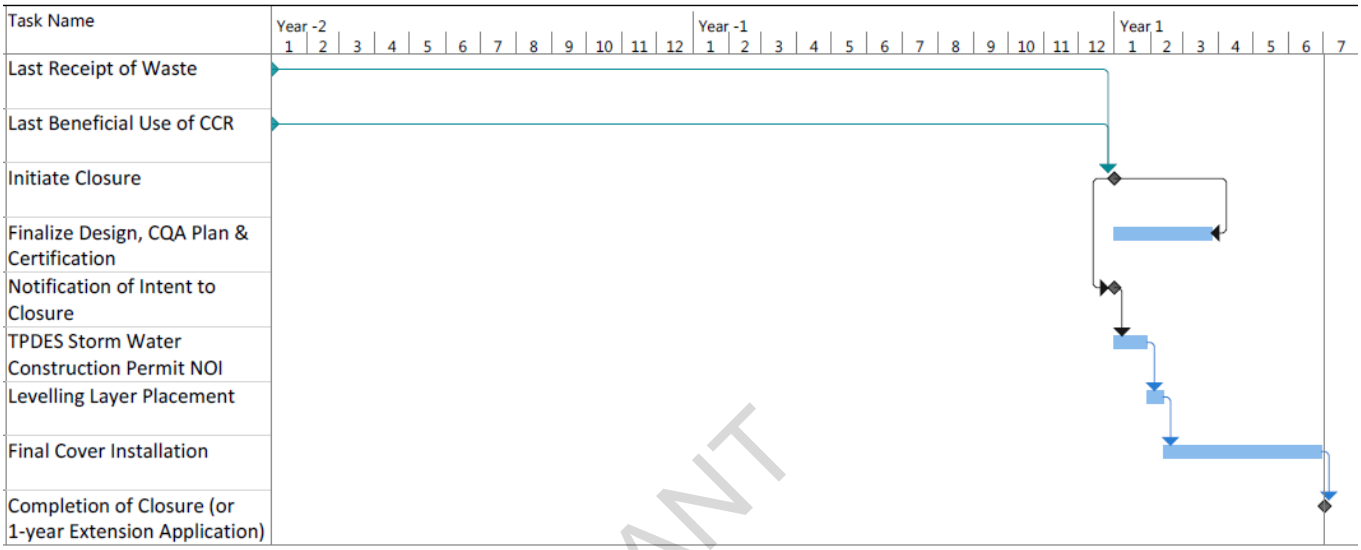
- Taken any steps necessary to implement steps in the Closure Plan;
- Submitted a completed application for any required state or agency permit or permit modification; or
- Taken any steps necessary to comply with prerequisite state standards to initiate or complete the closure of a CCR unit.

4.2 Completion of Closure Activities [§257.102(f)]

Closure of Ash Landfill 1 must be completed within 6 months of commencing closure. Completion of closure may be extended up to a maximum of 2 years via 1-year increments with documentation in accordance with §257.102(f)(2)(i) that, due to factors beyond the facility's control (e.g. significant weather delays, time required for dewatering CCR, delays due to state permitting or approval, etc.), it is not feasible to complete the closure within the required timeframe. An extension may also apply if the alternative closure requirements should apply to the CCR units in accordance with §257.103.

A Gantt chart illustrating the sequential steps of the CCR unit closure process, including identification of major milestones and estimated timeframes to complete each closure phase, is provided below.

Final Closure Schedule



4.2.1 Closure Certification

A certification from a qualified professional engineer verifying that closure has been completed in accordance with the Closure Plan must be obtained in accordance with §257.102(f)(3).

4.3 Notification of Intent to Close CCR Unit [§257.102(g)]

No later than the date of final closure initiation, a notification of intent to close the CCR unit must be prepared. The notification must include certification by a qualified professional engineer that the final cover system meets the requirements of §257.102(d)(3)(i) or (ii).

4.4 Notification of Closure Completion [§257.102(h)]

No later than 30 days after of completion of closure, a notification of closure of a CCR unit must be prepared. The notification must include certification by a qualified professional engineer that closure was completed in accordance with the Closure Plan.

4.5 Deed Notations [§257.102(i)]

Following closure of the CCR unit, a certified notation on the deed to the facility or site property, or on some other instrument that is normally examined during title searches, that will in perpetuity notify any potential purchaser of the property that the land has been used as a CCR unit and that future uses of the land are

restricted will be filed and recorded in the deed records of the office of the County Clerk of Robertson County.

A notification will be placed in the facilities operating record within 30 days of recording a notation to the deed to the property.

4.6 Closure Recordkeeping [§257.102(j)]

The owner or operator of the CCR unit must comply with the closure recordkeeping requirements specified in §257.105(i), the closure notification requirements specified in §257.106(i), and the closure internet requirements specified in §257.107(i).

5.0 CONCLUSION

This Final Closure Plan has been prepared by Golder Associates Inc. to describe the steps necessary to close the existing Ash Landfill 1 at OGSES at any point during the active life of the CCR unit with recognized and generally accepted good engineering practices.

If further information from Golder, please contact the undersigned at (281) 821-6868.

GOLDER ASSOCIATES INC.

William E. Gordon, PE
Senior Engineer

Jeffrey B. Fassett, PE
Associate Geotechnical Engineer

JBF/VK

6.0 CERTIFICATION

I hereby certify that this Closure Plan has been prepared in general accordance with normally accepted civil engineering practices and in accordance with the requirements of 40 CFR 257.102.

Jeffrey B. Fassett, PE
Golder Associates Inc.
Firm Registration Number F-2578

REFERENCE(S)
AERIAL PHOTO SOURCED FROM GOOGLE EARTH PRO DATED 2016

10/10/16

STATE OF TEXAS
JEFFREY B. FASSETT
85675
LICENSED PROFESSIONAL ENGINEER

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0 400 800
1" = 800' FEET

CLIENT
LUMINANT POWER
OAK GROVE

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-09-29
DESIGNED	VK
PREPARED	TNB
REVIEWED	MX
APPROVED	JBF

PROJECT
2016 COAL COMBUSTION RESIDUALS
ENGINEERING SERVICES

TITLE
GENERAL SITE MAP

PROJECT NO.	REV.	FIGURE
1648164	----	1

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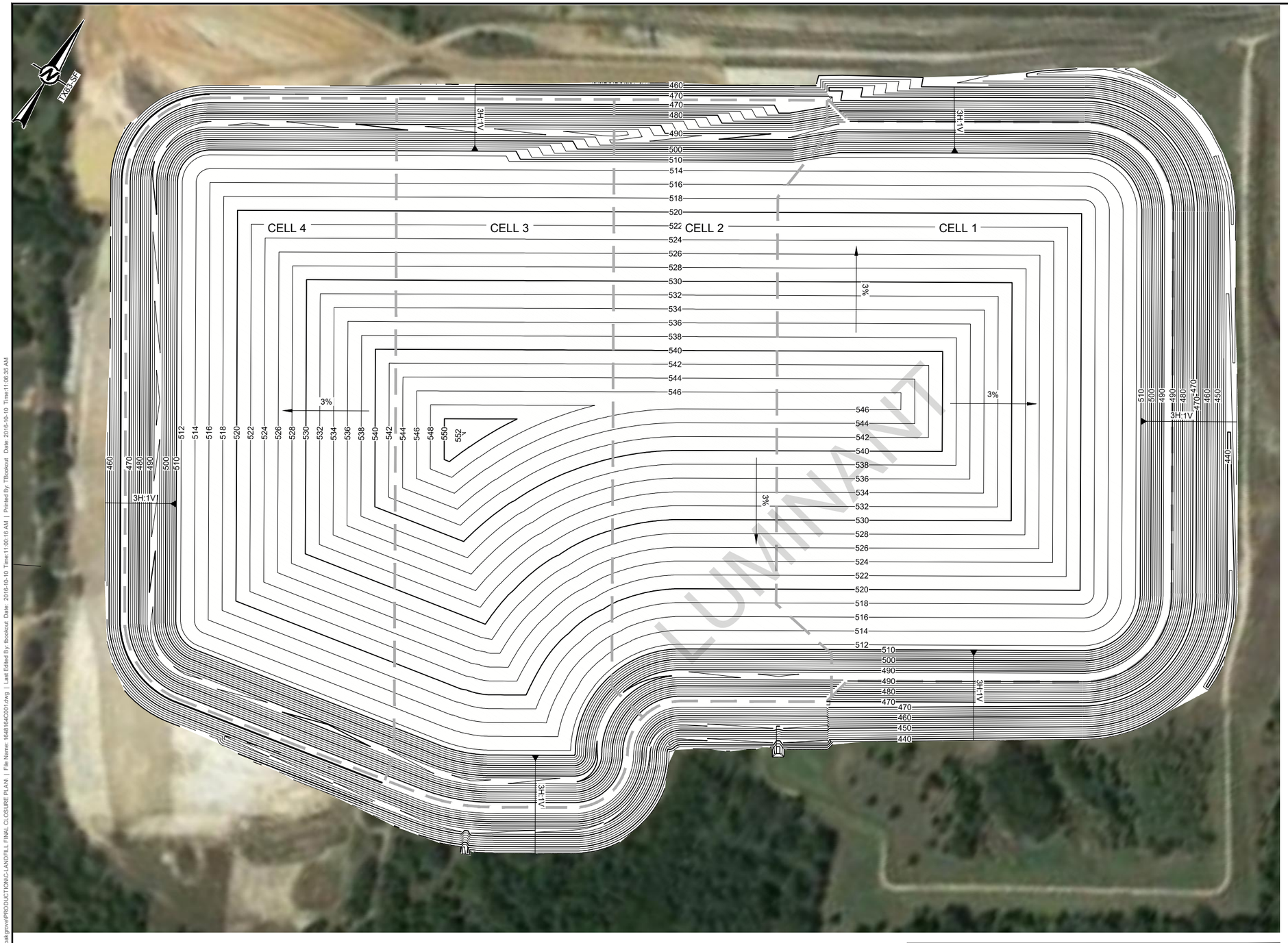

LEGEND

430 FGD ASH LANDFILL 1 FINAL COVER MAJOR CONTOURS

426 FGD ASH LANDFILL 1 FINAL COVER MINOR CONTOURS

REFERENCE(S)

AERIAL PHOTO SOURCED FROM GOOGLE EARTH PRO DATED 2016

10/10/16

STATE OF TEXAS
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LICENSED PROFESSIONAL ENGINEER

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ISSUED FOR

CLIENT REVIEW

0 150 300
1" = 300' FEET

CLIENT
LUMINANT POWER
OAK GROVE

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-09-29
DESIGNED	VK
PREPARED	TNB
REVIEWED	MX
APPROVED	JBF

PROJECT
2016 COAL COMBUSTION RESIDUALS
ENGINEERING SERVICES

TITLE
FINAL COVER GRADING PLAN
ASH LANDFILL 1

PROJECT NO.	REV.	FIGURE
1648164	----	2

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APPENDIX A
ALTERNATE FINAL COVER – INFILTRATION RATE COMPARISON

CALCULATIONS

Date:	9/26/2016	**Made by:**	JBF
Project No.:	1648164	**Checked by:**	MX
Subject:	Alternate Final Cover - Infiltration Rate Comparison	**Reviewed by:**	JBF
Project Short Title:	OGSES - Landfill Final Cover Plan		

OBJECTIVE

Compare the infiltration rate through a "prescriptive" final cover system with the infiltration rate through the alternate final cover system proposed for use in Ash Landfill 1.

GIVEN

The prescriptive final cover infiltration layer consists of a minimum 18-inch thick layer of earthen material with a permeability less than or equal to the permeability of the bottom liner. Ash Landfill 1was lined with a clay layer with a permeability of 1×10^{-7} cm/s. The alternate final cover system will replace the earthen material infiltration layer with a geomembrane. In addition, the proposed alternate final cover includes a geosynthetic drainage layer above the geomembrane.

METHOD

Estimate the infiltration rate through the earthen material infiltration layer using Darcy's equation. Estimate the infiltration through the geomembrane infiltration layer using the Giroud Equation (Ref. 1). Compare the infiltration rate through earthen material infiltration layer to the geomembrane infiltration layer.

Infiltration Through 18-inch earthen Infiltration Layer

Darcy's Equation

$Q = kiA$

where:

- Q = Leakage rate
- k = hydraulic conductivity
- i = hydraulic gradient = (h+t)/t
- h= head
- t = thickness
- A = area

Infiltration Layer Properties

k =	1.00E-07	cm/s
t =	1.5	ft
h =	0.5	ft (erosion layer saturated)
i =	1.33	
A =	1	acre

Q = 123 gal/acre/day

CALCULATIONS

Date:	9/26/2016	**Made by:**	JBF
Project No.:	1648164	**Checked by:**	MX
Subject:	Alternate Final Cover - Infiltration Rate Comparison	**Reviewed by:**	JBF
Project Short Title:	OGSES - Landfill Final Cover Plan		

Infiltration through geomembrane

Giroud's Equation Ref 1

$Q = C[1+0.1(h/t_s)^{0.95}]a^{0.1}h^{0.9}k_s^{0.74}$

where:

C = 0.21 for good contact
1.15 for poor contact

h = head (m)

t_s = thickness of underlying soil component (i.e. grading layer) (m)

a = area of hole (m^2)

k_s = hydraulic conductivity of underlying soil (m/s)

Geomembrane & Subgrade Properties

C =	1.15	(conservative)
h =	0.2	in (approximate thickness of drainage layer)
t_s =	0.5	ft
a =	1	cm^2 (equivalent to a 0.44 inch diameter hole - conservative)
k_s =	1.00E-03	cm/s (conservative for site soils)
Number of Defects =	2	per acre (conservative for good installation quality)

Q = 1.58E-06 m^3/sec/acre
36 gal/acre/day

CONCLUSION

Based on this analysis, the infiltration rate through a geomembrane final cover system will be less than the infiltration through a 1.5-ft thick infiltration layer with permeability of 1 x 10^{-7} cm/s.

REFERENCE

1) Giroud, J.P., "Equations for Calculating the Rate of Liquid Migration Through Composite Liners Due to Geomembrane Defects", Geosynthetics International, Vol. 4, Nos. 3-4, pp. 335-348, 1997.

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Established in 1960, Golder Associates is a global, employee-owned organization that helps clients find sustainable solutions to the challenges of finite resources, energy and water supply and management, waste management, urbanization, and climate change. We provide a wide range of independent consulting, design, and construction services in our specialist areas of earth, environment, and energy. By building strong relationships and meeting the needs of clients, our people have created one of the most trusted professional services organizations in the world.

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Golder Associates

Engineering Earth's Development, Preserving Earth's Integrity