January 20, 2015

Mr. Ed Mussler, III, PE, Supervisor
Permitting Branch, Solid Waste Section
Division of Waste Management, NCDENR
1646 Mail Service Center
Raleigh NC 27699

Dear Mr. Mussler,

On behalf of Green Meadow, LLC and Charah, Inc., HDR provides the following response to NCDENR's January 7, 2015 technical review letter (DIN 22502) regarding the permit application entitled:

> *Permit Application, Colon Mine Site, Structural Fill, Charah, Inc., Sanford, North Carolina*. Prepared for Charah, Inc. Prepared by HDR Inc. November 2014. DIN 22354.

As indicated in your letter, HDR recently submitted a revised permit application dated December 2014 in response to DIN 22536. That document and associated drawings represents the current permit application.

The Division's comments in DIN 22502 have been addressed and responses provided herein. A compact disc (CD) containing the revised or supplemental information in PDF format is included. Revisions in narrative documents are shown with deletions struckthrough (~~struckthrough~~) and additions underlined (underlined) along with a change line indicator in the left margin. As requested, upon completion of the permit application process the revisions will be combined into a final permit application document for the record.

The January 7, 2015 comments from the Division of Waste Management are restated below; HDR's responses on behalf of the applicant follow in *italics*.

Engineering Review

Facility Plan

1. 2.4.2- Leachate generation rates- How does this number compare to experience at the Asheville airport?

   Based on information provided by Charah, the leachate/contact water discharged from the Asheville airport site to the Buncombe County Metropolitan Sewer District (MSD) has averaged 1,418,000 gallons per month for Area 3 (30.8 acres) or 46,039 gallons per acre per month. This average includes varying surface conditions across the Area 3 containment area from open areas where all rainwater becomes contact water to areas that are above grade and covered with soil thereby diverting clean rain water to the sediment basins.

The HELP Model results included in the Calculations section of the Permit Application estimates an average annual flow rate of 43,760 cubic feet (327,325 gallons) per acre assuming a 20 foot thick layer of ash across the acre. However, the worst case condition for leachate handling would be contact water from a storm event immediately upon activating an area. A 2-year storm event was selected as the design storm since the largest subcell (15.3 acres) will take approximately five months to floor in the area with 20 feet of ash at the lower placement rate of 1,560,000 tons per year. The 2-year storm event for the area is 3.6 inches. This equates to 1,495,555 gallons within the largest cell area or 97,749 gallons per acre. The leachate pipes as shown in the Pipe Sizing calculation of the Leachate Calculation section have been designed to convey this storm event in 5.5 days. The subcell divider berms have been designed to store the entire storm event as shown in the Stormwater Calculation section. The leachate/contact water from each subcell will be piped to the sump in solid pipes, out to the leachate tank, and then pumped to the treatment plant.

Section 2.4.2 of the Facility Plan has been amended to include the information above.

2. 2.4.3.3 Final Disposal- The text indicates that leachate will be hauled by truck to the wastewater treatment facility. How many trips a day are anticipated under normal and storm loads?

   Section 2.4.3.3. of the Facility Plan has been revised to state "The primary leachate disposal will be via private sewer line to a wastewater treatment plant. A discharge permit is currently being sought and will be provided prior to operation of the system. "

   The revised Facility Plan is enclosed.

<u>Operations</u>

3. Records 1.1- Documentation of stormwater flap removal and valve adjustments from stormwater to leachate should be considered for recordkeeping

   Section 2.1.3 of the Operations Plan has been revised to describe the process for activating areas for ash placement which consists of opening valves, removal of rain flaps, verifying liner integrity, and documenting the process.

4. 1.9- Training materials used to train operators should be incorporated into the record.

   Section 1.10 of the Operations Plan has been revised to identify that employee training records and materials are kept onsite.

5. 2.1.2 (Facility 2.1.7) Acceptance Requirements- With what frequency will TCLP be run during the course of the movement to verify constancy with the initial results?

   While the Coal Ash Management Act of 2014 does not directly address this comment; Section .1700 of the Solid Waste rules provide a requirement to perform TCLP analysis annually on coal ash being used in a structural fill (15A NCAC 13B .1703 (a) (4)).

Section 2.1.2 of the Operations Plan has been modified to state that TCLP tests will be performed on each new ash source and at least annually for each source.

6. 2.2.2 LCS Maintenance- LCS – All new segments should be camera and cleaned as necessary to detect blockage or glue that could impede future inspections. Propose a schedule for checking and verifying integrity of the system, particularly early on when silting could be an issue.

   Section 2.2.2 of the Operations Plan has been revised to indicate all new segments shall be cleaned and videoed prior to putting into service. The leachate collection system will be video inspected once every two years, then cleaned if the video indicates a concern until the final cap system has been completely installed for the entire structural fill.

7. 2.2.3-There are activities that need to be accomplished including turning valves on or off, and removal of the storm flap. It is recommended that a process be developed to do this and document that the right valve is in the right position and that the flap has been removed with no damage to the liner and the documentation be kept in the facility record.

   [Section 2.2.3 of the Operations Plan (as referenced in the comment) describes the record keeping for leachate sampling. Section 2.1.3, Fill Sequencing, was the apparent reference and is responded to below.]

   Please refer to Response 3 for modification to Section 2.1.3 of the Operations Plan.

   The revised Operations Plan is enclosed.

<u>Closure Plan</u>

8. Introduction- first paragraph- revisions to the plan must be sent to the agency for modification of the permit prior to implementation.

   Section 1 of the Closure-Post Closure Plan has been revised to indicate any revisions to the Closure-Post Closure Plan shall be submitted to the department and approved prior to implementation.

9. 2.9- Certification of Closure should be submitted to the agency for any partial closure within 30-days.

   Section 2.9 of the Closure-Post Closure Plan has been revised to state that a certification signed and sealed by a registered professional engineer will be submitted to NCDENR within 30 days of the completion of the closure cap system or any partial closure of the cap system construction.

10. 3.7 A structural fill qualifies as a beneficial use and mine reclamation is a structural fill. What is the intended post-closure use of the facility beyond a field?

Section 3.7 of the Closure-Post Closure Plan indicates the property will be actively marketed as an industrial use site for development through the local and state economic development commission, as well as other real estate advertisement methods.

11. The Section financial assurance officer will provide guidance to the owner on the submittal of documentation for the instrument chosen, separately. Financial Assurance will be updated annually for construction, closures and inflationary increases.

    Comment noted. Charah/Green Meadow, LLC staff have been in contact with the Section's financial assurance officer. The required financial assurance will be applied as required prior to the operation of the facility as directed by the State.

    Section 2.8 of the Closure-Post Closure Plan has been revised to indicate the cost estimate will be updated annually.

    The revised Closure-Post Closure Plan is attached.

Engineering Plan

12. The liner stability analysis recommends the minimum bottom liner interface friction angle be 25 degrees. Is this reflected in the preconstruction testing requirements of the Technical specifications? Verify that the cross sections of the test are correct to match the analysis.

    Section 7 of the Engineering Plan indicates the minimum interface friction angle for the bottom liner shall be 26 degrees.

    Specification Section 01060 has been added to address the interface friction testing for both the base liner and the cap system. The following specifications have been revised to indicate the requirements for interface friction can be found in Section 01060.

    02240 – Leachate Collection Stone
    02276 – Soil Liner System
    02774 – LLDPE Geomembrane
    02775 – HDPE Geomembrane
    02777 – Drainage Composite
    02800 – Geosynthetic Clay Liner (GCL)

    Specification Sections 01060, 02240, 02276, 02774, 02775, 02777, and 02800 are enclosed.

HELP Modeling

13. With respect to the Help models of the various scenarios- How does the output match with experience by Charah at the Asheville Airport?

As discussed in Response 1 above, the worst case scenario for leachate management is to have a storm event the day a cell is activated for ash placement. HDR has developed several HELP model scenarios varying the thicknesses of ash placed above the liner system to show the impact on leachate generation as the structural fill is completed. In general, as more ash is placed, the leachate generation decreases due to the ability of the ash to absorb and retain the moisture. The leachate generation rates included in the calculations range from an average of 825 gallons per acre per day based on 60 feet of ash in place to an open cell condition where 97,749 gallons per acre are created from one 2-year, 24-hour storm event.

Information provided by Charah indicates the average leachate/contact discharge rate for Area 3 is 46,039 gallons per acre. This average includes varying conditions across the surface of the 30.8 acre containment area from open areas where all rainwater becomes contact water to areas that are above grade and covered with soil, thereby diverting clean rain water to the sediment basins.

The leachate generation calculations presented in the permit application bracket the actual field results seen at the Asheville Airport project.

14. For the open conditions, 100% runoff was allowed. Anything that contacts the ash is leachate. Is this number included in the leachate generation rates? What is the expected effect on the generation rate during operation if there is no runoff? The HELP model is iterative and a layer must be saturated before water moves to or from the next layer. Given the thickness of the ash in the model layers (20 feet) and the fact that the ash will be spread in thinner lifts, consideration might be given to breaking the thick layers into thinner ones. In general, the very bottom layer gives more representative results if layered as 1-2 feet thick. This lends to a more representative movement of the water in and out of the high permeability leachate collection system.

    HDR revised HELP Model Scenario 1 (20 feet of ash above the base liner system) to 0% runoff and the average annual leachate generation results increased from 897 to 1,227 gallons per acre per day. The revised results do not change the worst case for leachate generation (97,749 gallons per acre) which results from an open cell condition as discussed in Response 13 above. Additionally, HDR revised HELP Model Scenario 1 to break the 20 foot layer of ash into ten two-foot thick layers of ash. The leachate generation results were negligible and show a slight reduction in quantity generated per acre. The revised HELP model results have been added to Leachate Calculation section of the permit application as Attachment 6 to the Design of Leachate Collection System.

15. In the determination of leachate storage capacity, a 2-year, 24-hour rain is used for sizing. All of the other determinations used the 10-year, 24-hour storm. Why the difference and how does it affect the results?

    As discussed in Response 1 above, a 2-year storm event was selected as the design storm since the largest subcell (15.3 acres) will take approximately five months to floor in the area

with 20 feet of ash at the lower placement rate of 1,560,000 tons per year. The 10-year, 24-hour storm event was used for stormwater management on the closed cap and all other areas outside of the lined structural fill area.

16. While not specifically addressed by the statutes, please discuss the threatened and endangered species of the area and any potential cultural resources or lack thereof. Is it correct to assume this work was done prior to the issuance of a mining permit at some time in the past?

    A Threatened and Endangered Species Review and Habitat Assessment was conducted by ClearWater Environmental Consultants, Inc. for the site. An Archaeological Survey was conducted by TRC Environmental Corporation for the site. Both studies were included in the revised permit application dated December 31, 2014 submitted with HDR's response to completeness letter DIN 22536.

CQA Plan

17. Camera/Inspection of leachate lines after construction and before use is not specified, but highly recommended. In the experience of the section there is almost always an issue discovered in this process that can be fixed before the line is totally submerged under waste. For example, bends in the pipe or leftovers from the joining process can prohibit the movement of cameras or cleaning equipment, blockage due to dirt, rocks, and/or bottles is often found.

    Comment noted. Please refer to Response 6 above.

18. 6.2.4 -Are any of the materials sensitive to environmental exposure and are they properly speced to be covered, or have adequate UV protection? What is the UV standard for the geotextile of the drainage net?

    Geotextiles are sensitive to UV exposure. HDPE geomembrane's are not generally considered sensitive to UV exposure as they are predicted to last longer than 36 years in an exposed condition (GRI White Paper #6, February 2011).

    Section 02778 – Geotextiles is the specification for the geotextile component of the geocomposite. Page 02778-4 indicates geotextiles left uncovered for more than 90 days shall be replaced unless otherwise allowed by the Engineer. Additionally, Item C. under Part 2.2 of the specification has been added requiring manufacturer's certification that the material can withstand a minimum of 90 days of ultraviolet exposure.

    Page 02777-4 of Section 02777 – Drainage Composite has been revised to refer to Section 02778 for exposure limits.

    Revised Sections 02777 and 02778 are enclosed.

19. 10.2 Do you use traditional film or digital camera for photographic evidence?

Section 10.2 of the CQA Plan has been revised to indicate digital photographs or videos will be used to document the project.

A Revised CQA Plan is enclosed.

Technical Specs

20. There are no specifications or engineering for leachate storage tanks and secondary containment, or leachate lagoons. Please provide.

    Please refer to the Storage Tank technical specification and Tank Sizing calculation provided in the revised permit application dated December 31, 2014 submitted with HDR's response to completeness letter DIN 22536.

21. Are survey specifications needed? How many points and on what grid is the survey required? Make sure to remind the surveyor to survey at the same points for thickness, and that depth on side slopes is measured perpendicular to the slope.

    Specification Section 01060 has been added to indicate survey requirements. Survey requirements are also indicated in the CQA Plan.

22. 02220-What is the frequency of density testing on a berm? Is a test per unit foot and/or lift required as opposed to the 1 test per 10,000 ft2 mass area fill requirement?

    The testing frequency on a berm is the same as in the floor. Section 02220 3.2.D.3 has been revised to refer to the minimum test frequency indicated in Part 3.6.E.2 of the Section.

23. 02774- What are the specifications and conditions for the Interface Friction testing? (Section 2.3), such as layers and arrangements and confining pressure, friction etc. Are these tests required before placement of materials?

    Refer to Response 12 above on interface friction testing.

24. 02774 and 02275 – What are the specs for the nondestructive air pressure testing? (Section 3.Bb5b) Such as duration, pressure loss, accounting for temperature change and isolating the leak. Please ensure that it is recognized that repair of a leak by extrusion welding the flap is not an acceptable method. It should be cut out and wedge welded or have a cap strip placed over the area.

    Sections 02774 and 02775 indicate nondestructive air pressure testing to be performed in accordance with industry standard GRI GM6. The repair method for a failing non-destructive test is indicated in 3.1B4g and h respectively.

25. Specification 3.1A2e, what are the approved methods of determining thickness?

Part 3.1 A2e of Specification 02775 has been revised to indicate reference to Specification 01060 and the CQA Plan for approved methods of determining thickness.

Part 3.1 A of Specification 02774 has been revised to reflect the surface preparation of the CCP instead of surface preparation for soil liner.

26. 2777-2.3 Transmissivity Testing- Is the cross section correct? It uses soil against the upper fabric, but isn't ash the contact substance? Why is a confining pressure of 10,000 psi and gradient of 0.3 used? The transmissivity needed was determined with a 5k psi confining pressure and 0.02 gradient.

    The cross section and confining pressure for the transmissivity testing has been revised.

27. 02800 What is the reinforcement method for the GCL that is required?

    The reinforcement in a GCL is created during the manufacturing process by the fibers of a non-woven geotextile being needle-punched through the bentonite layer and into another non-woven geotextile. The needle-punched fibers give reinforced GCL higher internal shear strength.

28. Interface friction - Specify the specifications and layers.

    Section 01060 – Special Conditions has been added to indicate the interface friction testing requirements and layers.

Drawings

29. 01-08 Document flap removal and valve switch, and also verify that valves don't inhibit camera or cleaning equipment used in the cleaning of the leachate lines.

    Section 2.1.3 of the Operations Plan has been revised to describe the process for putting subcells into operation which consists of opening valves, removal of rain flaps, verifying liner integrity, and documenting the process. Full flow ball valves will be used to allow camera inspection and pipe cleaning.

The following items are provided for information and planning purposes.

General

30. Upon issuance of the Permit, any further modification or amendment to approved plans will require Section approval prior to implementation.

    Comment noted.

Prior to Construction – the following must be provided to the Section prior to commencement of construction;

31. Submit well abandonment records (Form GW-30) for each abandoned piezometer as needed during the progression of construction of each Subcell in electronic format (pdf).

    For each piezometer that is abandoned during construction, a well abandonment record (Form GW-30) will be submitted to NCDENR in electronic pdf format.

32. The permit will include conditions to submit the Construction Quality Assurance documentation for the constructed liner to the Section for review upon the completion of each permitted subcell or increment of construction. Should any discrepancies be indicated, the Section will contact the engineer for follow up. Placement of coal in the area prior to sign off by the section will be at the owner's risk.

    Section 2 of the Operations Plan has been revised to incorporate this comment.

33. Provide the approved Erosion and Sedimentation Control permit from the Division of Energy, Mining and Land Resources, in electronic format (pdf), for the Section's database record.

    The Erosion and Sedimentation Control permit is currently being reviewed. Upon approval, the permit will be submitted in electronic pdf format.

Prior to Initial Operation – the following must be provided to the Section prior to commencement of operations;

1. Once the monitoring wells have been installed, submit boring logs and well construction records (Form GW-1b) for each of the nine (9) compliance groundwater monitoring wells in electronic format (pdf).

    Comment noted.

2. Recent publication of the proposed CCR rules by the USEPA include provisions for groundwater sampling. Propose a ground water monitoring sampling schedule for the first six (6) months which addresses the initial baseline sampling of eight (8) independent background sampling events for the nine (9) compliance groundwater monitoring wells and one (1) background sampling event for the two (2) surface water monitoring locations. At least one sampling event must be completed before waste is put in the lined fill area. Plan to submit all results in electronic format (pdf).

    Charah/Green Meadow will implement a groundwater sampling procedure that adheres to the current rules and law.

In addition to the above edits, Clear Water Environmental Consultants, Inc. has provided an updated Stream and Wetland Delineation Map to HDR based upon their confirmation with the Army Corp of Engineers. This map has been added to the Related Documents section of the Permit Application. A copy is enclosed.

As a result, the following drawings have been revised to include the update: 00G-02, 00C-01, 00C-02, O1C-0101, 01C-02, and 01C-03. These revised drawings are enclosed.

If you have any questions, comments, or require additional information, please contact me at 704. 338.6843.

Sincerely,
HDR Engineering, Inc. of the Carolinas

Michael D. Plummer, PE
Project Manager

Enclosures:
- Facility Plan (revised)
- Operations Plan (revised)
- Closure-Post Closure Plan (revised)
- Calculation D
  - Design of Leachate Collection System Attachment 6 (new)
- CQA Plan (revised)
- Technical Specifications
  - 01060 – Special Conditions (new)
  - 02240 – Leachate Collection Stone (revised)
  - 02220 – Earthwork (revised)
  - 02276 – Soil Liner System (revised)
  - 02774 – LLDPE Geomembrane (revised)
  - 02775 – HDPE Geomembrane (revised)
  - 02777 – Drainage Composite (revised)
  - 02778 – Geotextiles (revised)
  - 02800 – Geosynthetic Clay Liner (GCL) (replaced)
- Related Documents
  - Stream and Wetland Delineation Map
- Drawings
  - 00G-02
  - 00C-01
  - 01C-01
  - 01C-02
  - 01C-03

Facility Plan

Colon Mine Site Structural Fill

Charah, Inc.

Sanford, NC

November 2014
Revised ~~December 2014~~ January 2015

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Table of Contents

List of Figures and Tables

Appendices

1 Introduction

This is a facility plan to reclaim the Colon Mine Site located in Lee County, North Carolina with coal combustion products (CCP) structural fill. The mine, once complete, will be reclaimed by encapsulating CCPs in a lined containment in order to re-establish the mine contours to a useful design.

Construction of the structural fill will begin once the North Carolina Department of Environment and Natural Resources (NCDENR) approves this permit application. Construction of the composite base liner system is anticipated to be completed in two phases. The Owner anticipates placing approximately 1,600,000 tons of CCPs a year in the 7.25 million cubic yard (cy) structural fill; therefore, placement will last approximately 5 to 5.5 years. The final closure cap is designed to minimize infiltration and erosion. In accordance with the North Carolina General Statutes, post-closure care will be performed for 30 years unless a revised schedule is approved by NCDENR.

1.1 Background

Green Meadow, LLC owns and Charah, Inc. will operate the Colon Mine Site located in Lee County, off Brickyard Road in Sanford, North Carolina under NCDENR Permit No. 53-05. The mine property, consisting of approximately 411 acres, is shown in the permit drawings. The property was previously owned and operated by General Shale. The mine was originally permitted in October 1972 according to information on the NCDENR website.

The structural fill, including associated perimeter berms, channels, and haul roads, will encompass approximately 137 acres, of which approximately 118 acres will be covered with a composite liner system for subsequent CCP placement. The proposed structural fill area is bounded on the east by the CSX railroad; on the north by a tributary to Roberts Creek; and on the south by Norfolk Southern railroad.

The structural fill is scheduled for construction in early 2015 with ash placement scheduled to begin in March 2015 to be in a position to comply with the schedule defined in the Coal Ash Management Act of 2014.

Figure 1 shows various site features including the proposed structural fill cells and the current property boundaries superimposed on an aerial photo. Figure 2 contains a survey of the structural fill property.

1.2 Responsible Party

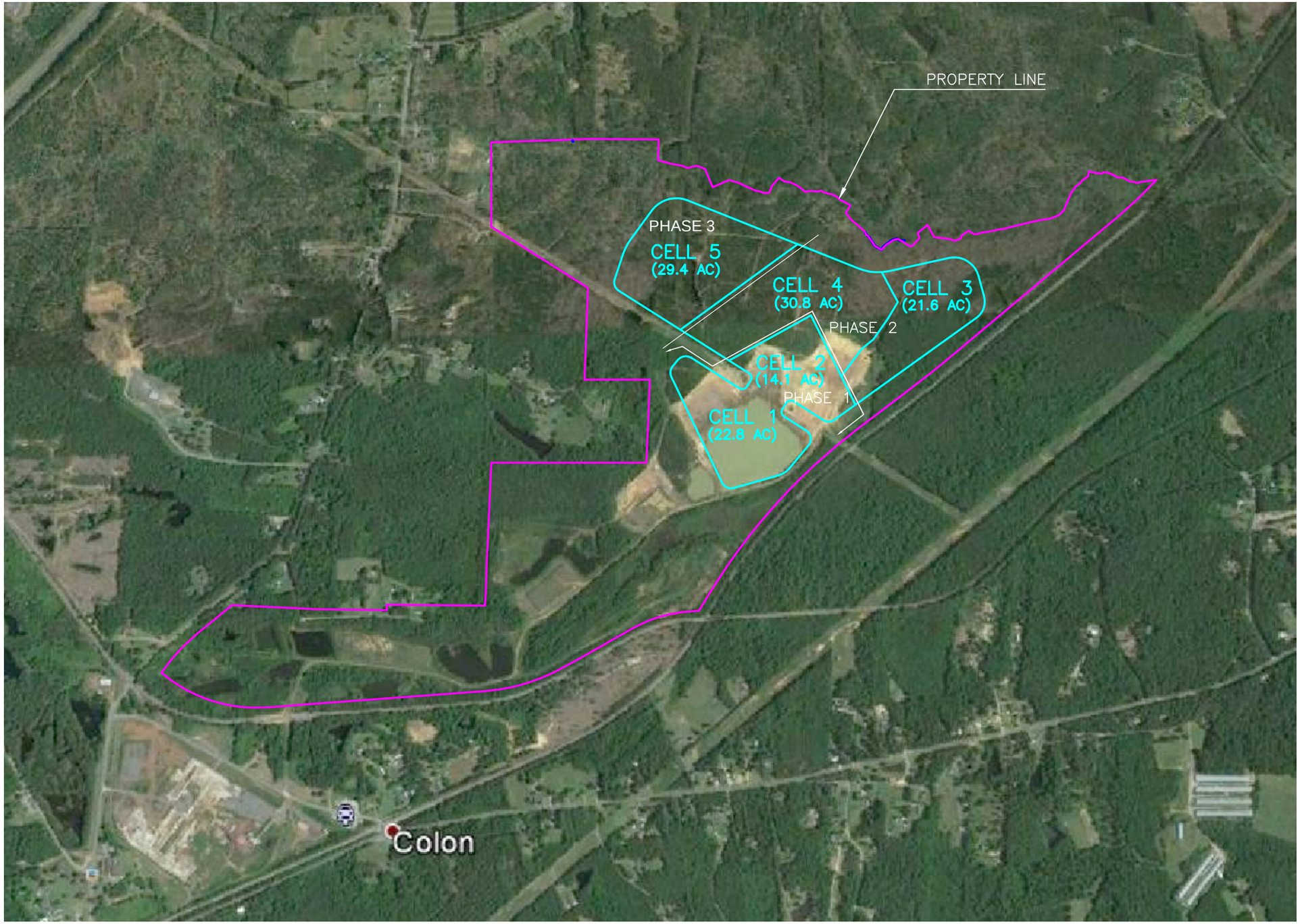
The owner of the Colon Mine Site is as follows.

Owner: Green Meadow, LLC
12601 Plantside Drive Louisville, KY 40299
(877) 314-7724, (502) 245-1353
Facility Contact: Mr. Charles E. Price

The Owner is also the Permittee and is responsible for this permit application

The company responsible for the operation and maintenance of the Colon Mine Site is as follows.

Operator: Charah, Inc.
12601 Plantside Drive Louisville, KY 40299
(877) 314-7724, (502) 245-1353
Facility Contact: Mr. Charles E. Price



HDR Engineering Inc.
of the Carolinas

440 S. Church St. Suite 1000
Charlotte, NC 28202-2075
704.338.6700
N.C.B.E.L.S. F-0116

COLON MINE SITE OVERVIEW

COLON MINE SITE

DATE
11/2014

FIGURE
1

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LINE TABLE

LINE	BEARING	LENGTH
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LINE TABLE

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L138	[illegible]	95.10
L139	[illegible]	93.09
L140	[illegible]	93.06
L141	[illegible]	86.51
L142	[illegible]	90.47
L143	[illegible]	92.87
L144	[illegible]	85.68
L145	[illegible]	47.58
L146	[illegible]	848.05
L147	[illegible]	808.46
L148	[illegible]	190.16
L149	[illegible]	95.30
L150	[illegible]	95.15
L151	[illegible]	95.30
L152	[illegible]	70.35
L153	[illegible]	88.08
L154	[illegible]	213.70
L155	[illegible]	414.51
L156	[illegible]	145.05
L157	[illegible]	146.77
L158	[illegible]	125.90
L159	[illegible]	103.21
L160	[illegible]	184.41
L161	[illegible]	192.77
L162	[illegible]	149.34
L163	[illegible]	145.98
L164	[illegible]	151.84
L165	[illegible]	151.51
L166	[illegible]	150.37
L167	[illegible]	146.99
L168	[illegible]	147.33
L169	[illegible]	148.22
L170	[illegible]	145.88
L171	[illegible]	95.90
L172	[illegible]	93.00
L173	[illegible]	104.26
L174	[illegible]	80.96
L175	[illegible]	97.39
L176	[illegible]	97.24
L177	[illegible]	98.73
L178	[illegible]	100.11
L179	[illegible]	99.02
L180	[illegible]	97.81
L181	[illegible]	98.47
L182	[illegible]	96.64
L183	[illegible]	103.52
L184	[illegible]	85.17
L185	[illegible]	141.30
L186	[illegible]	143.18
L187	[illegible]	138.73
L188	[illegible]	139.38
L189	[illegible]	140.04
L190	[illegible]	151.30
L191	[illegible]	140.94
L192	[illegible]	141.07
L193	[illegible]	1024.41
L194	[illegible]	329.71
L195	[illegible]	85.17
L196	[illegible]	86.96
L197	[illegible]	84.96
L198	[illegible]	85.72
L199	[illegible]	87.60
L200	[illegible]	88.70
L201	[illegible]	87.43
L202	[illegible]	90.07
L203	[illegible]	90.53
L204	[illegible]	85.60
L205	[illegible]	85.98
L206	[illegible]	89.80
L207	[illegible]	121.95

NOTES

1. Areas computed using coordinate geometry.
2. The property may be subject to right of ways, easements, restrictions and covenants either recorded or implied.
3. All distances shown are horizontal ground distances.
4. Rebar set at all corners unless otherwise noted.
5. Broken lines indicate property lines not surveyed.
6. All adjoining property owner information is taken from current deeds and tax records and are considered as "Now or Formerly".
7. Lawrence Associates makes no guarantees to the compaction or to the nonexistence of additional spoils areas.
8. Other underground utilities may exist but their locations are not known.
9. Wetland locations were generated by Clear Water and inserted in Lawrence Associates' survey.
10. Addresses provided by Lee County Public Works to determine drinking well locations and services to adjoining parcels within 500 feet of surveyed property.
11. Lee County Public Works provided parcels served by County water.
12. Topographic survey completed by Avonmage Mapping Services, Inc.
13. ALTA survey completed by Lawrence Associates,
106 West Jefferson Monroe, NC 28112
(704)-289-1013
www.lawrencesurveying.com

Flood Certification
I have examined the Flood Insurance Rate Map for Lee County North Carolina, Community Panel Number 3710962400J, Dated 06/2006, and hereby certify that a portion of this property is located in a special flood hazard area as determined by the Federal Emergency Management Agency.

This is to certify that this map or plat and the survey on which it is based were made in accordance with the 2011 Minimum Standard Detail Requirements for ALTA/ACSM Land Title Surveys, jointly established and adopted by ALTA and NSPS, and includes items 1, 3, 4, 11a, & 13 of Table A thereof.
The field work was completed on 8-19-14

Date of Plat or Map: 9-5-14

Andrew O. Lawrence, NCPLS L-4495

NORTH CAROLINA PROFESSIONAL SEAL L-4495 LAND SURVEYOR ANDREW O. LAWRENCE

Legend

Telephone Line	T
Power Line	ohe
Power pole	PP
Light pole	LP
Fire hydrant	FH
Water meter	WM
Water valve	WV

WNC
PROFESSIONAL ENGINEERS & SURVEYORS
WNC-PE&S, PLLC
1095 HENDERSONVILLE RD, SUITE G
ASHEVILLE, NC 28803
828-277-5074

Legal Description of General Shale Brick, Inc. and Cherokee Sanford Group, LLC Property located in City of Sanford, Lee County, North Carolina, and being further described as Tax Parcels [illegible]

[illegible]

General Shale Brick, Inc., Cherokee Sanford Group LLC Charah, Inc., Green Meadow LLC, Moore & Van Allen PLLC Chicago Title Insurance Company

Commitment Number: 14-12074CQ
Effective Date: July 11, 2014
Revision 1 August 11, 2014

TRACT SIX

34. Any right, easement, setback, interest, claim, encroachment, encumbrance, violation, variation or other adverse circumstance affecting the Title disclosed by plat(s) recorded in Plat Book 7, Page 67-G, Plat Book 10, Pages 66-76, and Plat Book 10, Page 208. (as not affect subject property)
35. Reservation of Minerals recorded in Mineral Book 1, page 28. (AS TO PARCEL 8) (as shown on map)
36. Easement(s) to Carolina Power & Light Company recorded in MP Book 13, page 478 and Book 402, page 723. (AS TO PARCEL 8) (MP Book 13, page 478, blanket easement not specific as to location and Book 402, page 723, as shown on map)
37. Reservation of mineral rights contained in Deed recorded in Book 543, page 795 and Book 471, page 538, as amended in Book 525, page 875. (AS TO PARCEL 8) (as shown on map)
38. Deed of Easement to Norfolk and Southern Railway Company recorded in Book 113, page 358. (AS TO PARCEL A4) (Power easement, as shown on map)
39. Terms and conditions of Agreement recorded in Book 258, page 612. (AS TO PARCEL A4) (Gate on south side of railroad, does not affect subject property)
40. Deed of Easement to the State Highway Commission recorded in Book 121, page 256. (AS TO PARCEL A4) (not enough information to determine impact)
41. Right of Way Easement recorded in Book 335, page 584. (AS TO PARCEL A4) (does not affect subject property, west side of Colon Road)
42. Deed of Easement to the City of Sanford recorded in Book 339, page 210. (AS TO PARCEL A4) (does not affect subject property, south side of Norfolk Southern Railroad)
43. Right of Way to Norfolk Southern Railway Company recorded in Book 56, page 362, in connection therewith Bill of Sale and Relinquishment of Easement recorded in Book 83, page 562. (AS TO PARCEL A4) (does not affect subject property, south of railroad)
44. Right of Way Agreements to State Highway Commission recorded in Book 119, pages 400 and 473. (AS TO PARCEL A4) (Book 119, page 400, does not affect subject property and Book 119, page 473, right of way for Colon Road)
45. General Permit to Home Telephone Company recorded in Book 255, page 429. (AS TO PARCEL A4) (does not affect subject property)
46. Easement to Central Electric Membership Corporation recorded in MP Book 108, page 231. (AS TO PARCEL A4) (blanket easement, not specific as to location)
47. Easements to Carolina Power & Light Company recorded in Book 238, page 201; Book 255, page 133, and Book 296, page 302. (AS TO PARCEL A4) (blanket easement, not specific as to location)
48. Deed of Easement to County of Lee recorded in Book 281, page 985, and as shown on Map Book 16, Pages 66-76. (AS TO PARCEL A4) (does not affect subject property)
49. Deed to Carolina Power & Light Company recorded in Book 25, page 41. (AS TO PARCEL A4) (does not affect subject property, south side of railroad)
50. Consent Notice recorded in Book 488, page 637 and as shown on map recorded in Plat Cabinet 7, Page 67-G. (AS TO PARCEL A4) (does not affect subject property, south side of Post Office Road)
51. Timber Deed recorded in Book 572, page 577 and assigned in Book 575, page 582. (AS TO PARCEL A4) (does not affect subject property)
52. Deed and Easement to Department of Transportation recorded in Book 722, page 22. (not enough information to determine impact)
53. Utility Station and Pipeline Easement to Public Service Company of North Carolina, Incorporated recorded in Book 848, page 841. (does not affect subject property)
54. Deed of Easement recorded in Book 855, page 800. (does not affect subject property)
55. Drainage Easements recorded in Book 943, page 879 and Book 912, page 206 and re-recorded in Book 948, page 205. (does not affect subject property)
56. Right of Way/Utility Easement recorded in Book 1105, page 386. (does not affect subject property)
57. Easement Deeds by Court Order recorded in Book 1333, page 167 and Book 1311, page 649. (telecommunication easement within the right of way of the railroad rightof way)
58. Deed of Easement recorded in Book 896, page 974. (does not affect subject property, west side of Colon Road)
59. Right of Way Agreement to Allied Communications recorded in Book 798, page 853. (blanket easement, not specific as to location)
60. Notice of Residual Petroleum recorded in Book 1317, page 379. (does not affect subject property, west side of Colon Road)
61. Deed of Easement to Michael Rawes and wife, Gladys Rawes recorded in Book 618, page 140. (as shown on survey)
62. Title to any portion of the Land lying within the right of way of Post Office Road and Birchard Road. (AS TO PARCEL A4) (not a matter of survey)
63. Title to that portion of the Land, if any, lying within the railroad right of way extending up to one hundred feet (100') on each side of the tracks or two hundred feet (200') in total width, whichever is greater and rights of way for railroad, switch tracks, spur tracks, railway facilities, easements, and other related interests, if any, on and across the Land. (AS TO PARCEL A4) (not a matter of survey)
64. Rights of others in and to the continuous and uninterrupted flow of the waters traversing or crossing the Land and riparian and/or littoral rights incident to the Land. (not a matter of survey)

TRACT SEVEN

65. Easement(s) to Carolina Power & Light Company recorded in Book 250, page 820. (blanket easement, not specific as to location)
66. Right of Way Agreement to Allied Communication recorded in Book 798, page 853. (blanket easement, not specific as to location)
67. Drainage Easement the Department of Transportation recorded in Book 912, page 206, as re-recorded in Book 948, page 205, and Book 943, page 879. (does not affect subject property, south side of railroad)
68. Easement Deed by Court Order in Settlement of Landowner Action recorded in Book 1333, page 167. (telecommunication easement within the right of way of the railroad rightof way)
69. Rights of others in and to the continuous and uninterrupted flow of the waters traversing or crossing the Land and riparian and/or littoral rights incident to the Land. (not a matter of survey)

TRACT EIGHT

70. Any right, easement, setback, interest, claim, encroachment, encumbrance, violation, variation or other adverse circumstance affecting the Title disclosed by plat(s) recorded in Plat Cabinet 2007, Slide 8. (as shown on map)
71. Easement(s) to Carolina Power & Light Company recorded in Book 396, pages 864, 867 and 870 and Book 451, page 852. (as shown on map)

ALTA SURVEY OF
GENERAL SHALE BRICK, INC. & THE
CHEROKEE SANFORD GROUP, LLC PROPERTY
FOR
CHARAH, INC.

West Sanford Township, Lee County, N.C.
DATE: 8-20-2014 DRAWN BY: Lawrence Associates
JOB #140807 CHECKED BY: TDT

250 0 250 500

SCALE 1" = 250'

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2 Facility Plan

2.1 Facility Plan

2.1.1 Facility Services

The Colon Mine Site facilities and activities may consist of the following.

- Administrative offices
- Equipment maintenance facility
- Mining/stockpiling operations and equipment
- CCP placement
- Railway off-loading area
- Structural fill operations
- Stormwater management devices

2.1.2 Facility Description

Sheet 00G-02, Facility Plan and Buffers, shows the Colon Mine Site property line. The plan includes all property, structures, and appurtenances designated as Colon Mine Site property, inclusive of the mining operations and the structural fill area; a total of approximately 411 acres.

The Colon Mine Site is located approximately five miles northeast of Sanford, North Carolina. The area surrounding the site consists of rural residential, wooded, and agricultural property. The site is bounded on the north by an unnamed tributary to Roberts Creek, on the east by the CSX railroad, and on the south by the Norfolk Southern railroad. The site is bisected by a Duke Energy power line right-of-way and consists of previously mined and wooded, unmined areas. There are several ponds on the southern half from previous mining activities. Onsite elevations range from approximately 226 to 336 mean sea level.

As described in Section 1 above, the structural fill, including stormwater management, leachate management, and haul roads, etc. will encompass approximately 137 acres, of which approximately 118 acres will be covered with a composite liner system for subsequent CCP placement.

2.1.3 Separation Requirements

Horizontal and vertical separation requirements are mandated in NCGS §130A-309.216 (c) and are discussed below.

2.1.3.1 HORIZONTAL SEPARATION REQUIREMENTS - LOCATION RESTRICTION DEMONSTRATION

Table 2 below summarizes the horizontal separation requirements.

Table 1 Structural Fill Horizontal Separation Requirements Summary

Feature	Restriction: A structural fill cannot be within
Property boundary	50 feet
Private dwelling or well	300 feet
Perennial stream or other surface water body[a]	50 feet
Floodplain	A 100-year floodplain[b]
Wetland	50 feet[c]

[a] The structural fill cannot be within 50 feet of the top of the bank of a perennial stream or other surface water body.

[b] In accordance with NCGS §130A-309.216 (c) (5), the structural fill cannot be placed "within a 100-year floodplain except as authorized under [NC]G.S. 143-215.54A(b). A site located in a floodplain shall not restrict the flow of the 100-year flood, reduce the temporary water storage capacity of the floodplain or result in washout of solid waste so as to pose a hazard to human life, wildlife, or land or water resources."

[c] In accordance with NCGS §130A-309.216 (c) (6), the structural fill cannot be placed "within 50 horizontal feet of a wetland, unless, after consideration of the chemical and physical impact on the wetland, the United States Army Corps of Engineers issues a permit or waiver for the fill."

The property boundary, private dwellings, groundwater wells, and floodplain buffers have been maintained as shown on Sheet G-02, Facility Plan and Buffers . Streams and wetlands were delineated and located onsite by Clearwater Environmental on August 8, 2014. The structural fill design impacts approximately 2,040 linear feet of streams and 0.62 acres of wetlands. Impacts to these will be permitted by the US Army Corp of Engineers and the NCDENR Division of Water Quality before construction occurs in these areas.

2.1.3.2 VERTICAL SEPARATION REQUIREMENT

NCGS §130A-309.216 (c) also mandates a vertical separation requirement for CCPs used as structural fill. The structural fill can not be placed within four feet of the seasonal high groundwater table per NCGS §130A-309.216 (c) (4). The bottom of ash has been designed to be a minimum four feet above the estimated seasonal high groundwater table. The proposed design satisfies the vertical separation requirements as shown on drawings provided with the Design Hydrogeological Report included in this Permit Application.

2.1.4 Types of CCP

The types of CCP specified for placement in the structural fill area are anticipated to be consistent with the CCP definition found in NCGS §130A-309.201 (4). This includes fly ash, bottom ash, boiler slag, or flue gas desulfurization materials.

2.1.5 Estimated Placement Rates

The anticipated filling rates of 6,000 to 8,000 tons per day which equates to 130,000 to 140,000 tons per month or 1,560,000 to 1,680,000 tons per year. This material will be brought to the site by truck, rail, or a combination thereof. Placement methods are detailed in the Operations Plan included in this Permit Application. Based on these filling rates, an assumed CCP density of 1.25 tons per cy, and an overall CCP capacity of approximately 7.25 million cy, this structural fill should take approximately 5.4 TO 5.8 years to complete.

2.1.6 Service Area

CCPs may come from power generation facilities located in North Carolina and South Carolina. Initial operations will receive ash from Duke Energy's Riverbend and Sutton facilities.

2.1.7 Procedures for CCP Acceptance

The structural fill will only accept CCPs that it is permitted to receive. The appropriate toxicity characteristic leaching procedure (TCLP) analyses are included in the Related Documents section of this application. The process will be repeated if the source changes. Any load that contains materials or CCPs that the structural fill is not allowed to accept will not be placed in the structural fill.

2.1.8 Equipment Requirements

Equipment requirements may vary in accordance with the method or scope of structural fill operations at any given time. Additional or different types of equipment may be provided as necessary to enhance operational efficiency; however, in order to ensure adequate operation of the proposed facility, arrangements shall be made to ensure that equipment is available for the following activities.

- Excavation of onsite soil
- Preparing the cells for CCP reception
- Spreading and compacting the CCP
- Moisture conditioning the CCP or structural fill
- Excavating and transporting cover soil
- Spreading and compacting cover soil
- Site maintenance, dust control, and clean-up work

The equipment onsite is currently used to manage mining operations. When the proposed structural fill is ready to accept CCPs, the equipment will use the procedures and techniques for spreading, compacting, and covering CCPs outlined in the Operations Plan included in this Permit Application. In the event the amount of CCP placement increases significantly, the need for additional equipment will be evaluated. Additional equipment may be rented to accommodate short term needs or purchased to accommodate increased CCP placement rates.

2.2 Containment and Environmental Control Systems

The base liner and final cap system will be constructed in accordance with NCGS §130A-309.216.

2.2.1 Base Liner System

The purpose of the base liner system is to contain CCPs within the structural fill and prevent groundwater contamination by the CCPs. The base liner area for the structural fill is approximately 118 acres and is shown on Sheet No. 00C-03, Top of Liner. The post-settlement bottom elevation of the ash will meet the minimum requirement of four feet above the seasonal high groundwater table. North Carolina law allows two different types of baseliner systems. The following describes the components of the regulatory base liner system options from top down and as shown on the drawings.

2.2.1.1 COMPOSITE BASE LINER SYSTEM OPTION 1

- 60 mil HDPE geosynthetic liner
- 24 inches of compacted soil liner with a permeability of 1 x 10^{-7} cm/sec

2.2.1.2 COMPOSITE BASE LINER SYSTEM OPTION 2

- 60 mil HDPE geosynthetic liner
- geosynthetic clay liner
- 18 inches of compacted soil liner with a permeability of 1 x 10^{-5} cm/sec

Option 2 was used as the basis of design for this permit application.

2.2.2 Final Cap System

The purpose of the final cap system is to contain CCP within the structural fill, prevent exposure of CCP, prevent infiltration into the structural fill, minimize erosion, and prevent stormwater from contacting CCP. The total area for the final cap system for the structural fill is approximately 118 acres (see Sheet 00C-04, Reclamation Plan). There are two proposed final cap system designs: a soil and geomembrane cap system option and a soil, geocomposite drainage layer and geomembrane cap system option. Each cap system has a top design and a side slope design. The components of the two proposed final cap systems are shown in Tables 2 and 3 below. The soil permeabilities are shown on the drawings.

Table 2 Final Cap System Design: Soil and Geomembrane Option

2% Top Design	4:1 Sideslope Design
• 6 inches topsoil	• 6 inches topsoil
• 12 inches low permeable soil layer	• 12 inches low permeable soil layer
• 24 inches unclassified soil layer	• 12 inches unclassified soil layer
• 30 inches drainage soil layer	• 18 inches drainage soil layer
• 40 mil polyethylene geomembrane	• 40 mil polyethylene geomembrane

Table 3 Final Cap System: Soil, Geocomposite Drainage Layer and Geomembrane Option

2% Top Design	4:1 Sideslope Design
• 6 inches topsoil	• 6 inches topsoil
• 66 inches soil layer	• 42 inches soil layer
• 250 mil geocomposite drainage layer	• 250 mil geocomposite drainage layer
• 40 mil polyethylene geomembrane	• 40 mil polyethylene geomembrane

2.2.3 Drainage, Erosion and Sediment Control

The erosion and sediment control structures are designed and maintained to manage the run-off generated by the 25-year storm event, convey it to the sediment basins, and conform to the requirements of the Sedimentation Pollution Control Law. Sediment basins were designed to pass the 10-year 24-hour design storm without employing use of the emergency spillways. Additional routing was performed to confirm that the emergency spillways can successfully pass the 25-year and 100-year storm events.

As part of the final cap system, diversion berms, side slope swales, and slope drains will be constructed to intercept run-off and prevent erosion. The side slope swales and diversion berms will be longitudinally sloped will carry run-off to slope drains that discharge into a perimeter channel. Channels will direct stormwater flow to sediment basins within the property.

Vegetation shall be established to protect the final cover system from erosion and to enhance the aesthetics of the closed structural fill. Plant species shall be selected based on the following criteria.

- Vegetation depth of rooting shall not extend to the geosynthetics per final cover design
- Final cover vegetation to be generally tolerant to local cover soil conditions
- Site climate adaptability (temperature, rainfall or drought tolerance, wind effects, exposure, and sunshine)
- Plant species shall be persistent and self-propagating
- Plant species shall exhibit a high percentage of surface coverage
- Plant species shall exhibit low long-term maintenance needs
- Additional procedures will be developed to implement and protect the integrity and quality of the final cover, and prevent soil erosion in disturbed areas

Calculations demonstrating the adequacy of the drainage and erosion and sediment control structures are provided in the Calculations portion of this Permit Application.

2.3 Total Structural Fill Capacity

The estimated volume of CCPs in the structural fill once it is complete is approximately 7.25 million cubic yards.

2.3.1 Available Soil Resources and Required Soil Quantities

The available soil resources for the construction of the proposed structural fill may come from a combination of onsite excavated soil from the structural fill footprint, onsite borrow soils, and offsite resources. Based on laboratory test data obtained from the Design Hydrogeologic Report, the hydraulic conductivity (k) of the onsite soils ranges from 6.23×10^{-5} cm/sec to 1.35×10^{-7} cm/sec. Generally the soils exhibiting the lower hydraulic conductivities were within the first few feet of the surface and tended to be more clayey. Construction of a base liner system using either onsite $k \leq 1 \times 10^{-7}$ cm/sec soils, or an alternate liner system design utilizing 18 inches of $k \leq 1 \times 10^{-5}$ cm/sec soil and a geosynthetic clay liner (GCL) is proposed. Soil borings indicate suitable onsite soils are available; however, a detailed borrow area study to determine the amount of suitable soils has not been completed.

The following table presents the estimates of the soil requirements for the structural fill construction based on the latest topographic survey available which is dated August 2014.

Table 4 Structural Fill Soil Requirements

Purpose	Material	Cap System Option 1 Quantity (cy)[a]	Cap System Option 2 Quantity (cy)[a]
Base Liner System[b]	18" of 1×10^{-5} cm/sec	305,000	305,000
Final Cap System	Topsoil	114,000	114,000
Final Cap System	Low Permeable Soil Layer	209,000	NA
Final Cap System	Unclassified Soil Layer	335,000	937,000
Final Cap System	Soil Drainage Layer	430,000	NA
	Total	**~1.4 million**	**~1.4 million**

[a] Each layer of the base liner and cap system assumes a 0.1 foot overbuild.
[b] 1×10^{-7} cm/sec base liner system was not used for this soil estimate.

Based on the topography shown on Sheet 00C-01, Existing Conditions, approximately 1.83 million cy of cut and 250,000 cy of fill are anticipated to construct the structural fill basegrades, perimeter berms, and perimeter roads. This represents an excess of approximately 1.58 million cy of soil that can be used for liner system or final cover construction if the soil meets the applicable specifications. Soils unsuitable for these uses can be stockpiled for operations or sold under the existing mining permit. Since Table 4 indicates that approximately 1.4 million cy will be required for the base system and closure, a net soil surplus of approximately 180,000 cy is anticipated, assuming all the soils onsite are suitable for use in the construction. Should there be a deficit in soils, the soil necessary to compensate for this deficit will be obtained from onsite borrow areas unidentified at this time or offsite sources. Two areas on Sheet 00C-02, Base Grade Plan, identified locations for potential future stockpiling of onsite soils. Erosion and sedimentation controls will be designed and permitted and any other necessary permits will be obtained prior to construction.

2.4 Leachate Management

The leachate management system includes features for collection, storage and disposal of leachate.

2.4.1 Leachate Collection System

NCGS §130A-309.216 (b) (2) mandates that, “[a] leachate collection system, which is constructed directly above the base liner and shall be designed to effectively collect and remove leachate from the project.” The base liner system will be constructed to maintain positive drainage post settlement to encourage leachate to drain to the sump.

The general leachate management system includes the collection, storage, treatment, and disposal of the leachate generated. The collection of leachate will be facilitated within the structural fill by the geocomposite drainage layer located directly on top of the base liner system and the use of perforated HDPE pipe laterals and header designed to hydraulically convey leachate to sump areas, which will contain submersible pumps. From there, leachate will be pumped through a solid wall HDPE forcemain to a leachate storage tank that will be located at the site. Clean-out riser pipes will be provided as shown on the drawings to allow for cleaning as necessary.

Leachate storage is provided in a 250,000 gallon storage tank with a secondary containment. Leachate storage may be managed in the structural fill as needed.

The Operator will dispose of the leachate properly at a wastewater treatment plant and will obtain a discharge permit for the leachate.

2.4.2 Leachate Generation Rates

Leachate is generated from a couple of sources: the liquids present in the ash at the time of placement and stormwater that infiltrates the CCP. Disposal of large quantities of liquid is currently prohibited in structural fills and unless it has rained during collection, most CCP is relatively dry; therefore, the majority of all leachate is derived from precipitation. Operations can greatly influence the diversion of precipitation from the placed CCP and hence impact the amount entering the system to be collected as leachate at some future date.

Construction of structural fill will result in a total lined area of approximately 118 acres. For a subcell 15.3 acres in size and using an estimated leachate generation rate of 43,761 cubic feet per acre per year as determined through HELP Model runs (see Calculations section of this Permit Application), a typical daily generation rate of 13,721 gallons per day is anticipated. A 250,000 gallon leachate storage tank represents approximately 18 days of storage capacity for the entire structural fill in operation. Storage capacity is also available within the subcell.

Based on information provided by Charah, the leachate/contact water discharged from the Asheville airport site to the Buncombe County Metropolitan Sewer District (MSD) has averaged 1,418,000 gallons per month for Area 3 (30.8 acres) or 46,039 gallons per acre per month. This average includes varying surface conditions across the Area 3 containment area from open areas where all rainwater becomes contact water to areas that are above grade and covered with soil thereby diverting clean rain water to the sediment basins.

The HELP Model results included in the Calculations section of the Permit Application estimates an average annual flow rate of 43,760 cubic feet (327,325 gallons) per acre assuming a 20 foot thick layer of ash across the acre. However, the worst case condition for leachate handling would be contact water from a storm event immediately upon activating an area. A 2-year storm event was selected as the design storm since the largest subcell (15.3 acres) will take approximately five months to floor in the area with 20 feet of ash at the lower placement rate of 1,560,000 tons per year. The 2-year storm event for the area is 3.6 inches. This equates to 1,495,555 gallons within the largest cell area or 97,749 gallons per acre. The leachate pipes as shown in the Pipe Sizing calculation of the Leachate Calculation section have been designed to convey this storm event in 5.5 days. The subcell divider berms have been designed to store the entire storm event as shown in the Stormwater Calculation section. The leachate/contact water from each subcell will be piped to the sump in solid pipes, out to the leachate tank, and then pumped to the treatment plant.

2.4.3 Leachate Management Systems

2.4.3.1 LEACHATE PIPELINE OPERATING CAPACITY

The 8-inch diameter design for the leachate collection laterals and headers is sufficient to drain leachate and allow for pipe cleaning and video recording. The maximum drainage length is 950 feet, as modeled on a two percent slope. The maximum drainage length will vary as the slope of the base liner varies. Leachate pipe spacing should be verified prior to leachate pipe placement. HDPE pipe will be used due to its chemical resistance to corrosion from leachate. The thickness and other physical properties of the pipe were selected to provide adequate structural strength to support the maximum static and dynamic loads and stresses imposed by the overlying materials and any equipment used in construction and operation of the structural fill.

The material surrounding the leachate collection pipes will consist of a coarse aggregate installed to provide a direct conduit between the pipe and CCP. The aggregate will be chemically compatible with the leachate generated and will be placed to provide adequate support to the pipes.

Calculations for various materials and conditions are included in the Calculations portion this Permit Application.

2.4.3.2 CAPACITY OF STORAGE AND TREATMENT FACILITIES

~~The proposed method for storing the extracted leachate from the structural fill will be to pump it to a 250,000 gallon storage tank with a secondary containment. Leachate will be stored until the tank can be emptied. Additional leachate can be stored in the structural fill as needed.~~ The primary leachate disposal will via private sewer line to a wastewater treatment plant. A discharge permit is currently being sought and will be provided prior to operation of the system

2.4.3.3 FINAL DISPOSAL PLANS AND DISCHARGE LIMITS

Leachate will be hauled by tanker trucks for disposal at a wastewater treatment plant. A discharge permit has not yet been obtained from a wastewater treatment plant. A copy of the discharge permit for the leachate will be included in the Operations Plan. The industrial discharge permit will be provided prior to the placement of ash within the structural fill.

2.5 Landowner Statement

NCGS §130A-309.215 (b) (1) e. requires that this permit application include a signed and dated statement by the owner of the land on which the structural fill is to be placed, acknowledging and consenting to the use of CCP as structural fill on the property and agreeing to record the fill in accordance with the requirements of G.S. 130A-[309].219. The Landowner Statement can be found in Appendix A of this Facility Plan.

2.6 Generator Contact Information

In accordance with NCGS §130A-309.215 (b) (1) f., the name, address, and contact information for the generator of the CCP is provided in Appendix B. Initial generators listed are Duke Energy's Riverbend and Sutton facilities. This information will be updated if new generators or new sources of CCP will be used as structural fill at the site.

2.7 Coal Combustion Product Generation Location

In accordance with NCGS §130A-309.215 (b) (1) g. the physical location of the project at which the CCP were generated is provided in Appendix B. This information will be updated if new generators or new sources of CCP will be used as structural fill at the site.

A

Landowner Statement

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Landowner Statement

In accordance with North Carolina General Statute §130A-309.215 (b) (1) e., I certify that Green Meadows, LLC own(s) the Colon Mine Site and I acknowledge and consent to the use of coal combustion products as structural fill on the property. I agree to record the fill in accordance with the requirements of North Carolina General Statute §130A-309.219.

Charles E. Price	Green Meadows, LLC
Printed Name	Company
Charles Price	President / CEO
Signature	Title
11-6-14	
Date	

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B

Coal Combustion Product Generator and Location Information

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Coal Combustion Product Generator and Location Information

Coal Combustion Product Generator Information

Company Name: Duke Energy

Company Address: 550 South Tryon Street

Charlotte, NC 28202

Contact Person: Chris Varner

Contact Person Email: chris.varner@duke-energy.com

Contact Person Telephone: (980) 373-2510

Coal Combustion Product Generation Location

Generation Location Address: Duke Energy – Riverbend Steam Station

175 Steam Plant Road

Mt. Holly, NC 28120

Generation Location Coordinates:

Latitude: 35.36022

Longitude: -80.97432

Generation Location Address: Duke Energy – Sutton Plant

801 Sutton Plant Road

Wilmington, NC 28401

Generation Location Coordinates:

Latitude: 34.28324

Longitude: -77.98595

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Operations Plan

Colon Mine Site Structural Fill

Charah, Inc.

Sanford, NC

November 2014
Revised ~~December 2014~~ January 2015

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Table of Contents

1 Introduction

1.1 Plan History

The following table provides a brief description of the revisions to the Operations Plan.

Revision	***Date of Document***	***Description of Revisions***
Initial Issue	October 15, 2014	Initial issuance of document.
Rev 1	December 31, 2014	Revised per NCDENR Comments DIN 22536
Rev 2	January 14, 2015	Revised per NCDENR Comments DIN 22502

1.2 Purpose

The purpose of this Operations Plan is to provide for the safe and efficient operation of the Colon Mine Site Structural Fill. This Operations Plan presents the operational requirements for 1) general facility operations, 2) operations management, 3) erosion and sedimentation control, and 4) vegetation management along with guidance for structural fill closure and required regulatory submittals. The Operations Plan also includes a structural fill life estimate.

The Colon Mine Site is located in Lee County, North Carolina at 1600 Colon Road, Sanford, NC 27330.

1.3 Contact Information

Correspondence and questions concerning the operation of the Colon Mine Site should be directed as follows.

Owner
Green Meadow, LLC
12601 Plantside Drive Louisville, KY 40299
(877) 314-7724
Facility Contact: Mr. Charles E. Price

Operator
Charah, Inc.
12601 Plantside Drive, Louisville, KY 40299
(502) 245-1353
Operations Contact: Mr. Scott Sewell

1.4 Safety

Operations at the Colon Mine Site were developed considering the health and safety of the facility's operating staff. The operating staff is provided with site-specific safety training prior to operations, and onsite activities are to be conducted according to the applicable sections of the Operator's Health and Safety Plan which shall be written to comply with all applicable OSHA standards. The Operator will prepare an Emergency Action Plan to address potential emergency situations at the site.

1.5 Access and Security Requirements

Security for the site consists of fencing, gates, berms, and wooded buffers. Unauthorized vehicle access to the site is prevented around the property by woodlands, fencing, gates, and stormwater conveyance features.

The access road to the site is of all-weather construction and will be maintained in good condition. Potholes, ruts, and debris on the road(s) will receive immediate attention in order to avoid damage to vehicles.

1.6 Equipment

In accordance with NCGS §130A-309.216 (a) (4) equipment will be provided that is capable of placing and compacting the coal combustion products (CCP) and handling the earthwork required during the periods that CCPs are received at the fill project. The structural fill site will have sufficient equipment to provide structural fill placement and compaction operations. Where possible, spare or substitute equipment will be provided as needed. If spare or substitute equipment is not available, other equipment may be obtained from other onsite operations. If other equipment is not available after 14 days, arrangements will be made for replacement equipment until the original equipment can be placed back in service.

1.7 Operating Hours

The Colon Mine Site is open for operation between the hours of 7:00 AM and 7:00 PM, Monday through Saturday. It is anticipated that this schedule will continue; however, operational hours may change as the need arises.

1.8 Signs

A sign providing facility name and operating hours will be posted at the site entrance and shall be maintained in good condition. Additional signs may be posted to facilitate facility operations as needed.

1.9 Training

Due to the diversity and nature of job tasks required at the site, personnel shall be adequately trained to handle facility operations and maintenance.

The site superintendent shall have a general understanding of all the tasks required for site operations. Individuals performing the various tasks shall have adequate training for the site-specific tasks they are assigned.

Noteworthy operations and maintenance tasks to be addressed in training include the following.

- Maintaining accurate records of fill loading (quantitative and qualitative)
- Operating requirements for stormwater segregation from exposed CCP material
- Operating and maintaining the leachate collection system (LCS)

1.10 Recordkeeping

An operating record is to be maintained onsite and include the following records.

- Leachate Collection System – Maintenance Documentation & Disposal Records
- Erosion and Sedimentation Control Inspection Logs
- Groundwater Monitoring (and Sampling) Report
- Precipitation Totals

- Daily Operation Record
- Employee Training Records and Materials
- or anything else as indicated in the Operations Plan

The above records are to be kept in the operating record for the active life of the Colon Mine Site and the 30-year post-closure period. Information contained in the operating record must be furnished upon request to the North Carolina Department of Environment and Natural Resources (NCDENR). Additional records kept onsite should include the following.

- Facility permit application
- Facility permits
- Record of the amount of structural fill placed on a monthly basis
- Regulatory agency inspection reports
- Construction documents
- Employee training records
- As-built drawings and specifications
- Health & Safety Plan
- Emergency Action Plan

1.11 Permit Drawings

Permit drawings are included in the structural fill permit application.

2 Operations Management

The primary objective of operations management at the Colon Mine Site is to place structural fill in the form of CCPs in compliance with permit conditions while operating in a safe manner. Prior to placement of CCP in a new cell, new subcell, or portion of a new subcell, the Owner will submit to NCDENR the Construction Quality Assurance documentation for the constructed base liner for review. Should any discrepancies be indicated, NCDENR will contact the Owner for follow up. Placement of CCP in new cell, new subcell, or portion of a new subcell prior to approval by NCDENR will be at the owner's risk.

The structural fill site has been designed to provide separation of contact water from non-contact water. Contact water is defined as water that contacts CCP material within the geomembrane lined limits of structural fill. Contact water will be managed as leachate while non-contact water will be managed as stormwater. Contact water and non-contact water separation are further described in subsequent sections of this plan.

Filling operations will generally proceed from high to low. The working face will be limited to as small an area as practical, at the owner's discretion. Contact water from the active face will be directed to the leachate collection system.

Intermediate cover will be placed as CCP fill reaches final grades to prevent contact water from entering the stormwater control features.

2.1 Structural Fill Placement and Sequencing

2.1.1 Structural Fill Capacity

The total anticipated airspace capacity for the Colon Mine Site is approximately 7.25million cubic yards and is based on a proposed 118-acre fill area.

2.1.2 Structural Fill Acceptance Requirements

In accordance with NCGS §130A-309.216 (a) (2) CCPs shall be collected and transported in a manner that will prevent nuisances and hazards to public health and safety. CCPs shall be moisture conditioned, as necessary, and transported in covered trucks or rail cars to prevent dusting. As such, the Colon Mine Site can accept CCPs defined as fly ash, bottom ash, boiler slag, or flue gas desulfurization materials in NCGS §130A-309.216 (4).

In accordance with NCGS §130A-309.215 (b) (1) d, a Toxicity Characteristic Leaching Procedure (TCLP) analysis has been performed on a representative sample from Duke Energy's Sutton Plant and Riverbend Steam Station CCP sources to be used in the structural fill project. Each was analyzed for, at a minimum, the following constituents: arsenic, barium, cadmium, lead, chromium, mercury, selenium, and silver. The TCLP results are included in the Related Documents section of this application. TCLP tests will be performed on each new ash source and at least annually for each source.

Asbestos containing material will not be placed in the structural fill site. In addition, the removal of CCP structural fill material from the site is prohibited without owner approval. Structural fill will be hauled and placed by dedicated and consistent operators.

2.1.3 Fill Sequencing

The Colon Mine Site will be developed in sequence from Cell 1 through Cell 5. CCP product will be placed in three to five foot operational lifts, high to low. A conceptual schematic of fill sequencing from high to low is included in the permit drawings; however, actual fill sequencing and lift heights may be modified at the Owner's discretion. More than one cell may be operational at a time. The cells may also be subdivided into subcells.

The following procedure shall be followed to activate an area for leachate collection prior to placing CCP.

- Remove all stormwater (i.e., water that has not contacted ash) ponded within the area. Stormwater may be pumped directly into the perimeter channel.
- Close the Stormwater valve. Ensure the valve is completely closed.
- Open the leachate valve. Ensure the valve is opened fully.
- Remove the rain flap by cutting above the weld to the sacrificial liner above the primary geomembrane (refer detail 8 on Drawing 00C-08). Visually inspect the area to confirm the integrity of the base liner. If the base liner appears damaged, repair it in accordance with the technical specifications.

Document on a site plan the location of the subcell where the stormwater valve was closed, the leachate valve was opened, the rain flap was removed, condition of the base liner, and the specifics of any repairs that were made. Place the documentation in the operating record.

2.1.4 Fill Placement

Structural fill placed at the Colon Mine Site will be transported to the facility via railcar or highway-rated vehicles. Upon reaching the site, off-road equipment may be utilized, within the facility boundary, to transport material to the active working area. After initial placement, additional operational equipment generally consisting of vibratory smooth drum rollers, sheepsfoot compactors, bulldozers, water trucks, spray trailers, track hoes, and service trucks may be utilized in fill placement.

Fill progression will be maintained to provide controlled drainage of contact water to the leachate collection system and stormwater runoff to the stormwater benches and perimeter ditches. No fill shall be placed in standing water.

2.1.5 Compaction Requirements and Testing

After the bottom liner is placed and approved, CCP placement may begin. The initial CCP lift placed should be two to three feet thick to protect the liner system. The initial lift shall be placed in a manner that minimizes development of folds in the geosynthetics. The surface should be lightly compacted to help avoid potential damage to the liner system.

Subsequent lifts of CCP should be placed in 12-inch thick loose lifts and compacted to at least 95 percent of its Standard Proctor (ASTM D698) maximum dry density. It may be necessary to adjust the moisture content of the CCP fill to achieve the specified compaction.

2.1.5.1 IN-PLACE DENSITY AND MOISTURE CONTENT TESTING

In-place density and moisture content testing shall be performed at a minimum frequency of one test per 10,000 tons placed. CCP shall be compacted to a minimum 95 percent of its Standard Proctor (ASTM D698) maximum dry density. Compacted moisture content shall be within five percent of the material's optimum moisture content as determined by ASTM D698. If field density tests indicate that the relative compaction or moisture content requirements are not met, the material shall be moisture conditioned and/or re-worked and re-tested until the compaction density and moisture requirements are met. The field density testing report should document any failing tests and re-work required to meet testing requirements.

In-place density tests shall be performed using the Sand Cone Method (ASTM D1556), Drive-Cylinder Method (ASTM D2937), or Nuclear Method (ASTM D6938). If the nuclear method is selected, a minimum of one comparison density test using the Sand Cone or Drive Cylinder method shall be performed for every three nuclear density tests, and correlations between the test methods shall be developed and reviewed by the Engineer. A sample of CCP material shall be collected from each density test location and placed in a sealed container for subsequent field and laboratory moisture testing.

A family of Proctor curves shall be developed for the onsite CCP material as standard Proctor moisture-density tests are performed as a reference for the field density testing. Laboratory proctors shall be conducted at one test per 50,000 tons of CCP placed. A minimum of one (1)

one-point field Proctor test shall be performed for each week of field density testing or if there is a noticeable change in material. Additional Standard Proctor samples shall be obtained and tested if one-point Proctor testing indicates that the estimated maximum dry density of the material varies by more than five pounds per cubic foot (pcf) from the nearest representative standard Proctor moisture-density relationship as determined by the one-point Proctor method.

Field moisture content testing shall be performed for each density test using the Direct Heating Method (ASTM D4959). The Nuclear Method (ASTM D6938) shall not be used for moisture content testing on the CCP material. Comparison laboratory moisture content testing shall be performed using the Oven Method (ASTM D2216), at an oven temperature of 60 degrees Celsius. The laboratory moisture content shall control in the event of a discrepancy between laboratory moisture content and in-place moisture content.

2.1.5.2 LABORATORY TESTING

Laboratory moisture content testing shall be performed in conjunction with the field density testing as described above. The laboratory moisture content testing shall be performed using the Oven Method (ASTM D2216), at an oven temperature of 60 degrees Celsius.

2.1.6 Cover Requirements

2.1.6.1 INTERIM COVER SOIL

Interim cover soil should be applied, as needed, for dust control and stormwater management. The interim cover may be applied at a thickness suited to its purpose. For example, the interim cover soil may be applied in thinner layers to provide dust control and it may be applied in thicker layers where protection from surface erosion is desired.

Interim cover layer may be placed on exterior slopes and in areas where final structural fill grades have been reached. Interim cover will be seeded within seven days in accordance with erosion and sediment control requirements. Vegetation shall be removed and the interim cover soil shall be scarified or removed prior to placing any overlying CCP material or final cover system. Interim cover soil is not required, but may be used to protect the CCP materials and segregate contact water from stormwater.

2.1.6.2 FINAL COVER

The final cover consists of a six foot thick system of layers for the top slopes and a four foot thick system of layers for the sideslopes. Each area has two options. Option 1 has a one foot thick drainage soil placed directly above the HDPE geomembrane. Option 2 replaces the drainage layer soils with unclassified soils and has a geocomposite placed immediately above the HDPE geomembrane. See the table below and the details on the drawings for additional information.

Layer	Sideslope Option 1	Top slope Option 1	Sideslope Option 2	Top slope Option 2
Topsoil	6 inches	6 inches	6 inches	6 inches
Low Perm Soil	12 inches	12 inches	NA	Not used
Unclassified Soil	12 Inches	24 inches	42 inches	66 inches
Drainage Soil	18 inches	30 inches	NA	NA
Geocomposite	Not used	Not used	used	used
HDPE Geomembrane	40 mil	40 mil	40 mil	40 mil

The final cover system construction for the structural fill site will begin 30 working days or 60 calendar days, whichever is less, after CCP placement completion unless otherwise approved by NCDENR.

Please refer to the Closure/Post-Closure Plan included in this Permit Application for final cover specifications and maintenance requirements.

2.1.7 Dust, Litter, Odor, and Vector Control

Litter, odors, and vectors are not anticipated to be concerns. The material placed in the structural fill does not attract vectors, and windblown material is not anticipated to be a problem. Additionally, CCP materials are not typically associated with odors.

2.1.7.1 DUST CONTROL

In accordance with NCGS §130A-309.216 (a) (9) the structural fill project will be operated with sufficient dust control measures to minimize airborne emissions and to prevent dust from creating a nuisance or safety hazard and shall not violate applicable air quality regulations.

The primary potential source of dust emissions on site is the top deck area and active area of structural fill placement. These areas are at a higher risk for producing dust due to vehicular and equipment traffic and earthwork-like construction. Exterior slopes are less of a dust control concern, as they have interim cover soil which is vegetated.

Dust emissions can be controlled through a variety of methods identified herein. Dust control methods may be characterized as products and/or applications, structural wind breaks and/or covers, and operational methods.

Dust control methods for the facility include the following.

- Watering
- Establishing vegetative cover
- Mulching
- Structural controls consisting of:
    - Wind breaks (i.e. fencing and/or berms), and
    - Temporary coverings (i.e. tarps)
- Spray applied dust suppressants consisting of, and not limited to:
    - Anionic asphalt emulsion
    - Latex emulsion
    - Resin in water
    - Polymer based emulsion
    - Mineral mortar coatings (i.e. posi-shell)
- Calcium chloride
- Soil stabilizers (i.e. soil cements)
- Operational soil cover
- Modifying the active working area

- Modifying operations during dry and windy conditions

The operator may use, and is not limited to, combinations of these dust control methods or any method that is technically sound to control dust for specific site conditions. If the operator intends to use a dust control method not presented above, the proposed dust control method will be evaluated on a case by case basis to assess the effectiveness with specific site conditions. For the purposes of this Operations Plan, interim cover soil will be defined as soil material applied at a suitable thickness to provide dust control.

The effectiveness of the dust control methods implemented should be evaluated through visual observations of dust prone areas. Equipment operators shall continuously observe the active face and other areas within the facility for dust emissions.

If fugitive dust emissions are observed and observations indicate dust control measures are not achieving their intended purpose, then appropriate corrective actions will be taken. Dust control measures should be reapplied, repaired, or added, as necessary, to control dust emissions. The operator will construct, install, apply, and/or repair dust control measures prior to the end of the work day to control dust emissions during non-operating hours. The operator shall also implement dust control measures as preventative controls rather than in response to fugitive dust emissions.

A wheel wash system may be necessary to minimize dust and tracking of CCPs outside the facility.

2.2 Leachate and Contact Water Management

In accordance with NCGS §130A-309.216 (a) (5) the CCP structural fill project will be effectively maintained and operated as a nondischarge system to prevent discharge to surface water resulting from the project.

As previously described, the structural fill site has been designed to provide separation of contact water from non-contact water (stormwater). Contact water will be treated as leachate and conveyed to the LCS. Contact water which contacts exposed CCP material within the lined footprint will be conveyed through the LCS. Stormwater will be routed to onsite sediment basins prior to discharge from the site.

2.2.1 Leachate Collection System

The LCS includes a synthetic composite drainage layer and leachate collection pipes with clean-outs. Leachate generated in each cell drains by gravity via perforated header pipes to a series of sumps and then pumped to a central lift station where it is then pumped into a 250,000 gallon storage tank with a secondary containment. Leachate will either be transported to a wastewater treatment plant or discharged directly into a sanitary sewer system. ~~New leachate collection systems should be water pressure cleaned or inspected by video recording after a year of initial placement of CCPs in order to ensure proper drainage.~~

All loading of leachate tankers will take place on the loading pad next to the storage tank. Prior to loading the operator will insure that the leachate diverter valve is open on the drain pad so any leachate that may be spilled during loading operations will drain back into the lift station.

It will be the responsibility of the tanker operator to ensure that the load is within legal transportable limits. If the load exceeds permissible limits then the tanker operator will:

- Go back to the loading drain pad
- Verify that the leachate diverter valve is open
- Discharge a quantity of leachate sufficient to meet the maximum transport weight capacity

The owner is responsible for the operation of the leachate collection and removal system and for maintaining the system as designed for the life of the structural fill and the post-closure period. The department may allow the constructor or operator to stop managing leachate upon a satisfactory demonstration that leachate from the project no longer poses a threat to human health and the environment. Leachate shall be collected and treated as necessary so that water quality standards and criteria are not violated. A recording rain gauge will be maintained onsite to record precipitation at the structural fill site. Precipitation records are included with the operating record and are maintained and used by the Operator to compare with leachate generation rates.

2.2.2 LCS Maintenance

The maintenance of the leachate collection system's physical facilities (consisting of high-density polyethylene (HDPE) piping and storage unit(s)) and records will be performed by or under the direct supervision of the Owner or Owner's representative. Visual observations of proper LCS performance will be made periodically to verify that the LCS is performing properly.

New leachate collection systems ~~may~~ will be water pressure ~~cleaned~~ washed ~~or~~ and inspected by video recording prior to putting the system into service. Until the structural fill unit is closed, t~~T~~he system will be re-inspected by video once every two years, then cleaned if video indicates a concern. ~~i~~If it becomes apparent that the system is not functioning properly, it may be inspected by video. ~~Results~~ Records of the collection system cleanings ~~or~~ and inspections shall be kept onsite ~~in accordance with recordkeeping requirements~~. ~~The documentation shall include at the minimum following details.~~ A report shall document each video and/or cleaning activity and shall include the following details at a minimum.

- General details (a signed letter/report with company name that performed the cleaning/video inspection, dates & time for jet-cleaning/video inspection, any historical issues associated with jet-cleaning/video inspection, etc.)
- Pipe IDs that were jet-cleaned/video inspected; for example: Cleanout 1 was jet cleaned/video inspected
- Length of each pipe jet-cleaned/video inspected; for example: Cleanout 1 was jet cleaned/video inspected for 400 feet
- Any obstruction or unusual situation that occurs during jet-cleaning/video inspection. For example: Cleanout 2 was jet cleaned 20 feet only as pressure hose did not go beyond

- The maintenance frequency of the LCS may be modified based on consecutive inspection results and observed operating conditions

2.2.3 LCS Record Keeping and Sampling

~~Records will be maintained documenting the leachate line maintenance~~. Untreated leachate shall be sampled and analyzed at least semi-annually concurrently with the groundwater sampling. Leachate will be sampled as a composite grab sample from the effluent line of the leachate collection system. The leachate must be analyzed for the same constituents as the groundwater monitoring wells in the Water Quality Monitoring Plan included with the Design Hydrogeological Report contained in this Permit Application. The results must be submitted to NCDENR with groundwater results.

2.3 Stormwater Management System

The stormwater management system includes slope drains, culverts, perimeter channels, etc., that convey stormwater to the sediment basins. Stormwater that does not come in contact with structural fill will be treated as non-contact water. To improve operations, stormwater should be diverted from the active area. Excessive surface water at the working face creates difficulties for maneuvering equipment and prevents the operator from achieving maximum compaction of structural fill. To divert stormwater runoff away from the working face, temporary diversion berms may be installed as dictated by the direction of grade. In addition, interim soil cover may be placed over structural fill that has reached final grade. This cover will be uniformly graded and compacted to prevent the formation of erosion channels. In the event that channels do form, the cover should be promptly repaired.

Typically, all stormwater runoff that has not contacted structural fill will be drained from the active fill areas and routed to the peripheral drainage channels that surround each working area. The stormwater channels, culverts, and sedimentation ponds are designed to convey and discharge all stormwater runoff from a 25-year, 24-hour-duration storm event. Within the active portion of the site, all working areas are to be maintained and graded to allow stormwater to flow away from the active face and toward the peripheral drainage channels. Interceptor berms to control the flow of runoff from the surface are to be constructed so that runoff will not be allowed to cascade down the side slopes.

The stormwater management system within the structural fill boundary will be constructed during each phase of partial closure. A series of permanent swales and structures to control the flow of runoff from the finished and capped structural fill will be used. These swales and structures will assist in the prevention of erosion damage to the structural fill's final cover. The stormwater management structures will be in accordance with the closure plan for the full buildout. Minor modifications to the locations of terraces, inlet structures and slope drains may be required depending on the prevailing grades of the structural fill cover at the time of closure due to settlement. If such modifications are needed, an investigation will be performed to confirm that worst case input parameters will not be exceeded. If any of the worst case input parameters exceed, original calculations will be revised prior to closure to confirm that original design intent is met.

The stormwater management system outside the structural fill footprint will be constructed along with each cell construction. The stormwater channels are constructed around the perimeter of the site as shown on the closure plan so that stormwater from the closed fill areas will flow into these ditches and then into the stormwater detention ponds. The stormwater detention areas are designed to control all runoff from this nearly impervious final cover cap.

Stormwater collection and conveyance measures will be inspected and maintained in accordance with the current Erosion and Sedimentation Control (E&SC) Plan.

The following shall be performed on all permitted systems.

- Removal of debris, if any
- Inspection of inlets, outlets and culverts
- Removal of sediments when the storage volume or conveyance capacity of the system is below design level or when the system is rendered ineffective on account of clogging/sedimentation of the pond bottom
- Any breach of the system's integrity shall be immediately repaired. Whenever erosion is detected, measures shall be taken to stabilize and protect the affected area
- Mowing and removal of grass clippings

2.3.1 Stormwater Discharge

The stormwater system at the site was designed to assist in preventing the discharge of pollutants. Structural fill operation shall not cause a discharge of pollutants into waters of the United States, including wetlands, that violates any requirement of the Clean Water Act, including but not limited to NPDES requirements, pursuant of Section 402. In addition, under the requirements of Section 404 of the Clean Water Act, the discharge of dredge or fill material into waters of the state that would be a violation of the requirements shall not be allowed.

Operations of the site shall not cause the discharge of a non-point source of pollution to waters of the United States, including wetlands, that violates any requirements of an area-wide or statewide water quality management plan that has been approved under Section 208 or 319 of the Clean Water Act, as amended.

2.3.2 Contact and Stormwater Maintenance Requirements

All drainage features (i.e., diversion ditches, berms, risers, discharge pipes, etc.) will be inspected and maintained in accordance with the current E&SC Plan and documented for signs of damage, settlement, clogging, silt buildup, or washouts. If necessary, repairs to drainage control features will be made as early as practical. The stormwater controls and/or erosion control measures shall be employed to correct any erosion which exposes CCP or causes malfunction of the stormwater management system. Such measures shall be implemented within three days of occurrence. If the erosion cannot be corrected within seven days of occurrence the structural fill site operator shall notify the Department and propose a correction schedule.

2.4 Water Quality Monitoring Requirements and Management

In accordance with NCGS §130A-309.216 (a) (6) the structural fill project will be effectively maintained and operated to ensure no violations of groundwater standards adopted by the Commission pursuant to Article 21 of Chapter 143 of the General Statutes due to the project. Groundwater and surface water will be monitored in accordance with the Water Quality Monitoring Plan included with the Design Hydrogeological Report contained in this Permit Application.

Groundwater monitoring wells are located around the facility's perimeter. A readily accessible, unobstructed path shall be maintained so that monitoring wells may be accessed using four-wheel drive vehicles. Care must be taken to prevent any damage to the wells.

3 Erosion and Sedimentation Control

Erosion and sedimentation control during filling operations will consist of monitoring and repairing E&SC stormwater conveyance features and surface erosion as defined in this Operations Plan and the current E&SC plan. Monitoring and maintenance of the E&SC system will be in accordance with the current E&SC Plan.

4 Vegetation Management

Vegetation will be established to minimize erosion and to ensure no visible CCP migration to adjacent properties. Temporary and permanent seeding will be applied as required. Temporary and permanent seeding will be applied in accordance with Technical Specification 02485, Seeding included in this Permit Application.

5 Site Closure

The Colon Mine Site will be closed in accordance with the design drawings and Closure/Post-Closure Plan. The Closure/Post-Closure Plan outlines the sequence for closing the site and the post-closure maintenance activities. Closure is designed to minimize the need for long-term maintenance and to control the post-closure release of contaminants. Closure activities may be revised as appropriate for materials, specifications, technology advancements, or changes in regulations at the time the site is closed or in post-closure. In general, the site development is designed so that final cover can be established as soon as practical.

6 Required Regulatory Submittals

Water Quality Monitoring Reports will be submitted to NCDENR in accordance with the Water Quality Monitoring Plan included with the Design Hydrogeological Report contained in this Permit Application.

Closure and Post-Closure Plan

Colon Mine Site Structural Fill

Charah, Inc.

Sanford, NC

November 2014
Revised ~~December 2014~~January 2015

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Appendix

1 Introduction

The purpose of the Closure/Post-Closure Plan is to outline the steps for the Operator to follow during closing of the structural fill and the post-closure maintenance activities for the structural fill. Closure is designed to minimize the need for long term maintenance and to control the post-closure release of contaminants. The proposed Closure Plan should be re-evaluated by a registered professional engineer prior to closure activities. Closure activities may be revised as appropriate for materials, specifications, technological advances or changes in regulations at that time. Any revisions shall be submitted to the department and approved prior to implementation. The proposed top of coal combustion products (CCP) contours for the structural fill are shown on Sheet 00C-04, Reclamation Plan, contained in the facility permit application.

Phasing of the structural fill development is designed so that final cover can be established as soon as possible. The final cover will be constructed in stages as cells of the structural fill reach final grade. The final structural fill contours will have erosion control benches and side slopes at a maximum 4H:1V. The top of the structural fill is designed for a minimum two percent slope.

Final closure of each structural fill cell will commence when the Operator declares that no more CCP will be placed or as directed by the North Carolina Department of Environment and Natural Resources (NCDENR).

Prior to beginning closure of each structural fill cell, the Operator shall notify NCDENR that a notice of intent to close the structural fill cell has been placed in the operating record. Closure activities for the structural fill cell shall begin no later than 30 working days or 60 calendar days, whichever is less, after CCP placement has ceased (in accordance with North Carolina General Statute (NCGS) §130A-309.218(a)(1)) unless otherwise approved by NCDENR.

The final cover system for the closed phase will be certified by a professional engineer as being completed in accordance with the Closure/Post-Closure Plan.

Following closure operations, the facility may be developed.

If the structural fill must be closed prior to reaching the final contours, the surface of the structural fill will be sloped to a minimum grade of two percent and maximum grade of 4H:1V. A final cover will be established over the structural fill cell being closed.

2 Closure Plan

A Closure Plan is required by North Carolina General Statute (NCGS) §130A-309.218 (b) (1) to be submitted to the North Carolina Department of Environment and Natural Resources (NCDENR) for large structural fill projects. Large structural fill projects are defined in NCGS §130A-309.218 (b) as involving placement of 8,000 or more tons of CCP per acre or 80,000 or more tons of CCP in total per project. NCGS §130A-309.218 (b) (1) requires a closure plan to describe the cap system and the methods and procedures used to install the cap system; provide an estimate of the largest area of the structural fill that will require a cap system; provide

an estimate of the maximum inventory of CCPs onsite; and provide a schedule for completing closure. In addition, NCGS §130A-309.219 requires specific recordation once closure is complete.

2.1 Cap System Description

NCGS §130A-309.218 (b) (1) a. requires the Closure Plan describe the cap liner system and the methods and procedures that will be used to install the cap in conformance with NCGS § 130A-309.216 (b). The cap will be built in accordance with NCGS §130A-309.216 (b) (3), minimizing infiltration and erosion. There are two proposed cap systems for the structural fill. A decision on which cap system to use will be made before closure begins and will be based on cost, soil availability and other factors. One proposed cap system consists of (from top down to CCP): topsoil, a low permeable soil layer, an unclassified soil layer, a drainage soil layer and a geomembrane. The other proposed cap system consists of (from top down to CCP): topsoil, a low permeable soil layer, a geocomposite drainage layer and a geomembrane. The thickness of some of the layers will vary depending on the location of the cap on the structural fill. The top of the structural fill will have a six foot cap and the side slopes of the structural fill will have a four foot cap as shown in Table 1 below.

Table 1 Cap System Thickness

	Soil/Geomembrane Cap		**Soil/Geocomposite Drainage Layer/Geomembrane Cap**	
Layer	**Top**	**Side Slope**	**Top**	**Side Slope**
Topsoil thickness	6 inches	6 inches	6 inches	6 inches
Low permeable soil layer thickness	12 inches	12 inches	66 inches	42 inches
Unclassified soil layer thickness	24 inches	12 inches	NA	NA
Drainage soil layer thickness	30 inches	18 inches	NA	NA
Geocomposite drainage layer	NA	NA	250 mil	250 mil
PE geomembrane	40 mil	40 mil	40 mil	40 mil
Total Cap Thickness[a]	**6 feet**	**4 feet**	**6 feet**	**4 feet**

[a] Ignores the nominal thickness of the geocomposite drainage layer and the PE geomembrane.

The Operator will prepare the supporting CCP surface or interim cover for the closure cap. Vegetation shall be removed and the interim cover soil shall be scarified or removed prior to placing any overlying material. The surface to be covered with geomembrane will be rolled and compacted so as to be free of irregularities, protrusions, loose materials, and abrupt changes in grade. Prior to geomembrane placement, perimeter anchor trenches will be excavated. The geomembrane panels will be placed one at a time and field seamed.

Soil materials will be placed directly on top of a geomembrane or geocomposite in such a manner as to ensure there is no damage to the geomembrane or geocomposite. Typically, a minimum thickness of one foot of soil is specified between a low ground-pressure dozer and the geomembrane or geocomposite. The soils must be free of objects that could cause damage to the geomembrane or geocomposite.

Soil materials will be placed in six-inch compacted lifts with equipment only operating over previously placed soil material. The lifts will be placed with sufficient number of passes to achieve 90% compaction (Standard Proctor) and compacted by tracking using low-ground

pressure construction equipment meeting the requirements of the project specifications. The topsoil will be a six-inch thick layer of soil capable of promoting the growth of vegetation. The total thickness of the final cover shall be at least six feet on the top of the structural fill and at least four feet on the side slopes of the structural fill.

2.2 Surface Water Runoff and Run-on

Surface water running off the structural fill during and after a rainfall event will be collected and routed off the cover by erosion control benches and slope drains. Surface water that flows toward the structural fill from uphill areas (run-on) will be intercepted and channeled away from the structural fill and final cover surface by diversion channels and perimeter berms.

2.3 Erosion Control

Erosion will be controlled by vegetation, erosion control benches and diversion of run-off. Vegetation will aid in reducing soil erosion. Benches break the velocity of sheet flow over the closed structural fill, control development of erosion features before they damage the final cover, and divert runoff into manageable flow volumes. Sediment laden runoff will be collected in the sediment basins.

2.4 Dust Control

Dust control during closure construction will be managed as outlined in the Operations Plan and appropriate for closure construction.

2.5 Estimate of Largest Area to Require Closure

NCGS §130A-309.218 (b) (1) b. requires the Closure Plan to provide an estimate of the largest area of the structural fill project that will require a cap at any time during the overall construction period. The largest area requiring closure at any time will be 51.2 acres.

2.6 Estimate of Maximum Inventory of Coal Combustion Products

NCGS §130A-309.218 (b) (1) c. requires the Closure Plan to provide an estimate of the maximum inventory of CCPs ever onsite over the construction duration of the structural fill. The structural fill is sized to hold an estimated total of approximately 7.25 million cubic yards of CCPs in five cells.

2.7 Closure Schedule

NCGS §130A-309.218 (b) (1) d. requires the Closure Plan to provide a schedule for completing all activities necessary to satisfy the closure criteria. In accordance with NCGS §130A-309.218 (a) (1), cap application will start no later than 30 working days or 60 calendar days, whichever is less, after CCP placement has ceased. Closure construction is anticipated to take up to a year to complete. Refer to the Reclamation Timeline in the Earthwork Calculations section for the anticipated closure schedule.

2.8 Closure Cost Estimate

The cost to complete closure is calculated on a per acre basis. The final cap thickness varies between the top (i.e., flatter slope) and the side slopes (i.e., 4H:1V slope). In addition, both of the cap cross-sections have the option to be constructed with or without a geocomposite. The calculations included in Appendix A of this section cover each of the possible options. The cost estimates include, as warranted, the items listed below.

- Mobilization, Administration & Bonds
- Surveying & Control
- Topsoil Layer
- Low Permeable Soil Layer
- Unclassified Soil Layer
- Lateral Drainage Soil Layer (depending on option)
- Geocomposite Drainage Layer (depending on option)
- Geomembrane (40 mil double sided textured polyethylene)
- Seeding/Fertilizing/Mulching
- Contingency
- Engineering - Plans & Specs
- CQA & Certification
- Construction Management

Selection of the closure cap option will depend on the availability and pricing of materials at the time of closure. The cost estimate will be updated annually.

2.9 Certification

A certification signed and sealed by a registered professional engineer will be submitted to NCDENR within 30 days of the completion of the closure cap system or any partial closure of the cap system construction. The certification will verify that the closure has been completed in accordance with the Closure Plan and the law.

2.10 Recordation

NCGS §130A-309.219 requires recordation of the structural fill project (with more than 1,000 cubic yards of CCP) with the Register of Deeds. The recordation will include a statement with the volume and location of the coal combustion residuals and will identify the parcel of land where the structural fill is located. The statement will be signed and acknowledged by the landowners in the form prescribed by NCGS 47-38 through NCGS 47-43. NCGS §130A-309.219 will be consulted for all the information required in the statement and the format of the statement prior to the creation of the statement. In accordance with NCGS §130A-309.219 (b) the statement will be submitted to the Register of Deeds within 90 days after completion of the structural fill project using coal combustion residuals. NCDENR will be notified by the Operator of the closure completion, certification by a professional engineer that closure was completed in accordance with the Closure/Post-Closure Plan, deed notation, and placement of these records into the structural fill's operating record.

3 Post-Closure Plan

A Post-Closure Plan is required by NCGS §130A-309.218 (b) (2) to be submitted for large structural fill projects. NCGS §130A-309.218 (b) (2) requires a post-closure plan to describe the monitoring and maintenance activities required for the structural fill project; provide contact information for a person or office responsible for the structural fill project during the post-closure period; describe the planned uses of the property during the post-closure period; and provide a cost estimate for the post-closure period activities.

Large structural fill projects are required by NCGS §130A-309.218 (b) to perform post-closure care. In accordance with NCGS §130A-309.218 (b), the post-closure care will be conducted for 30 years, unless NCDENR permits a decrease in the post-closure care period or requires an increase in the post-closure care period.

Post-closure care of the facility after closure will consist of the following elements:

- Inspection and maintenance of final cap systems, including
    - Repairs to the cover as necessary to correct the effects of settlement, subsidence, erosion, or other events
    - Preventing run-on and run-off from eroding and damaging the cap system (see Sections 2.2 and 2.3 of this Closure/Post-Closure Plan)
- Operation, inspection and maintenance of the leachate collection system.
- Control of access with fences and/or signs.

The final cover system will be inspected quarterly for signs of settlement, erosion, and bare spots. Additional inspections will be performed after large storm events. Depressions in the cover that pond water or otherwise impair the function of the final cover will be filled and/or regraded. Areas subject to regrading will be revegetated. Erosion damage will be repaired, and the source of the damage will be corrected, if possible. The grass will be mowed at least twice annually. Bare spots will be revegetated with grass seed. Any deep-rooted or woody vegetation that may have established itself on the cover soil will be removed so that deep root growth will not compromise the integrity of the geosynthetics of the final cover.

The leachate collection system shall be inspected on a quarterly basis. The pipeline, manholes, pumps, and the leachate storage system will be inspected and maintained as needed.

Following completion of the post-closure care period of the structural fill, the Operator will submit NCDENR a certification, signed by a registered professional engineer, verifying that post-closure care has been completed in accordance with the post-closure plan and will place the certification in the operating record.

3.1 Post-Closure Monitoring and Maintenance Requirements

In accordance with NCGS §130A-309.218 (b) (2) a., a description of the monitoring and maintenance activities required is listed in Table 2.

Table 2 Post-Closure Monitoring & Maintenance Activities and Their Frequencies

Activity	Frequency
General Site Inspection Cap System Stormwater Management System Utilities Leachate Collection System Other Miscellaneous Inspections	Quarterly[a]
Mowing	at least twice per year or as needed
Water Quality Monitoring	per Water Quality Monitoring Plan
Groundwater Monitoring System Inspection	Semiannually

[a] The cap system and stormwater management system will be inspected within seven days of a major storm event.

A description of the monitoring and maintenance activities follows.

3.2 General Site Inspection & Maintenance

A general site inspection will occur quarterly. This inspection will include a cap system inspection, a stormwater management system inspection, utilities inspection, a leachate collection system inspection, and other miscellaneous inspections. In addition to inspections, general maintenance will be performed. This general maintenance includes maintaining the vegetation onsite, removing woody waste, and mowing at least twice per year or as needed. The quarterly site inspection has been allocated $5,000 per inspection; actual costs may vary. A checklist for quarterly inspection tasks is provided in Appendix B. These and other inspection records must be maintained in a central location and made available for any NCDENR inspections.

3.2.1 Cap System Inspection & Maintenance

In accordance with NCGS §130A-309.218 (b) (3) the integrity and effectiveness of the cap system will be maintained. This will include repairing the system as necessary to correct the defects of settlement, subsidence, erosion, or other events and preventing run-on and runoff from eroding or otherwise damaging the cap system (NCGS §130A-309.218 (b) (3)). The cap system will be inspected quarterly or within seven days of a major storm event, whichever is more frequent. The cap system will be inspected for evidence of settlement, subsidence, erosion, and other damage or potential damage.

Cap maintenance will be performed as necessary to maintain the integrity and effectiveness of the cap system. To account for erosion control and cover maintenance in the post-closure period, some reconstruction of the cap (including grassing and soil fill material) has been considered. An annual average cap maintenance of one acre per year of regrassing, and 400 CY of top soil replacement and 400 CY of protective cover replacement per year have been estimated.

3.2.2 Stormwater Management System Inspection & Maintenance

The stormwater management system (sediment basins, perimeter channels, etc.) will be inspected at least quarterly or within seven days of a major storm event, whichever is more frequent, to ensure the system is functioning properly. The current Erosion & Sediment Control

Plan may require more frequent inspections and should be followed. Maintenance will be performed as necessary. A lump sum amount of $2,000 has been allocated for annual stormwater management system maintenance and a lump sum amount of $1,200 has been allocated for each stormwater monitoring event. Two stormwater monitoring events have been allocated each year for an annual total of $2,400 for stormwater monitoring; actual costs may vary.

3.2.3 Utilities

Some utilities at the site will be maintained in operational condition during the post-closure period and will be inspected quarterly. The estimated power requirement is $500 a month which is equal to $6,000 a year; actual costs may vary.

3.2.4 Leachate Collection System Operation, Inspection & Maintenance

In accordance with NCGS §130A-309.218 (b) (4) the leachate collection system will continue to operate and be maintained during the post-closure care period. The parts of the leachate collection system that are above ground or easily accessible will be inspected quarterly. This will include inspections of the pipelines, manholes, pumps, and the leachate storage system. Maintenance will be performed as necessary in order to ensure the leachate collection system is functioning properly.

Leachate disposal has been measured using the HELP Model to estimate the average quantity of leachate requiring offsite treatment and disposal. The 30-year average during the post-closure period is approximately 9,200 gallons per acre per year. For the 118 acre footprint (based on the construction baseline), the average annual volume of leachate is 1,094,800 gallons. The annual post-closure leachate treatment cost is estimated to be $0.0235 per gallon for an annual leachate treatment amount of $25,500; actual costs may vary. In addition, a lump sum leachate system maintenance cost has been assumed to be $2,500 per year.

The owner may request from the Department to stop managing leachate from the project if the owner can demonstrate that leachate from the project through a post-closure care leachate monitoring program no longer poses a threat to human health and the environment (NCGS §130A-309.218 (b) (4)). If the owner is allowed to stop managing leachate from the project, the owner will stop operating the leachate collection system and may dismantle portions of the leachate collection system that are not under the structural fill project. The leachate collection system inspection and maintenance frequency will be revised if the structural fill is no longer required to operate the leachate collection system.

3.2.5 Other Miscellaneous Inspection & General Maintenance

Any security control devices such as fences and gates located at the site will be inspected quarterly. Repairs will be made as necessary to ensure the security of the structural fill project. A lump sum amount of $500 is assumed as cost associated with fence repairs and other security management; actual costs may vary.

3.3 Mowing

Vegetation on the cap system will be maintained. Mowing will occur at least twice per year or as needed. The unit cost of mowing is assumed to be $24.00 per acre; actual cost may vary. Therefore two events at $24.00/acre x 118 acres = $5,700 per year (or $2,850 per event).

3.4 Water Quality Monitoring, System Inspection & Maintenance

In accordance with NCGS §130A-309.218 (b) (5), the groundwater monitoring system will be monitored and maintained in accordance with NCGS §130A-309.216. The groundwater monitoring system will be inspected at least semiannually, or at least during a groundwater monitoring event, whichever is sooner. A checklist for semiannual inspection tasks is provided in Appendix B. Groundwater monitoring system inspections will include inspecting the groundwater monitoring wells, covers, pads, etc. for damage. Maintenance will be performed as necessary. Groundwater and surface water will continue to be monitored according to the Water Quality Monitoring Plan for the structural fill throughout post-closure.

There are nine groundwater monitoring wells and two surface water sampling locations that require semi-annual sampling and reporting per the Water Quality Monitoring Plan. The unit cost per semiannual monitoring event is estimated to be $6,000. Groundwater monitoring well maintenance is assumed to have a lump sum amount of $1,000 per year for well maintenance and replacement; actual cost may vary.

3.5 Administrative Costs

Professional engineering services expected during the post-closure period include investigations of documented problems from the inspection reports. An annual cost of $2,000 per year has been estimated to cover miscellaneous administrative costs; actual costs may vary.

3.6 Contact Person Information

In accordance with NCGS §130A-309.218 (b) (2) b., the name, address, and telephone number of the person or office responsible for the project during the post-closure period is listed below.

Charles E. Price
12601 Plantside Drive
Louisville, KY 40299
(877) 314.7724

3.7 Proposed Post-Closure Use of the Property

NCGS §130A-309.218 (b) (2) c. requires that a description of the planned uses of the property during the post-closure period be included in the post-closure plan. ~~At this time, no planned uses have been identified for the property.~~ The property will be actively marketed as an industrial use site for development through the local and state economic development commission as well as other real estate advertisement methods. In accordance with NCGS §130A-309.218 (b) (2) c., any post-closure use of the property will not disturb the integrity of the cap system, base liner system, or any other components of the containment system or the

function of the monitoring systems, unless necessary to comply with the requirements of this subsection. NCDENR will be consulted prior to any disturbance of the structural fill project and/or its containment system. Prior to any disturbance, the Operator will demonstrate that disturbance of the cap system, base liner system, or other component of the containment system will not increase the potential threat to public health, safety, and welfare; the environment; and natural resources as required by NCGS §130A-309.218 (b) (2) c.

3.8 Post-Closure Cost Estimate

Reference Appendix A in this section for an annual cost estimate for the post-closure activities in accordance with NCGS §130A-309.218 (b) (2) d.

3.9 Post-Closure Care Completion Certification

In accordance with NCGS §130A-309.218 (c), “following completion of the post-closure care period, [the Operator will] submit a certification, signed by a registered professional engineer, to [NCDENR], verifying that post-closure care has been completed in accordance with the post-closure plan, and include the certification in the operating record.”

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A

Closure/Post-Closure Cost Estimates

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Closure Cost Estimate – Soil/Geomembrane Cap

The following is an estimate of closure costs; actual costs may vary.

				Soil/Geomembrane Cap					
				Top			Side Slope		
Item	Description	Unit Price	Unit	Thickness (in)	Quantity	Total	Thickness (in)	Quantity	Total
1	Mobilization, Administration & Bonds	4%	of Items 2-9		4%	$ 4,000		4%	$ 3,200
2	Surveying & Control	$ 1,600	Acres		1	$ 1,600		1	$ 1,600
3	Topsoil Layer	$ 11.60	CY	6	900	$ 10,400	6	900	$ 10,400
4	Low Permeable Soil Layer*	$ 6.70	CY	12	1,700	$ 11,400	12	1,700	$ 11,400
5	Unclassified Soil Layer*	$ 6.70	CY	24	3,300	$ 22,100	12	1,700	$ 11,400
6	Drainage Soil Layer*	$ 6.70	CY	30	4,100	$ 27,500	18	2,500	$ 16,800
7	Geocomposite Drainage Layer	$ 0.70	SF		0	$ -		0	$ -
8	Geomembrane (40 mil double sided textured polyethylene)	$ 0.60	SF		43,560	$ 26,100		43,560	$ 26,100
9	Seeding/Fertilizing/Mulching	$ 1,500	Acre		1	$ 1,500		1	$ 1,500
10	Contingency	10%	of Items 1-9		10%	$ 10,500		10%	$ 8,200
11	Engineering - Plans & Specs	6%	of Items 1-9		6%	$ 6,300		6%	$ 4,900
12	CQA & Certification	6%	of Items 1-9		6%	$ 6,300		6%	$ 4,900
13	Construction Management	5%	of Items 1-9		5%	$ 5,200		5%	$ 4,100
					Cost Per Acre	$ 132,900		Cost Per Acre	$ 104,500

*The permeabilities for the soil layers may be different; however, the costs have been assumed to be the same with the exception of the topsoil.

Closure Cost Estimate – Soil/Geocomposite Drainage Layer/Geomembrane Cap

The following is an estimate of closure costs; actual costs may vary.

				Soil/Geocomposite Drainage Layer/Geomembrane Cap					
				Top			Side Slope		
Item	Description	Unit Price	Unit	Thickness (in)	Quantity	Total	Thickness (in)	Quantity	Total
1	Mobilization, Administration & Bonds	4%	of Items 2-9		4%	$ 5,200		4%	$ 4,300
2	Surveying & Control	$ 1,600	Acres		1	$ 1,600		1	$ 1,600
3	Topsoil Layer	$ 11.60	CY	6	900	$ 10,400	6	900	$ 10,400
4	Low Permeable Soil Layer*	$ 6.70	CY	66	8,900	$ 59,600	42	5,700	$ 38,200
5	Unclassified Soil Layer*	$ 6.70	CY		0	$ -		0	$ -
6	Drainage Soil Layer*	$ 6.70	CY		0	$ -		0	$ -
7	Geocomposite Drainage Layer	$ 0.70	SF		43,560	$ 30,500		43,560	$ 30,500
8	Geomembrane (40 mil double sided textured polyethylene)	$ 0.60	SF		43,560	$ 26,100		43,560	$ 26,100
9	Seeding/Fertilizing/Mulching	$ 1,500	Acre		1	$ 1,500		1	$ 1,500
10	Contingency	10%	of Items 1-9		10%	$ 13,500		10%	$ 11,300
11	Engineering - Plans & Specs	6%	of Items 1-9		6%	$ 8,100		6%	$ 6,800
12	CQA & Certification	6%	of Items 1-9		6%	$ 8,100		6%	$ 6,800
13	Construction Management	5%	of Items 1-9		5%	$ 6,700		5%	$ 5,600
					Cost Per Acre	$ 171,300		Cost Per Acre	$ 143,100

*The permeabilities for the soil layers may be different; however, the costs have been assumed to be the same with the exception of the topsoil.

Annual Post-Closure Care Cost Estimate

The following is an estimate of post-closure costs; actual costs may vary.

1	Quarterly Site Inspections	4	Events	$5,000	$20,000
2	Cap System Maintenance				
	a. Seeding/Fertilizing/Mulching	1	acres	$1,500	$1,500
	b. Topsoil Replacement	400	CY	$11.60	$4,600
	c. Protective Cover Replacement	400	CY	$6.70	$2,700
3	Stormwater Management	1	LS	$2,000	$2,000
4	Stormwater Monitoring	2	Events	$1,200	$2,400
5	Utilities	12	Events	$500	$6,000
6	Mowing	2	Events	$2,850	$5,700
7	Fence Repairs and Security	1	LS	$500	$500
8	Administration	1	Events	$2,000	$2,000
9	Leachate System Maintenance	1	Events	$2,500	$2,500
10	Leachate Collection and Treatment	1,085,600	gallons	$0.0235	$25,500
11	Water Quality Monitoring & Report	2	Events	$6,000	$12,000
12	Groundwater Monitoring System Maintenance	1	Events	$1,000	$1,000
13	Contingency	10%		$88,400	$8,800
	Annual Total				$97,200
	30-YR Total				$2,916,000

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B

Post-Closure Inspection Checklists

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Quarterly Tasks

Date: _____

Name: _____

Action	Action Completed	Comments/Follow up
Inspection of leachate pipelines, manholes, pumps		
Inspection of leachate storage system		
Inspection of power to leachate sump pumps (if applicable)		
Inspection of grass condition & removal of woody waste		
Inspection of security control devices		
Inspection of utilities		
Inspection of cap system for evidence of settlement, subsidence, erosion or other damage*		
Inspection of stormwater management system (sediment basins, perimeter channels, etc.)*		
Other:		
Other:		
Other:		
Other:		

*Complete these tasks quarterly or within seven days of a major storm event, whichever is more frequent.

Notes:

Semiannual Tasks

Date: _____

Name: _____

Action	Action Completed	Comments/Follow up
Inspection of groundwater monitoring wells, covers, pads, etc		
Other:		
Other:		
Other:		

Notes:

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Calculations

Colon Mine Site Structural Fill

Charah, Inc.

Sanford, NC

November 2014
Revised ~~December 2014~~ January 2015

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Table of Contents

Attachment 6

HELP Model Scenario 1 Supplemental Results

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Memo

Date:	Friday, January 16, 2015
Project:	Colon Mine Site Structural Fill
To:	Mike Plummer
From:	Sarah Futrell
Subject:	HELP model Scenario 1 Supplemental Results

As requested, I completed additional HELP model runs for the Colon Mine Site Structural Fill. Please see the write up below for the analysis that was performed.

I used the HELP model files that were saved in the "HELP Model" folder in ProjectWise for the runs. In order to confirm that I had the correct files and inputs, I reran the first 20-foot lift HELP model with no changes. I spot-checked the values to the ones reported in the Structural Fill Permit application, specifically the values reported in the last few lines of the table in Attachment 1 – HELP Model Results Charah Colon Mine Site of the Design Leachate Collection System calculations (under "Output Data"). The values matched so I assumed that I had the same files and inputs that were run originally.

0% Runoff HELP Model Run

I reran the first 20-foot lift for the Colon Mine Site Structural Fill HELP model showing 0% possibility for runoff. I modified the original HELP model run to show a 0% possibility for runoff (instead of a 100% possibility for runoff). I did not make any other revisions to the original HELP model run (other than revising the title). I reran the HELP model for the first 20-foot lift for the Colon Mine Site Structural Fill and got the following results.

Output Data*	**Original HELP Model Run (100% Runoff Possibility)**	**Revised HELP Model Run (0% Runoff Possibility)**	**Difference**
Average Annual Leachate Collected in Collection Layer (ft^3)	43,760	59,880	16,120
Average Annual Head on Primary Base Liner (inches)	2.90 E-02	3.90 E-02	1.0 E-02
Peak Day Leachate Collected in Collection Layer (ft^3)	539	545	6
Peak Day Head on Primary Base Liner (inches)	2.53 E-01	2.59 E-01	0.06 E-01
Waste Final Moisture Content (%) – Layer 1	0.2332	0.2453	0.0121

* *from table in Attachment 1 – HELP Model Results Charah Colon Mine Site of the Design Leachate Collection System Calculations*

Attachment 1 is the output of the revised 0% runoff HELP model run.

Ten 2-foot Lifts HELP Model Run

I ran a HELP model of the Colon Mine Site Structural Fill with ten 2-foot lifts instead of one 20-foot lift. I had to go into the original HELP model run and add in each 2-foot lift. I used the same inputs as the 20-foot lift for the 2-foot lifts with the exception being the lift thickness. I did not make any other revisions to the original HELP model run (other than revising the title). I reran the HELP model with the ten 2-foot lifts for the Colon Mine Site Structural Fill and got the following results.

Output Data*	**Original HELP Model Run (100% Runoff Possibility – one 20-foot lift)**	**Revised HELP Model Run (100% Runoff Possibility – ten 2-foot lifts)**	**Difference**
Average Annual Leachate Collected in Collection Layer (ft^3)	43,760	43,558	-202
Average Annual Head on Primary Base Liner (inches)	2.90 E-02	2.80 E-02	-0.1 E-02
Peak Day Leachate Collected in Collection Layer (ft^3)	539	410	-129
Peak Day Head on Primary Base Liner (inches)	2.53 E-01	1.96 E-01	-0.57 E-01
Waste Final Moisture Content (%) – Layer 1 ***(last lift of 10 lifts for 10-lift run)***	0.2332	0.2695	0.0363
Waste Final Moisture Content (%) – Layer 10 ***(first lift of 10 lifts for 10-lift run, N/A for original run)***	N/A	0.2344	N/A

** from table in Attachment 1 – HELP Model Results Charah Colon Mine Site of the Design Leachate Collection System Calculations*

N/A = Not Applicable

Attachment 2 is the output of the ten 2-foot lifts HELP model run.

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**                                                                      **
**                                                                      **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE           **
**                                                                      **
**              HELP Version 3.95 D          (10 August 2012)           **
**                              developed at                            **
**        Institute of Soil Science, University of Hamburg, Germany     **
**                              based on                                **
**              US HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)           **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY               **
**                    USAE WATERWAYS EXPERIMENT STATION                 **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY         **
**                                                                      **
**                                                                      **
**************************************************************************
**************************************************************************

 TIME:  13.33     DATE:  15.01.2015

 PRECIPITATION DATA FILE:      U:\HELP Model\Sanford\Charah Sanford.d4
 TEMPERATURE DATA FILE:        U:\HELP Model\Sanford\Charah Sanford.d7
 SOLAR RADIATION DATA FILE:    U:\HELP Model\Sanford\Charah Sanford.d13
 EVAPOTRANSPIRATION DATA F. 1: U:\HELP Model\Sanford\Charah Sanford.d11
 SOIL AND DESIGN DATA FILE  1: U:\HELP Model\Sanford\Charh Colon-first lift SF
Revision.d10
 OUTPUT DATA FILE:             U:\HELP Model\Sanford\Sanford 0% SF Revision.out

 **************************************************************************
      TITLE:  Coal Ash-First Lift (20-feet) (0% Runoff Possibility)
 **************************************************************************
                            WEATHER DATA SOURCES
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          NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                   COEFFICIENTS FOR    RALEIGH              NORTH CAROLINA

                   NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

      JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
      -------     -------     -------     -------     -------     -------
        3.55        3.43        3.69        2.91        3.67        3.66
        4.38        4.44        3.29        2.73        2.87        3.14

          NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                   COEFFICIENTS FOR    RALEIGH              NORTH CAROLINA

              NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

      JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
      -------     -------     -------     -------     -------     -------
       39.60       41.60       49.30       59.50       67.20       73.90
       77.70       77.00       71.00       59.70       50.00       42.00

          NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                   COEFFICIENTS FOR    RALEIGH              NORTH CAROLINA
                     AND STATION LATITUDE  =  35.87 DEGREES

 **************************************************************************
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LAYER DATA 1

VALID FOR 5 YEARS

NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE SPECIFIED BY THE USER.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	240.00	INCHES
POROSITY	=	0.5410	VOL/VOL
FIELD CAPACITY	=	0.1870	VOL/VOL
WILTING POINT	=	0.0470	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3100	VOL/VOL
EFFECTIVE SAT. HYD. CONDUCT.	=	0.1600E-03	CM/SEC

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.26	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0100	VOL/VOL
EFFECTIVE SAT. HYD. CONDUCT.	=	9.700	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	950.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER

MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
EFFECTIVE SAT. HYD. CONDUCT.	=	0.2000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 4

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 16

THICKNESS	=	18.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. CONDUCT.	=	0.1000E-06	CM/SEC

****

GENERAL DESIGN AND EVAPORATIVE ZONE DATA 1

VALID FOR 5 YEARS

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 1000. FEET.

SCS RUNOFF CURVE NUMBER	=	91.21	
FRACTION OF AREA ALLOWING RUNOFF	=	0.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.580	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	9.738	INCHES
FIELD CAPACITY OF EVAPORATIVE ZONE	=	3.366	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.846	INCHES
SOIL EVAPORATION ZONE DEPTH	=	18.000	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL INTERCEPTION WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	82.089	INCHES
TOTAL INITIAL WATER	=	82.089	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION DATA 1

VALID FOR 5 YEARS

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM RALEIGH NORTH CAROLINA

STATION LATITUDE	=	35.87	DEGREES
MAXIMUM LEAF AREA INDEX	=	4.50	
START OF GROWING SEASON (JULIAN DATE)	=	86	
END OF GROWING SEASON (JULIAN DATE)	=	310	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.70	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.0	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.0	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	78.0	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.0	%

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	58.8678	0.2453
2	0.0036	0.0142
3	0.0000	0.0000
4	7.6860	0.4270
TOTAL WATER IN LAYERS	66.557	
SNOW WATER	0.000	
INTERCEPTION WATER	0.000	
TOTAL FINAL WATER	66.557	

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 2	0.15018	545.13965
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00059
AVERAGE HEAD ON TOP OF LAYER 3	0.130	
MAXIMUM HEAD ON TOP OF LAYER 3	0.259	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.67	6061.1177
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.5149	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0470	

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.26	2.82	4.37	2.63	3.53	5.42
	4.57	6.26	2.81	3.77	2.52	2.90
STD. DEVIATIONS	2.96	0.95	1.30	1.89	2.64	1.99
	2.29	5.93	1.69	2.69	1.66	1.28
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
POTENTIAL EVAPOTRANSPIRATION						
TOTALS	1.892	2.205	3.293	4.787	6.327	6.770
	7.049	5.890	4.466	3.365	2.345	1.543
STD. DEVIATIONS	0.140	0.177	0.179	0.403	0.445	0.263
	0.410	0.413	0.352	0.062	0.182	0.125
ACTUAL EVAPOTRANSPIRATION						
TOTALS	1.193	1.541	2.189	3.179	4.706	4.073
	4.978	3.914	2.729	1.267	0.913	0.791
STD. DEVIATIONS	0.095	0.154	0.276	0.684	1.211	1.405
	1.282	1.455	1.165	0.187	0.268	0.186
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	1.4455	1.0959	1.3129	1.7164	1.7174	1.4532
	1.6274	1.3730	1.2568	1.6458	1.0353	0.8164
STD. DEVIATIONS	1.3287	1.4186	0.6877	1.1018	1.1304	0.9370
	0.3283	0.1967	0.2634	1.3171	0.6714	0.5917
LATERAL DRAINAGE RECIRCULATED FROM LAYER 2 INTO L. 1						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0403	0.0335	0.0366	0.0494	0.0479	0.0419
	0.0454	0.0383	0.0362	0.0459	0.0298	0.0228
STD. DEVIATIONS	0.0370	0.0437	0.0192	0.0317	0.0315	0.0270
	0.0092	0.0055	0.0076	0.0367	0.0193	0.0165

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES		CU. FEET	PERCENT
PRECIPITATION	44.86	(9.753)	162856.3	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
POTENTIAL EVAPOTRANSPIRATION	49.932	(0.3704)	181254.19	
ACTUAL EVAPOTRANSPIRATION	31.474	(1.0164)	114251.99	70.155
LATERAL DRAINAGE COLLECTED FROM LAYER 2	16.49581	(7.71703)	59879.797	36.76849
DRAINAGE RECIRCULATED FROM LAYER 2 INTO L. 1	0.00000	(0.00000)	0.000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00002	(0.00001)	0.074	0.00005
AVERAGE HEAD ON TOP OF LAYER 3	0.039	(0.018)		
CHANGE IN WATER STORAGE	-3.106	(8.8749)	-11275.55	-6.924

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 ******************************************************************************
 ******************************************************************************
 **                                                                          **
 **                                                                          **
 **               HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE              **
 **                                                                          **
 **               HELP Version 3.95 D          (10 August 2012)              **
 **                                developed at                              **
 **        Institute of Soil Science, University of Hamburg, Germany         **
 **                                  based on                                **
 **               US HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)              **
 **                   DEVELOPED BY ENVIRONMENTAL LABORATORY                  **
 **                     USAE WATERWAYS EXPERIMENT STATION                    **
 **                FOR USEPA RISK REDUCTION ENGINEERING LABORATORY           **
 **                                                                          **
 **                                                                          **
 ******************************************************************************
 ******************************************************************************

 TIME:  13.54     DATE:  15.01.2015

 PRECIPITATION DATA FILE:      U:\HELP Model\Sanford\Charah Sanford.d4
 TEMPERATURE DATA FILE:        U:\HELP Model\Sanford\Charah Sanford.d7
 SOLAR RADIATION DATA FILE:    U:\HELP Model\Sanford\Charah Sanford.d13
 EVAPOTRANSPIRATION DATA F. 1: U:\HELP Model\Sanford\Charah Sanford.d11
 SOIL AND DESIGN DATA FILE  1: U:\HELP Model\Sanford\Charh Colon-first ten 2ft lifts
SF Revision .d10
 OUTPUT DATA FILE:             U:\HELP Model\Sanford\Sanford ten 2ft lifts SF
Revision.out

 ******************************************************************************
      TITLE:  Coal Ash-First Lift (Ten 2-foot Lifts)
 ******************************************************************************
                            WEATHER DATA SOURCES
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          NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
                   COEFFICIENTS FOR    RALEIGH             NORTH CAROLINA

                   NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

      JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
      -------     -------     -------     -------     -------     -------
        3.55        3.43        3.69        2.91        3.67        3.66
        4.38        4.44        3.29        2.73        2.87        3.14


          NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                   COEFFICIENTS FOR    RALEIGH             NORTH CAROLINA

              NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

      JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
      -------     -------     -------     -------     -------     -------
       39.60       41.60       49.30       59.50       67.20       73.90
       77.70       77.00       71.00       59.70       50.00       42.00


          NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                   COEFFICIENTS FOR    RALEIGH             NORTH CAROLINA
                     AND STATION LATITUDE  =  35.87 DEGREES
```

****

LAYER DATA 1

VALID FOR 5 YEARS

NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE SPECIFIED BY THE USER.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	24.00	INCHES
POROSITY	=	0.5410	VOL/VOL
FIELD CAPACITY	=	0.1870	VOL/VOL
WILTING POINT	=	0.0470	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3100	VOL/VOL
EFFECTIVE SAT. HYD. CONDUCT.	=	0.1600E-03	CM/SEC

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	24.00	INCHES
POROSITY	=	0.5410	VOL/VOL
FIELD CAPACITY	=	0.1870	VOL/VOL
WILTING POINT	=	0.0470	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3100	VOL/VOL
EFFECTIVE SAT. HYD. CONDUCT.	=	0.1600E-03	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	24.00	INCHES
POROSITY	=	0.5410	VOL/VOL
FIELD CAPACITY	=	0.1870	VOL/VOL
WILTING POINT	=	0.0470	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3100	VOL/VOL
EFFECTIVE SAT. HYD. CONDUCT.	=	0.1600E-03	CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	24.00	INCHES
POROSITY	=	0.5410	VOL/VOL
FIELD CAPACITY	=	0.1870	VOL/VOL
WILTING POINT	=	0.0470	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3100	VOL/VOL
EFFECTIVE SAT. HYD. CONDUCT.	=	0.1600E-03	CM/SEC

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                        LAYER  5
                        --------
          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                     =     24.00   INCHES
POROSITY                      =      0.5410 VOL/VOL
FIELD CAPACITY                =      0.1870 VOL/VOL
WILTING POINT                 =      0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.3100 VOL/VOL
EFFECTIVE SAT. HYD. CONDUCT.=      0.1600E-03 CM/SEC

                        LAYER  6
                        --------
          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                     =     24.00   INCHES
POROSITY                      =      0.5410 VOL/VOL
FIELD CAPACITY                =      0.1870 VOL/VOL
WILTING POINT                 =      0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.3100 VOL/VOL
EFFECTIVE SAT. HYD. CONDUCT.=      0.1600E-03 CM/SEC

                        LAYER  7
                        --------
          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                     =     24.00   INCHES
POROSITY                      =      0.5410 VOL/VOL
FIELD CAPACITY                =      0.1870 VOL/VOL
WILTING POINT                 =      0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.3100 VOL/VOL
EFFECTIVE SAT. HYD. CONDUCT.=      0.1600E-03 CM/SEC

                        LAYER  8
                        --------
          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                     =     24.00   INCHES
POROSITY                      =      0.5410 VOL/VOL
FIELD CAPACITY                =      0.1870 VOL/VOL
WILTING POINT                 =      0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.3100 VOL/VOL
EFFECTIVE SAT. HYD. CONDUCT.=      0.1600E-03 CM/SEC

                        LAYER  9
                        --------
          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                     =     24.00   INCHES
POROSITY                      =      0.5410 VOL/VOL
FIELD CAPACITY                =      0.1870 VOL/VOL
WILTING POINT                 =      0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.3100 VOL/VOL
EFFECTIVE SAT. HYD. CONDUCT.=      0.1600E-03 CM/SEC
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                           LAYER 10
                           --------
               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =     24.00   INCHES
          POROSITY                     =      0.5410 VOL/VOL
          FIELD CAPACITY               =      0.1870 VOL/VOL
          WILTING POINT                =      0.0470 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3100 VOL/VOL
          EFFECTIVE SAT. HYD. CONDUCT.=      0.1600E-03 CM/SEC

                           LAYER 11
                           --------
                 TYPE 2 - LATERAL DRAINAGE LAYER
                   MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =      0.26   INCHES
          POROSITY                     =      0.8500 VOL/VOL
          FIELD CAPACITY               =      0.0100 VOL/VOL
          WILTING POINT                =      0.0050 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.0100 VOL/VOL
          EFFECTIVE SAT. HYD. CONDUCT.=       9.700     CM/SEC
          SLOPE                        =      2.00   PERCENT
          DRAINAGE LENGTH              =    950.0    FEET

                           LAYER 12
                           --------
                 TYPE 4 - FLEXIBLE MEMBRANE LINER
                   MATERIAL TEXTURE NUMBER  35
          THICKNESS                    =      0.06   INCHES
          EFFECTIVE SAT. HYD. CONDUCT.=      0.2000E-12 CM/SEC
          FML PINHOLE DENSITY          =      1.00   HOLES/ACRE
          FML INSTALLATION DEFECTS     =      1.00   HOLES/ACRE
          FML PLACEMENT QUALITY        =  3 - GOOD

                           LAYER 13
                           --------
                   TYPE 3 - BARRIER SOIL LINER
                   MATERIAL TEXTURE NUMBER  16
          THICKNESS                    =     18.00   INCHES
          POROSITY                     =      0.4270 VOL/VOL
          FIELD CAPACITY               =      0.4180 VOL/VOL
          WILTING POINT                =      0.3670 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.4270 VOL/VOL
          EFFECTIVE SAT. HYD. CONDUCT.=      0.1000E-06 CM/SEC
******************************************************************************
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GENERAL DESIGN AND EVAPORATIVE ZONE DATA 1

VALID FOR 5 YEARS

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 1000. FEET.

SCS RUNOFF CURVE NUMBER	=	91.21	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.580	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	9.738	INCHES
FIELD CAPACITY OF EVAPORATIVE ZONE	=	3.366	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.846	INCHES
SOIL EVAPORATION ZONE DEPTH	=	18.000	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL INTERCEPTION WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	82.089	INCHES
TOTAL INITIAL WATER	=	82.089	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION DATA 1

VALID FOR 5 YEARS

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM RALEIGH NORTH CAROLINA

STATION LATITUDE	=	35.87	DEGREES
MAXIMUM LEAF AREA INDEX	=	4.50	
START OF GROWING SEASON (JULIAN DATE)	=	86	
END OF GROWING SEASON (JULIAN DATE)	=	310	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.70	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.0	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.0	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	78.0	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.0	%

****

FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	6.4685	0.2695
2	5.4839	0.2285
3	4.5799	0.1908
4	5.4410	0.2267
5	5.6616	0.2359
6	5.8330	0.2430
7	6.0110	0.2505
8	5.7544	0.2398
9	5.3914	0.2246
10	5.6254	0.2344
11	0.0063	0.0246
12	0.0000	0.0000
13	7.6860	0.4270
TOTAL WATER IN LAYERS	63.942	
SNOW WATER	0.000	
INTERCEPTION WATER	0.000	
TOTAL FINAL WATER	63.942	

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	3.575	12975.5439
DRAINAGE COLLECTED FROM LAYER 11	0.11307	410.43771
PERCOLATION/LEAKAGE THROUGH LAYER 13	0.000000	0.00045
AVERAGE HEAD ON TOP OF LAYER 12	0.098	
MAXIMUM HEAD ON TOP OF LAYER 12	0.196	
LOCATION OF MAXIMUM HEAD IN LAYER 11 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.67	6061.1177
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3724	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0470	

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.26	2.82	4.37	2.63	3.53	5.42
	4.57	6.26	2.81	3.77	2.52	2.90
STD. DEVIATIONS	2.96	0.95	1.30	1.89	2.64	1.99
	2.29	5.93	1.69	2.69	1.66	1.28
RUNOFF						
TOTALS	0.489	0.242	0.579	0.162	0.373	0.551
	0.513	1.443	0.529	0.574	0.313	0.395
STD. DEVIATIONS	0.785	0.166	0.386	0.281	0.776	0.349
	0.414	2.668	0.737	0.741	0.326	0.378
POTENTIAL EVAPOTRANSPIRATION						
TOTALS	1.892	2.205	3.293	4.787	6.327	6.770
	7.049	5.890	4.466	3.365	2.345	1.543
STD. DEVIATIONS	0.140	0.177	0.179	0.403	0.445	0.263
	0.410	0.413	0.352	0.062	0.182	0.125
ACTUAL EVAPOTRANSPIRATION						
TOTALS	1.187	1.542	2.190	3.150	4.680	3.930
	4.571	3.686	2.519	1.200	0.892	0.784
STD. DEVIATIONS	0.110	0.158	0.278	0.672	1.241	1.381
	1.214	1.481	1.114	0.273	0.214	0.166
LATERAL DRAINAGE COLLECTED FROM LAYER 11						
TOTALS	1.2390	1.1479	1.1285	1.1362	1.0550	0.9212
	1.1371	0.9527	0.9246	0.8668	0.8294	0.6609
STD. DEVIATIONS	1.0025	0.9399	1.1432	0.9283	0.7108	0.4687
	0.7121	0.5514	0.5059	0.4907	0.3156	0.3635
LATERAL DRAINAGE RECIRCULATED FROM LAYER 11 INTO L. 1						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 13

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 12

AVERAGES	0.0345	0.0352	0.0315	0.0327	0.0294	0.0265
	0.0317	0.0266	0.0266	0.0242	0.0239	0.0184
STD. DEVIATIONS	0.0279	0.0291	0.0319	0.0267	0.0198	0.0135
	0.0199	0.0154	0.0146	0.0137	0.0091	0.0101

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES		CU. FEET	PERCENT
PRECIPITATION	44.86	(9.753)	162856.3	100.00
RUNOFF	6.163	(4.6070)	22371.77	13.737
POTENTIAL EVAPOTRANSPIRATION	49.932	(0.3704)	181254.19	
ACTUAL EVAPOTRANSPIRATION	30.331	(1.0151)	110100.95	67.606
LATERAL DRAINAGE COLLECTED FROM LAYER 11	11.99936	(6.57376)	43557.676	26.74608
DRAINAGE RECIRCULATED FROM LAYER 11 INTO L. 1	0.00000	(0.00000)	0.000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 13	0.00002	(0.00001)	0.058	0.00004
AVERAGE HEAD ON TOP OF LAYER 12	0.028	(0.016)		
CHANGE IN WATER STORAGE	-3.629	(8.0546)	-13174.12	-8.089

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Construction Quality Assurance (CQA) Plan

Colon Mine Site Structural Fill

Charah, Inc.

Sanford, NC

November 2014
Revised ~~December 2014~~January 2015

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Table of Contents

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1 General

This Construction Quality Assurance (CQA) Plan has been prepared to provide the Owner, Engineer, and CQA Consultant the means to govern the construction quality and to document construction operations in accordance with the engineering drawings.

More specifically, this CQA Plan addresses the components required to construct base liners systems and closure systems. The common components of a base liner system often include many of the following layers: soil subgrade, compacted soil liner, a geosynthetic clay liner, HDPE geomembrane, a drainage geocomposite, a granular drainage material, geotextiles, perforated collection piping, sumps/manholes, and fittings. The common components of a closure system often include many of the following layers: soil subgrade, compacted soil liner, a geosynthetic clay liner, HDPE geomembrane, a drainage geocomposite, a granular drainage material, geotextiles, perforated collection piping, soil ballast and topsoil. As many of the components are the same or similar, this CQA plan is organized by the components of the work. This plan is intended to be used for both liner systems and closure systems; therefore it includes material components that may not be used on every construction project.

The CQA Plan is divided into the following sections:

1 General
2 Soil Liner
3 Geosynthetic Clay Liner
4 Geomembrane Liner
5 Drainage Geocomposite
6 Earthen Drainage & Protective Components
7 Geotextile
8 High Density Polyethylene Pipe, Manholes, & Fittings
9 Surveying
10 Documentation

1.1 Scope of Construction Quality Assurance Plan

The scope of this CQA Plan includes the CQA of the soils and geosynthetic components of the liner and LCR systems for the subject facility. The CQA for the selection, evaluation, and placement of the soils is included in the scope. This document is intended to be used in concert with the CQC requirements presented in the project specifications.

1.2 Definitions

1.2.1 Construction Quality Assurance

In the context of this plan, construction quality assurance is defined as a planned and systematic program employed by the Owner to assure conformity of the constructed systems (ex. Liner systems, Leachate Collection and Removal (LCR) systems, and protective cover system) with the design drawings, and the project specifications. CQA is provided by the CQA Consultant as a representative of the Owner and is independent from the Contractor and all

manufacturers. The CQA program is designed to provide adequate confidence that items or services meet contractual and regulatory requirements and will perform satisfactorily in service.

1.2.2 Construction Quality Control

Construction Quality Control refers to actions taken by manufacturers, fabricators, installers, or the Contractor to ensure that the materials and the workmanship meet the requirements of the design plans and project specifications. For earthen components such as the soil liner, the leachate collection material and protective cover soils, CQC is often provided by the Contractor's CQC Consultant. In the case of geosynthetic components, material quality control is provided by manufacturer certifications and the CQC for the installation of the various geosynthetics is provided by the Contractor's CQC Consultant. The manufacturer's specifications and quality control (QC) requirements are included in this CQA Plan by reference only.

1.2.3 Minimum Average Roll Value (MARV)

Geosynthetics are commonly specified on a minimum or maximum average roll value (MARV). The MARV is the value two standard deviations away from the average value for the product.

1.2.4 CQA/CQC Certification Document

At the completion of construction, a certification document will be prepared by the CQA Consultant and be submitted to the state regulatory agency. The certification report will include all QC testing performed by the Geosynthetics Manufacturers, all CQC testing performed by the CQC Consultant, or Geosynthetic Installers, and all CQA conformance testing performed by the CQA Consultant.

1.2.5 Units

In this CQA Plan, all properties and dimensions are expressed in U.S. units.

1.2.6 References

The CQA Plan includes references to the test procedures of the ASTM International (ASTM), and the "Geosynthetic Research Institute" (GRI).

1.3 Governance between Documents

The CQA Plan is intended to be a supporting document to improve the overall documentation of the Work. The CQA Plan is less specific than the project specifications, and conflicts may exist between the documents. The Contractor is instructed to bring all apparent discrepancies or conflicts to the attention of the Engineer or CQA Consultant for resolution. The Engineer has the sole authority to determine resolution of conflicts existing within the Contract Documents. The more stringent requirement shall control the resolution, unless otherwise determined by the Engineer. ~~The General Conditions of the contract documents should be consulted for guidance in conflict resolution; for many HDR projects this is Section 00700 - General Conditions.~~

1.4 Parties to Construction Quality Assurance

The lines of authority and communications between each of the parties involved in the CQA and CQC are illustrated in Figure 1.

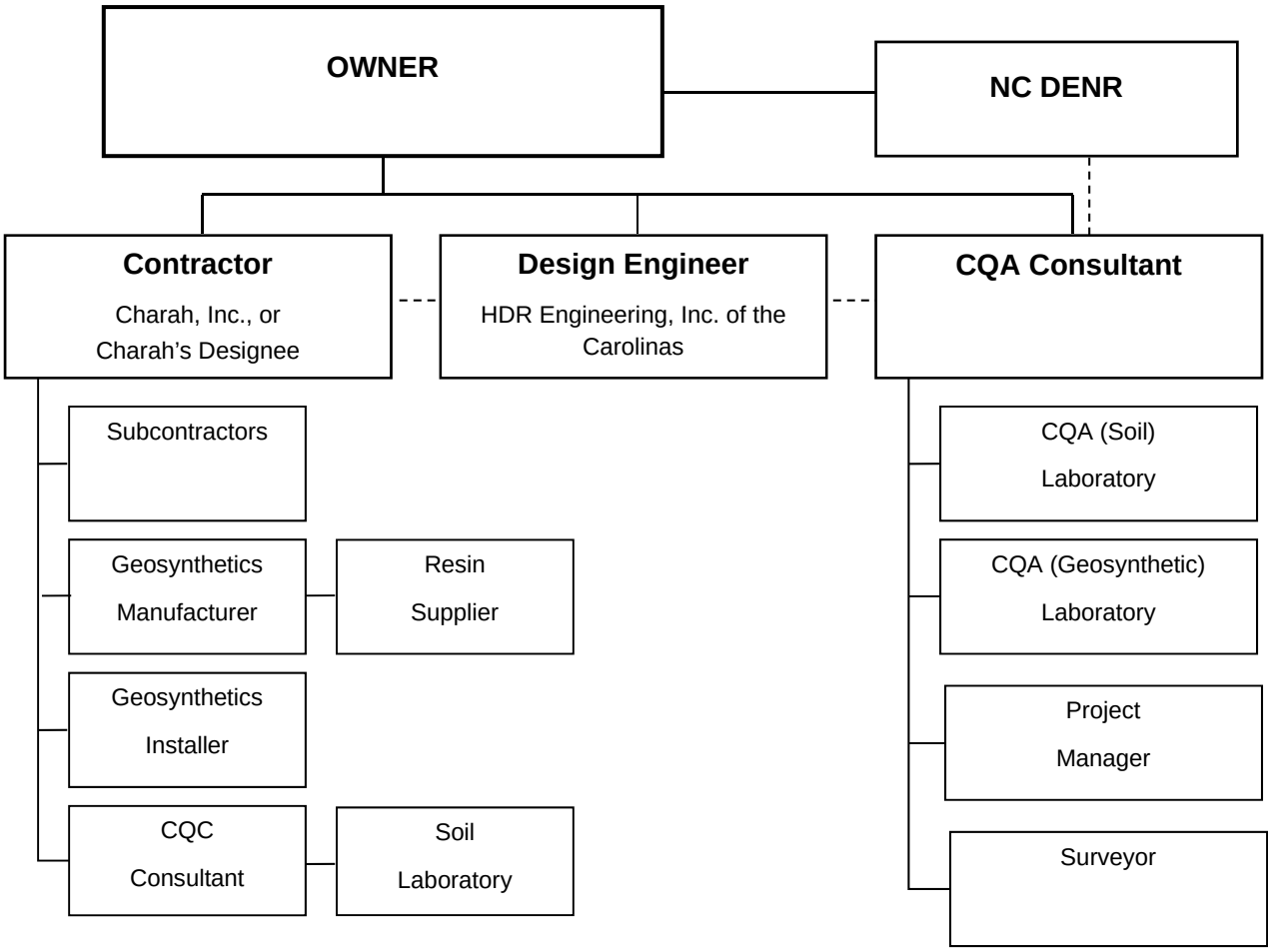

Figure 1 CQA/CQC Lines of Authority and Communication

1.4.1 Owner

The Owner is Green Meadow LLC, who owns and/or is responsible for the facility.

1.4.2 Project Manager

The Project Manager is the official representative of the Owner. The Project Manager serves as communications coordinator for the project, initiating the resolution, preconstruction, and construction meetings outlined in this section. The Project Manager shall also be responsible for proper resolution of all quality issues that arise during construction.

1.4.3 Design Engineer

The Design Engineer is responsible for the engineering design, drawings, plans and project specifications for the liner system and protective cover system. The Design Engineer is HDR Engineering, Inc. of the Carolinas.

1.4.4 Contractor

The Contractor is responsible for the construction of the project and system components in accordance with contract specifications. The Contractor is responsible for all of their subcontractors. The Contractor is responsible for submittal coordination and the overall CQC on the project. The Contractor may be the Owner.

1.4.5 Geosynthetics Manufacturer

The Geosynthetics Manufacturer(s) is (are) responsible for the production of geomembranes, geosynthetic clay liners, geonets, and geotextiles. The manufacturers are responsible for Quality Control (QC) during manufacture of the geosynthetic components, certification of the properties of the geosynthetic components, and field installation criteria.

1.4.6 Geosynthetics Installer

The Geosynthetics Installer(s) may be the Contractor or a subcontractor to the Contractor and is (are) responsible for field handling, storing, placing, seaming, protection of (against wind, etc.), and other aspects of the geosynthetics installations, including the geomembranes, geosynthetic clay liners and geotextiles. The Geosynthetics Installer may also be responsible for transportation of these materials to the site and for the preparation and completion of anchor trenches.

1.4.7 Construction Quality Assurance Consultant

The CQA Consultant is a representative of the Owner and is responsible for observing, testing, and documenting activities related to the CQC/CQA of the earthworks at the site and the installation of the geosynthetic components of the liner and leachate collection/removal systems. The CQA Consultant is also responsible for issuing a facility certification report sealed by a registered professional engineer.

1.4.8 Geosynthetics Construction Quality Assurance Laboratory

The Geosynthetics CQA Laboratory is a party, independent from the Owner, which is responsible for conducting tests on conformance samples of geosynthetics used in the liner and LCR systems. The Geosynthetics CQA Laboratory service cannot be provided by any party involved with the manufacture, fabrication, or installation of any of the geosynthetic components.

1.4.9 Soils Construction Quality Assurance Laboratory

The Soils Construction Quality Assurance Laboratory is a party, independent from the Owner, which is responsible for conducting geotechnical tests on conformance samples of soils used in the liner system. The Soils CQA Laboratory service cannot be provided by any party involved with the Contractor.

1.4.10 Construction Quality Control Consultant

The CQC Consultant is a representative of the Contractor and is responsible for the earthwork and soil liner quality control sampling and testing. The term CQC Consultant shall be used to designate the registered professional engineer in charge of the quality control work. The personnel of the CQC Consultant also include Quality Control Monitors who are also located at the site for construction observation and monitoring. The CQC Consultant is responsible for the timely conveyance of CQC testing results to the CQA Consultant.

1.4.10.1 GEOSYNTHETICS CONSTRUCTION QUALITY CONTROL LABORATORY

The Geosynthetics CQC Laboratory is responsible for conducting conformance tests on samples of geosynthetics at the direction of the CQC Consultant.

1.4.10.2 SOILS CONSTRUCTION QUALITY CONTROL LABORATORY

The Soils Construction Quality Control Laboratory is responsible for conducting geotechnical tests on soil samples at the direction of the CQC Consultant.

The Owner may choose to employ the CQA consultant to perform some, or all, of the CQC Consultant duties.

1.5 Qualifications of the Parties

The following qualifications are required of all parties involved with the manufacture, fabrication, installation, transportation, and CQC/CQA of all materials for the project. Where applicable, these qualifications shall be submitted by the Contractor to the Project Manager for review and approval.

1.5.1 Contractor

Qualifications of the Contractor are specific to the construction contract and independent of this CQA Plan. A complete up to date version of each geosynthetic component manufacturer's QC Plan shall be incorporated into the Contractor's CQC Plan.

1.5.2 Geosynthetics Manufacturers

Each Geosynthetics Manufacturer must satisfy the qualifications presented in the project specifications and must be prequalified and approved by the Project Manager.

The physical properties of each geosynthetic product must be certified by the geosynthetics manufacturer. The properties certified must include, at a minimum, those identified in the project specifications. Manufacturer’s certification must be approved by the CQA Consultant before the product is used.

1.5.3 Geosynthetic Installer(s)

The Geosynthetic Installer(s) will be trained and qualified to install the geosynthetics components of the liner system. Each Geosynthetics Installer must meet the requirements of the project specifications and be approved by the Project Manager. The Geomembrane Installer must be approved by the Geomembrane Manufacturer.

1.5.4 Construction Quality Assurance Consultant

The CQA Consultant will act as the Owner's CQA representative and will report to the Project Manager. The CQA Consultant will perform conformance testing to satisfy the requirements of this CQA Plan, will observe the CQC work performed by the CQC Consultant, and will prepare the certification document incorporating both CQA and CQC test data. The CQA Consultant will have experience in the CQC/CQA aspects of geomembrane liner system construction and soils testing, and be familiar with ASTM and other related industry standards. The activities of the CQA Consultant will be performed under the supervision of a registered professional engineer.

1.5.5 Construction Quality Control Consultant

The CQC Consultant will be a subcontractor to the Contractor. The CQC Consultant will be experienced with soils, including soil liners, and geosynthetics, including geomembranes, geosynthetic clay liners geonets, and geotextiles. The CQC Consultant will satisfy the

requirements of the project specifications and be approved by the Project Manager. The activities of the CQC Consultant will be performed under the supervision of a registered professional engineer.

1.5.6 Geosynthetics Construction Quality Control Laboratory

The Geosynthetics CQC Laboratory is a subcontractor of the CQC Consultant and will have experience in testing geosynthetics and be familiar with ASTM, GRI, and other applicable test standards. The laboratory shall be accredited under the GAI-LAP program for all tests required for the project. The Geosynthetics CQC Laboratory will be capable of providing test results within 24 hours or a reasonable time after, as agreed to at the outset of the project, receipt of samples, and will maintain that standard throughout the installation.

1.6 Site and Project Control

To guarantee a high degree of quality during installation, clear, open channels of communication are essential. To that end, meetings are critical.

1.6.1 CQA/CQC Resolution Meeting

Prior to field mobilization by the Contractor, a Resolution Meeting will be held. This meeting will include all parties then involved, including the Project Manager, the CQA Consultant, the Engineer, the Contractor, and the CQC Consultant.

The purpose of this meeting is to begin planning for coordination of tasks, anticipate any problems which might cause difficulties and delays in construction, and, above all, review the CQA and CQC Plans to all of the parties involved. It is very important that the rules regarding testing, repair, etc., be known and accepted by all.

This meeting should include all of the following activities.

- Provide relevant documents to all involved parties.
- Review critical design details of the project.
- Review the seam layout drawing provided by the Geomembrane/Geosynthetic Installer.
- Review the site-specific CQA and CQC Plans and make any appropriate modifications to the plans to ensure that all necessary testing activities are specified.
- Reach a consensus on the CQA/CQC quality control procedures, especially on methods for determining acceptability of the soils and geosynthetics.
- Review the proposed liner system and protective cover system.
- Select testing equipment and review protocols for testing and placement of general earthwork materials.
- Confirm methods for the soil liner material selection testing, acceptable zone determinations, and test strip installation.
- Confirm the methods for documenting and reporting, and for distributing documents and reports, and confirm the lines of authority and communication.

The meeting will be documented by the Project Manager and minutes will be transmitted to all parties.

1.6.2 Preconstruction Meeting

A Preconstruction Meeting will be held at the site prior to placement of the geosynthetic liner system. At a minimum, the meeting will be attended by the Project Manager, Engineer, the CQA Consultant, the Contractor, the CQC Consultant, and the Geosynthetic/Geomembrane Installation Superintendent.

Specific activities considered for this meeting include the following.

- Make any appropriate modifications to the CQA and CQC Plans.
- Review the responsibilities of each party.
- Review lines of authority and communication.
- Review methods for documenting and reporting, and for distributing documents and reports.
- Establish protocols for testing.
- Establish protocols for handling deficiencies, repairs, and retesting.
- Review the time schedule for all operations.
- Establish rules for writing on the geomembrane, i.e., who is authorized to write, what can be written, and in which color.
- Outline procedures for packaging and storing archive samples.
- Review panel layout and numbering systems for panels and seams.
- Establish procedures for use of the extrusion seaming apparatus, if applicable.
- Establish procedures for use of the fusion seaming apparatus, if applicable.
- Finalize field cutout sample sizes.
- Review seam testing procedures.
- Review repair procedures.
- Establish soil stockpiling locations (if any).

The meeting will be documented by the Project Manager and minutes will be transmitted to all parties. The Resolution Meeting and the Preconstruction Meeting may be held as one meeting or separate meetings, depending on the direction of the Project Manager.

1.6.3 Weekly Progress Meetings

A weekly progress meeting will be held between the Project Manager, the CQA Consultant, the Contractor, the CQC Consultant, the Geosynthetic/Geomembrane Installation Superintendent, and representatives from any other involved parties. This meeting will discuss current progress, planned activities for the next week, and any new business or revisions to the work. The CQA Consultant will log any problems, decisions, or questions arising at this meeting in his daily report. Any matter requiring action which is raised in this meeting will be reported to the appropriate parties.

Meeting frequency may be adjusted depending on the schedule of the project and the mutual agreement of all parties involved.

1.6.4 Problem or Work Deficiency Meetings

A special meeting will be held when and if a problem or deficiency is present or likely to occur. At a minimum, the meeting will be attended by all interested parties, the Contractor, the Project Manager, and the CQA Consultant. If the problem requires a design modification, the Engineer should also be present. The purpose of the meeting is to define and resolve the problem or work deficiency as follows:

- define and discuss the problem or deficiency;
- review alternative solutions; and
- implement an action plan to resolve the problem or deficiency.

The meeting will be documented by the Project Manager and minutes will be transmitted to affected parties.

2 Soil Liner

This section of the CQA Plan addresses the soil components of the liner system, and outlines the soils CQA program to be implemented with regard to materials confirmation, laboratory and field confirmation test requirements, overview and interfacing with the Contractor's CQC Program, and resolution of problems.

2.1 Earthwork Construction

2.1.1 Subgrade

The subgrade material below the controlled fill will be prepared by the Contractor prior to the placement of structural fill. The CQA and CQC Consultants will observe the proof roll by the Contractor. They must both agree that the pre-fill subgrade is acceptable before structural fill may be placed. If agreement cannot be reached, the Contractor shall further prepare the area or implement the plan from the work deficiency meeting. The CQA Consultant may conduct additional testing as deemed appropriate.

2.1.2 Structural/Controlled Fill

The Contractor shall place fill in accordance with the project specifications. The CQC Consultant shall provide testing of the controlled fill material in accordance with the project specifications. The CQA Consultant will provide confirmation testing of the controlled fill as deemed appropriate.

2.2 Soil Liner System

2.2.1 Soil Liner Subgrade

Testing will be conducted by the CQC Consultant as observed by the CQA Consultant. The subgrade material below the subbase is composed of controlled fill and in situ soils. The surface of the subgrade will be prepared prior to the construction of the subbase. The CQA Consultant will visually examine the surface of the subgrade to verify that any potentially deleterious materials have been removed.

2.2.2 Soil Liner Material

The soil liner material shall be placed and compacted in accordance with the project specifications. The CQC Consultant shall conduct field density and moisture tests at the frequency presented in the project specifications. The CQA Consultant shall provide conformance tests at a frequency of approximately 10 percent of the required CQC tests. Additional CQA conformance testing may be performed at the discretion of the CQA Consultant.

Hydraulic conductivity, Atterberg limits, and percent fines testing of the soil liner material shall be performed by the CQC Consultant in accordance with the project specifications. Additional CQA conformance testing may be performed at the discretion of the CQA Consultant.

Sealed topographic surveys shall be used to document thickness requirements. Interim thickness measurement shall be conducted in accordance with the project specifications by the CQC Consultant and observed by the CQA Consultant. Refer to Section 9 for surveying requirements.

2.3 Soils Testing

2.3.1 Test Methods

All testing used to evaluate the suitability or conformance of soils materials will be carried out in accordance with the project specifications.

2.3.2 Soils Testing Requirements

The soil CQC testing must comply with the minimum frequencies presented in the project specifications. The frequency of CQA testing required will be determined by the CQA Consultant in light of the potential variability of materials and the acceptance/failure rate of the CQC testing.

2.4 Soils Construction Quality Assurance

CQA will be performed on all soil components of the liner construction. CQA evaluation will consist of: (1) monitoring the work and observing the CQC testing; and (2) performing laboratory and field conformance tests. Laboratory CQA conformance tests will be conducted on samples taken at the borrow source, stockpile, and during the course of the work prior to construction. Field CQA conformance tests will be conducted during the course of the work.

2.4.1 Monitoring

The CQA Consultant shall monitor and document the construction of all soil components. Monitoring the construction work for the subbase soil and the soil component of the liner system includes the following:

- observing CQC testing to determine the water content and other physical properties of the subbase and soil component of the liner system during compaction and compilation of the data;
- monitoring the loose thickness of lifts as placed;
- monitoring the action of the compaction and/or heavy hauling equipment on the construction surface (i.e., penetration, pumping, cracking. etc.); and
- monitoring the number of passes used to compact each lift.

2.4.2 Construction Quality Assurance Judgmental Testing

During construction, the frequency of conformance testing may be increased at the discretion of the CQA Consultant when visual observations of construction performance indicate a potential problem. Additional testing for suspected areas will be considered when:

- the rollers slip during rolling operation;
- the lift thickness is greater than specified;
- the fill material is at an improper moisture content;
- fewer than the specified number of roller passes are made;
- dirt-clogged rollers are used to compact the material;
- the rollers may not have used optimum ballast;
- the fill materials differ substantially from those specified; or
- the degree of compaction is doubtful.

2.4.3 Perforations in Soil Liner

Perforations that must be filled will include, but not be limited to:

- soil density test locations;
- permeability sampling locations; and/or
- destructive thickness checks.

Unless otherwise noted, or as directed by the Project Manager, all perforations of the subbase by probes or sample tubes will be backfilled with soil in accordance with project specifications or with bentonite. The CQA Consultant will observe and confirm that adequate procedures are being employed.

2.4.4 Deficiencies

If a defect is discovered in the earthwork product, the CQC Consultant will immediately determine the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the CQC Consultant will determine the extent of the deficient area by additional tests, observations, a review of records, or other appropriate means. If the defect is related to adverse site conditions, such as overly wet soils or surface desiccation, the CQC Consultant will define the limits and nature of the defect.

2.4.4.1 NOTIFICATION

After determining the extent and nature of a defect, the CQC Consultant will notify the Project Manager, the CQA Consultant, and Contractor and schedule appropriate retests when the work deficiency is corrected. The CQA Consultant shall observe all retests on defects.

2.4.4.2 REPAIRS AND RETESTING

The Contractor will correct the deficiency to the satisfaction of the CQA Consultant. If a project specification criterion cannot be met, or unusual weather conditions hinder work, then the CQC Consultant will develop and present suggested solutions to the Project Manager and CQA Consultant for approval.

The CQC Consultant must retest all areas represented by failing tests after they have been reworked by the Contractor. All retests performed by the CQC Consultant must verify that the defect has been corrected before the Contractor proceeds with additional work in the area of the deficiency. The CQA Consultant will verify that all installation requirements are met and that all submittals are provided.

3 Geosynthetic Clay Liner (GCL)

3.1 Manufacturing

The Contractor will submit a list of material properties for the purposed product to the engineer for review as a shop drawing. When the material is approved, that list shall be provided to the CQA Consultant. The Contractor will also provide the CQA Consultant with a written certification from the GCL Manufacturer along with the manufacturers QC test results. These documents should demonstrate that the materials actually delivered have properties which meet or exceed all property values specified for the GCL.

The CQA Consultant will examine all manufacturer certifications to determine if the property values listed on the certifications meet or exceed those specified for the GCL. Any deviations will be reported to the Engineer.

3.2 Labeling

The GCL Manufacturer will label all rolls of GCL in accordance with the project specifications. The CQA Consultant will examine rolls upon delivery. Any rolls labeled for other projects or that otherwise deviate from the specification or the approved shop drawings will be marked as nonconforming. All nonconforming rolls shall be immediately identified to the Contractor and then reported to the Engineer.

3.3 Shipment and Storage

During shipment and storage, the GCL will be protected as required by the project specifications. The CQA Consultant will observe rolls upon delivery at the site. Any damage to the GCL during shipment and storage should be noted. The CQA Consultant shall determine if damaged rolls may be repaired and used or discarded. Use of repaired rolls shall be documented in the CQA report.

3.4 Handling and Placement

The Geosynthetic Installer will handle the GCL in such a manner as required by the project specifications. Any noncompliance will be noted by the CQA Consultant and reported to the Engineer.

3.5 Seams and Overlaps

The GCL will be seamed or overlapped in accordance with project specifications. If both seaming and overlapping is used on discrete locations of the project, then the areas that are seamed shall be noted in the CQA report, otherwise a note stating which method was used is sufficient.

3.6 Repair

All holes or tears in the GCL will be repaired in accordance with the project specifications. The CQA Consultant will observe all repairs and note them in the CQA report.

3.7 Placement and Materials

The CQA consultant shall observe placement of all materials placed directly above a GCL and inform the contractor immediately of any actions that are degrading the quality of the GCL or the overlying material.

4 Geomembrane Liner

4.1 Geomembrane Manufacturer's Certification

Compliance testing will be performed by the Geomembrane Manufacturer to demonstrate that the product meets the manufacturers' standards and the project specifications. The manufacturer shall submit a package of certifications and the quality control test results to the Contractor. The Contractor shall distribute the package upon receipt to the CQA consultant prior to the installation of any geomembrane material.

The quality control certificate will be signed by a responsible party employed by the Geomembrane Manufacturer, such as the production manager. In addition to the end product certifications and test results, the package should include the following information.

4.1.1 Raw Material

- Resin Supplier's name and resin production plant.
- Identification (brand name and number), and production date of the resin.
- Copies of the quality control certificates issued by the Resin Supplier.
- Reports on the tests conducted by the Geomembrane Manufacturer to verify the quality of the resin used to manufacture the geomembrane rolls assigned to the project.
- A statement that the percentage of reclaimed polymer added to the resin is in accordance with the project specifications.

4.1.2 Rolls and Sheets

- Roll numbers and identification.
- Property sheets including, at a minimum, all specified properties, measured using test methods indicated in the project technical specifications, or equivalent.
- Sampling procedures and results of testing.

4.2 Conformance Testing

The CQA Consultant may perform additional testing for purposes of conformance evaluation. If the results of the Geomembrane Manufacturer's and the CQA Consultant's testing differ, the testing will be repeated by the CQA Consultant's laboratory, and the Geomembrane Manufacturer will be allowed to monitor this testing. The results of this latter series of tests will prevail, provided that the applicable test methods have been followed.

The CQA Consultant will review the manufacturers' documents and verify that:

- the reported property values certified by the Geomembrane Manufacturer meet all of the project technical specifications; and
- the measurements of properties by the Geomembrane Manufacturer are properly documented and that the test methods used are acceptable.

The CQA Consultant shall report any discrepancies with the above requirements to the Project Manager.

4.3 Handling, and Storage

4.3.1 Handling

The CQA Consultant will verify that:

- handling equipment used on the site is adequate, meets manufacturer's recommendations, and does not pose any risk of damage to the geomembrane; and
- the Geomembrane Installer's personnel handle the geomembranes with care.

Upon delivery at the site, the CQA Consultant will conduct a surface observation of all rolls and sheets for defects and damage. This examination will be conducted without unrolling rolls or unfolding sheets unless defects or damages are found or suspected.

The CQA Consultant will indicate to the Project Manager:

- any rolls or sheets, or portions thereof, that should be rejected and removed from the site because they have severe flaws; and
- any rolls or sheets that have minor repairable flaws.

4.3.2 Storage

The CQA Consultant will document that the Contractor's storage of the geomembrane provides adequate protection against moisture, dirt, shock, and other sources of damage or contamination.

4.4 Geomembrane Installation

4.4.1 Earthwork

4.4.1.1 SURFACE PREPARATION

The CQC Consultant and the Geomembrane Installer will certify in writing that the surface on which the geomembrane will be installed meets line and grade, and the surface preparation requirements of the project specifications. The certificate of acceptance will be given by the CQC Consultant to the CQA Consultant prior to commencement of geomembrane installation in the area under consideration. The CQA Consultant will give a copy of this certificate to the Project Manager.

To ensure a timely covering of the soil liner surface, the Project Manager may allow subgrade acceptance in areas as small as one acre. After the supporting soil has been accepted by the Geomembrane Installer, it will be the Geomembrane Installer's responsibility to indicate to the Project Manager of any change in the supporting soil condition that may require repair work. If the CQA Consultant concurs with the Geomembrane Installer, then the Project Manager will ensure that the supporting soil is repaired.

4.4.1.2 ANCHORAGE SYSTEM

The CQA Consultant will verify that anchor trenches have been constructed according to project specifications and design drawings.

4.4.2 Geomembrane Placement

4.4.2.1 FIELD PANEL IDENTIFICATION

The CQA Consultant will document that the Geomembrane Installer labels each field panel with an "identification code" (number or letter-number consistent with the layout plan) agreed upon by the CQC Consultant, Geomembrane Installer, and CQA Consultant at the CQA/CQC Preconstruction Meeting.

The Geomembrane Installer will establish a table or chart showing correspondence between roll numbers and field panel identification codes. This documentation shall be submitted to the CQC Consultant and CQA Consultant weekly for review and verification. The field panel identification code will be used for all quality control and quality assurance records.

4.4.2.2 FIELD PANEL PLACEMENT

4.4.2.2.1 Location

The CQA Consultant will verify that field panels are installed at the location indicated in the Geomembrane Installer's layout plan, as approved.

4.4.2.2.2 Installation Schedule

The CQA Consultant will evaluate every change in the schedule proposed by the Geomembrane Installer and advise the Project Manger on the acceptability of that change. The CQA Consultant will verify that the condition of the supporting soil has not changed detrimentally during installation.

The CQA Consultant will record the identification code, location, and date of installation of each field panel.

4.4.2.2.3 Placement of Geomembrane

The CQA Consultant will verify that project specification related restrictions on placement of geomembrane are fulfilled. Additionally, the CQA Consultant will verify that the supporting soil has not been damaged by weather conditions.

Wrinkles and folds shall be prevented to the extent possible and repaired when they are not prevented.

The CQA Consultant will inform the Project Manager if the above conditions are not fulfilled.

4.4.2.2.4 Damage

The CQC Consultant will visually observe each panel for damage after placement and prior to seaming. The CQC Consultant will advise the CQA Consultant which panels or portion of panels were rejected or marked for repair. Damaged panels, or portions of damaged panels, which have been rejected will be marked and their removal from the work area recorded by the CQA Consultant.

4.4.3 Field Seaming

4.4.3.1 SEAM LAYOUT

The Geomembrane Installer will provide the CQA Consultant with a seam layout drawing, i.e. a drawing of the facility to be lined showing all expected seams. The CQA Consultant and Engineer will review the seam layout drawing and verify that it is consistent with the accepted state of engineering practice and this CQA Plan. In addition, panels not specifically shown on the seam layout drawing may not be used without the Project Manager's prior approval.

A seam numbering system compatible with the panel numbering system will be agreed upon at the Resolution and/or Preconstruction Meeting. An on-going written record of the seams and repair areas shall be maintained by the Geomembrane Installer with weekly review by the CQA Consultant.

4.4.3.2 REQUIREMENTS OF PERSONNEL

The Geomembrane Installer will provide the CQA Consultant with a list of proposed seaming personnel and their experience records. This document will be reviewed by the Project Manager and the CQA Consultant for compliance with project specifications.

4.4.3.3 SEAMING EQUIPMENT AND PRODUCTS

Field seaming processes must comply with project specifications. Proposed alternate processes will be documented and submitted to the CQA Consultant for his approval. Only seaming apparatus which have been specifically approved by make and model will be used.

4.4.3.4 NONDESTRUCTIVE SEAM CONTINUITY TESTING

The Geomembrane Installer will nondestructively test all field seams over their full length using test methods approved by the project specifications. The CQA Consultant shall periodically observe the nondestructive testing to ensure conformance with this CQA Plan and the project specifications.

For approximately 10% of the noncomplying tests, the CQA Consultant will:

- observe continuity testing of the repaired areas performed by the Geomembrane Installer;
- confirm the record location, date, test unit number, name of tester, and compile the record of testing provided by the Geomembrane Installer;
- provide a walkthrough inspection of all impacted seam areas and verify that the areas have been tested in accordance with the CQA Plan and project specifications; and
- verify that the Geomembrane Installer has marked repair areas with the appropriate color-coded marking pencil.

4.4.3.5 DESTRUCTIVE SEAM TESTING

Destructive seam tests will be performed by the CQC consultant at locations and a frequency in accordance with the project specifications. The CQA Consultant will perform conformance tests on a minimum of 10% of the CQC destructive seam test samples obtained. Additional destructive seam tests may be required at the CQA Consultant's discretion. Selection of such locations may be prompted by suspicion of contamination, excessive grinding, off center and/or offset seams, or any other potential cause of imperfect seaming.

4.4.3.5.1 Geosynthetics CQA Laboratory Testing

Destructive test samples will be packaged and shipped by the CQA Consultant in a manner that will not damage the test sample. The Project Manager will be responsible for storing the archive samples. These procedures will be fully outlined at the Resolution and/or Preconstruction Meeting. Samples will be tested by the Geosynthetics CQA Laboratory.

Conformance testing will include "Seam Strength" and “Peel Adhesion" in accordance with project specifications. All geomembrane destructive test samples that fail to meet project specifications shall be saved and sent to the CQA Consultant for observation.

The Geosynthetics CQA Laboratory will provide preliminary test results no more than 24 hours after they receive the samples. The CQA Consultant will review laboratory test results as soon as they become available.

4.4.3.5.2 Defining Extent of Destructive Seam Test Failure

All defective seam test failures must be bounded by seam tests from which destructive samples passing laboratory tests have been taken. The CQC Consultant will document repair actions taken in conjunction with all destructive seam test failures.

4.4.4 Defects and Repairs

All seams and non-seam areas of the geomembrane will be examined by the CQA Consultant for identification of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. Each suspected location, both in seam and non-seam areas, will be nondestructively tested using methods in accordance with the project specifications. Each location which fails the nondestructive testing will be marked by the CQC Consultant and repaired by the Geomembrane Installer. Repair procedures will be in accordance with project specifications or procedures agreed to by the Project Manager in the Preconstruction Meeting. The CQA Consultant will observe all repair procedures and advise the Project Manager of any problems.

4.4.5 Backfilling of Anchor Trench

Anchor trenches will be will be backfilled and compacted as outlined in the earthwork specifications. The soil used to backfill the anchor trench shall meet the specifications for soil liner and placed in a manner that doesn’t stress or damage the geosynthetics. The CQA Consultant will review the backfilling operation and advise the Project Manager of any problems.

Liner edges that are constructed with run-out instead of anchor trenches (such as construction phase boundaries) will be protected with plywood sheets above the geosynthetics. Subsequent cell construction must always lap the prior certification limits such that all areas are certified to

be in conformance with the plans and specifications. The CQA consultant shall review the procedures to excavate the plywood sheet prior to extending the liner section. The entire length of seam to previously constructed areas shall be thoroughly inspected for conformance. Any liner component (soil and geosynthetic) that is damaged, whether by excavation or other cause, shall be properly repaired and inspected by the CQA consultant. Any deficiencies noted such as insufficient GCL overlaps or failing seams shall be addressed to prevent reoccurrence in the new construction.

4.4.6 Materials in Contact with Geomembranes

The quality assurance procedures indicated in this subsection are only intended to assure that the installation of these materials does not damage the geomembrane. Although protective geosynthetics and geotextiles have been incorporated into the liner system, all reasonable measures to protect the geomembrane and provide additional quality assurance procedures are necessary to assure that systems built with these materials will be constructed to ensure proper performance.

4.4.6.1 SOILS

Prior to placement, the CQA Consultant will visually confirm that all soil materials to be placed against the geomembrane comply with project specifications. The Geomembrane Installer will provide the CQA Consultant a written surface acceptance certificate. All soil materials shall be placed and compacted in accordance with project specifications.

4.4.6.2 SUMPS AND APPURTENANCES

The CQA Consultant will review:

- installation of the geomembrane in appurtenance areas, and connection of the geomembrane to appurtenances;
- that extreme care is taken while seaming around appurtenances since neither nondestructive nor destructive testing may be feasible in all of these areas;
- testing is conducted in all areas that are feasible;
- the geomembrane has not been visibly damaged while making connections to appurtenances;
- the installation of the geomembrane shall be exercised so as not to damage sumps; and

The CQA Consultant will inform the Project Manager if the above conditions are not fulfilled or observed to be in accordance with project specifications.

5 Drainage Geocomposite

5.1 Material Requirements

All HDPE drainage composite shall be manufactured in accordance with the project specifications.

5.2 Manufacturing

The drainage composite manufacturer will provide the Contractor and the CQC Consultant with a written certification, signed by a responsible party, that the drainage composites actually delivered have properties which meet or exceed the specified properties.

The CQA Consultant will examine all manufacturers' certifications to ensure that the property values listed on the certifications meet or exceed the project specifications. Any deviations will be reported to the Project Manager.

5.3 Labeling

The drainage composite manufacturer will identify all rolls of drainage composite in accordance with project specifications. The CQA Consultant will examine rolls upon delivery and any deviation from the above requirements will be reported to the Project Manager.

5.4 Shipment and Storage

Drainage composite cleanliness is essential to its performance; therefore, the shipping and storage of drainage composite must be in accordance with the project specifications. The CQA Consultant will examine rolls upon delivery and any deviation from the above requirements will be reported to the Project Manager.

The CQA Consultant will check that drainage composites are free of dirt and dust just before installation. The CQA Consultant will report the outcome of this review to the Project Manager; and, if the drainage composites are judged dirty or dusty, they will be washed by the drainage composite Installer prior to installation.

Washing operations will be observed by the CQA Consultant and improper washing operations will be reported to the Project Manager.

5.5 Handling and Placement

The drainage composite Installer will handle all drainage composites in a manner in accordance with the project specifications. The CQA Consultant will note any noncompliance and report it to the Project Manager.

5.6 Stacking and Joining

Adjacent drainage composites will be joined according to construction drawings and project specifications. The CQA Consultant will note any noncompliance and report it to the Project Manager.

When several layers of drainage composites are stacked, care should be taken to ensure that stacked drainage composites are placed in the same direction. A stacked drainage composite will never be laid in perpendicular directions to the underlying drainage composite unless otherwise specified by the Engineer. The CQA Consultant will observe the stacking of drainage composites and will note any noncompliance and report it to the Project Manager.

5.7 Repair

Any holes or tears in the drainage composite will be repaired in accordance with project specifications. The CQA Consultant will observe any repair, note any noncompliance with the above requirements, and report them to the Project Manager.

5.8 Placement of Soil Materials

All soil materials placed over the drainage composite should be placed in accordance with project specifications so as to ensure:

- the drainage composite and underlying geomembrane are not damaged;
- wrinkles and folds are prevented to the extent possible and repaired when not prevented;
- minimal slippage of the drainage composite on the underlying geomembrane occurs;
- the material is not exposed for longer than is allowed by the project specifications; and
- no excess tensile stresses occur in the drainage composite.

Any noncompliance will be noted by the CQA Consultant and reported to the Project Manager.

6 Earthen Drainage & Protective Components

6.1 Introduction

This section of the CQA plan addresses the earthen components of a cap or liner system that will be placed above various geosynthetics. For cap systems these components include sand and gravel drains, “erosion layers” and topsoil layers. For liner systems these components include sand drains, gravel drains, and soil buffer layers (“protective cover”). This section outlines the CQA program to be implemented with regard to materials confirmation, laboratory and field test requirements, overview and interfacing with the Contractor's CQC Program, and resolution of problems.

6.2 General Placement

6.2.1 Wrinkles and Folds in Geosynthetics

All earthen materials placed directly above a geosynthetic shall be placed by the contractor in a manner that minimizes wrinkles and folds. The CQA Consultant shall monitor placement and document any areas in which folding occurs so that the Contractor can make repairs to the geosynthetics. It may be necessary to adjust the time of day or the method of placement in order to minimize wrinkling of the geosynthetics. Failure of the Contractor to control wrinkles shall be reported by the CQA consultant to the Project Manager for resolution.

6.2.2 Abrasion and Puncture of Geosynthetics

The CQA consultant shall be aware of activities during the placement of earthen materials above the geosynthetics that may result in abrasion or puncture. The CQA consultant shall investigate any activity that is a cause for concern and shall document all investigations. The

documentation shall include a description of the activity that is causing concern; the location; a description of the damage to the geosynthetic (if any); a description of the repair; and preventative measures to be implemented to avoid future incidents of a similar nature.

Activities that may be cause for concern include:

- sharp turns;
- spinning of wheels or tracks;
- digging in placed material; and
- pushing material across a geosynthetic.

6.2.3 Equipment Separation

The CQC consultant shall check that the specified separation between equipment and geosynthetics is maintained. That CQA consultant shall observe and report any problems to the Project Manager.

6.2.4 Exposure

Some geosynthetics, especially geotextiles, degrade when exposed to ultraviolet light. The project specifications may require that these materials be covered within a certain number of days. The CQA consultant shall document when these materials are covered in a timely fashion. If current progress indicates that any materials will not be covered within the time defined in the project specifications the CQA consultant shall report that information to the Project manager and Contractor.

6.3 ~~Sand~~Soil and Gravel (granular) Drainage Material

The CQC Consultant will provide testing of the granular material at the frequency specified in the project specifications. The CQA Consultant will observe that placement of the granular material is done in a manner to protect the geomembrane, and review the gradation and density test data provided by the CQC Consultant. The CQA Consultant may conduct confirmation testing as deemed appropriate.

6.4 Soil Buffer Layer Material

The soil buffer layer material (~~protective cover~~i.e., subcell divider berms) shall be placed in accordance with project specifications. The CQC Consultant will provide classification testing of the material at the frequency specified in the project specifications. The CQA Consultant will observe that the placement of the soil buffer is done in a manner to protect any filter geotextile or cushion geotextile and review the classification data provided by the CQC Consultant. The CQA Consultant may conduct confirmation classification testing as deemed appropriate.

6.5 Erosion Layer Material

The erosion layer shall be placed in accordance with the project specifications. The CQC Consultant will provide gradation and thickness testing of the material at the frequency specified in the project specifications. The CQA Consultant will observe that placement of the material is accomplished in a manner to protect the geomembrane and review the gradation and thickness

test data provided by the CQC Consultant. The CQA Consultant may conduct confirmation gradation and thickness testing as deemed appropriate.

6.6 Topsoil Layer Material

The topsoil layer shall be placed in accordance with the project specifications. The CQC Consultant will provide nutrient and thickness testing of the material at the frequency specified in the project specifications. The CQA Consultant will observe that placement of the material is accomplished in a manner to protect the erosion layer, and review the test data provided by the CQC Consultant. The CQA Consultant may conduct confirmation testing as deemed appropriate.

6.7 Materials Testing

6.7.1 Test Methods

All testing used to evaluate the suitability or conformance of earthen materials will be carried out in accordance with the project specifications.

6.7.2 Material Testing Requirements

Laboratory CQA conformance tests may be conducted on samples taken at the borrow source, stockpile, and during the course of work prior to construction. Field conformance tests will be conducted by the CQC during the course of the work.

The material CQC testing must comply with the minimum frequencies presented in the project specifications. The frequency of CQA testing may be adjusted by the CQA Consultant in light of the potential variability of the materials and the acceptance/failure rate of the CQC testing.

6.8 Deficiencies

If a defect is discovered in the earthwork product, the CQC Consultant will immediately determine the extent and nature of the defect and report it to the CQA Consultant. If the defect is indicated by an unsatisfactory test result, the CQC Consultant will determine the extent of the deficient area by additional tests, observations, a review of records, or other means that the CQA Consultant deems appropriate.

6.8.1 Notification

After determining the extent and nature of a defect, the CQC Consultant will notify the Project Manager and Contractor and schedule appropriate retests when the work deficiency is corrected. The CQA Consultant shall observe all retests on defects.

6.8.2 Repairs and Retesting

The Contractor will correct the deficiency to the satisfaction of the CQA Consultant. If a project specification criterion cannot be met, or unusual weather conditions hinder work, then the CQC Consultant will develop and present to the Project Manager suggested solutions for his approval.

All retests recommended by the CQC Consultant must verify that the defect has been corrected before any additional work is performed by the Contractor in the area of the deficiency. The

CQA Consultant will verify that all installation requirements are met and that all submittals are provided.

7 Geotextile

7.1 Manufacturing

Compliance testing will be performed by the manufacturer to demonstrate that the product meets the manufacturers' standards and the project specifications. The manufacturer shall submit a package of certifications and the quality control test results to the Contractor. The Contractor shall distribute the package upon receipt to the CQA consultant prior to the installation of any material.

The quality control certificate will be signed by a responsible party employed by the Geosynthetics Manufacturer, such as the production manager.

The CQA Consultant will examine all manufacturer certifications to ensure that the property values listed on the certifications meet or exceed those specified for the particular type of geotextile. Any deviations will be reported to the Project Manager.

The inspection methods, handling techniques, and property values identified in the specifications for the filter geotextile shall also apply to geotextile portion of the geocomposite drainage media.

7.2 Labeling

The Geosynthetics Manufacturer will identify all rolls of geotextile in conformance with the project specifications. The CQA Consultant will examine rolls upon delivery and any deviation from the above requirements will be reported to the Project Manager.

7.3 Shipment and Storage

During shipment and storage, the geotextile will be protected as required by the manufacturer’s recommendations and the project specifications. The CQA Consultant will observe rolls upon delivery at the site and any deviation from the above requirements will be reported to the Project Manager.

7.4 Handling

The Geosynthetics Installer will handle all geotextiles in such a manner as required by the project specifications. Any noncompliance will be noted by the CQA Consultant and reported to the Project Manager.

7.5 Seams and Overlaps

All geotextiles will be seamed or overlapped in accordance with project specifications or as approved by the CQA Consultant and Engineer. The CQA consultant shall walk the material after placement to confirm that the proper methods have been used.

7.6 Repair

Any holes or tears in the geotextile will be repaired in accordance with the project specifications. The CQA Consultant shall observe any repairs and note any noncompliance with the above requirements and shall report them to the Project Manager.

7.7 Exposure

The CQA consultant shall document the placement time of the material and track the exposure time until the material has been covered. Any material that is exposed to UV radiation longer than the time allowed by the project specifications shall be reported to the Project Manager.

8 High Density Polyethylene Pipe, Manholes, and Fittings

8.1 Material Requirements

All HDPE manholes, pipe, and fittings shall be produced in accordance with the project specifications.

8.2 Quality Control

8.2.1 Manufacturer

Prior to shipment of HDPE manholes or pipes, the manufacturer shall provide to the Contractor:

- a properties sheet including, at a minimum, all specified properties, measured using test methods indicated in the project technical specifications; and
- a certification by the HDPE pipe manufacturer that values given in the properties sheet are minimum values and are guaranteed by the HDPE pipe manufacturer.

8.2.2 Verification and Identification

Prior to the installation, the Contractor will provide the Project Manager and the CQA Consultant with a quality control certification for each lot/batch of HDPE pipe provided. The quality control certificate will be signed by a responsible party employed by the HDPE pipe manufacturer, such as the Production Manger. The quality control certificate will include:

- the lot/batch number and material identification; and
- sampling procedures and results of quality control tests.

The CQA Consultant will:

- review these documents and verify that the property values certified by the HDPE pipe manufacturer meet all of the project technical specifications;
- the measurements of properties by the HDPE pipe manufacturer are properly documented and that the test methods used are acceptable;

- verify that the quality control certificates have been provided at the specified frequency for all lots/batches of pipe, and that each certificate identifies the pipe lot/batch related to it; and
- report any discrepancies with the above requirements to the Project Manager.

8.3 Nondestructive Testing

The CQA Consultant will report any nonconformance of testing methods to the Project Manager.

8.3.1 Pressure Testing

All HDPE pipe used outside of the lined area must be nondestructively tested. These pipe joints will be tested using the pressure test as provided in the project technical specifications.

8.3.2 Video Surveying

All HDPE pipe used inside the lined area is to be free of deleterious materials and obstructions. If video inspection of the pipes is the method required by the specifications to demonstrate this, the CQA Consultant shall observe the actual videoing of the pipes and immediately report any problems noted to the Contractor and Project Manager.

The CQA consultant shall review the video documentation submitted by the Contractor and compare it to the notes and repairs made to confirm that the documentation is complete and accurate.

9 Surveying

9.1 Introduction

Surveying of lines and grades is conducted on an ongoing basis during construction. Close CQC of the surveying is absolutely essential to ensure that slopes are properly constructed. The surveying conducted at the site shall be performed by the Contractor.

9.2 Goals

The survey component of the work has two major goals, to construct the work per the plans and specifications and to document the completed work for the CQA report.

9.3 Survey Control

Permanent benchmarks and baseline control points are to be established for the site at locations convenient for daily tie-in. The vertical and horizontal controls for this benchmark will be established within normal land surveying standards. All surveys should note the horizontal and vertical datums used for control.

9.4 Surveying Personnel

The Contractor's survey crew will consist of a senior surveyor and as many assistants as are required to satisfactorily undertake the work. All surveying personnel will be experienced in the provision of these services including supplying detailed, accurate documentation.

All surveying will be performed under the direct supervision of a licensed land surveyor (PLS) licensed in the state in which the project is located. The licensed land surveyor may be the senior surveyor.

9.5 Precision and Accuracy

A wide variety of survey equipment is available to meet the requirements of this project. The survey instruments used for this work should be sufficiently precise and accurate to meet the needs of the project. All survey instruments should be capable of reading to a precision of 0.01 foot and with a setting accuracy of 20 seconds. (5.6×10^{-3} degrees).

The contour intervals and confidence level of all topographic drawings shall be clearly stated on the drawing and should be appropriate for the tolerances required by the specifications.

9.6 Lines and Grades

The subgrade, top of soil liner with final surfaces shall be surveyed to verify the lines and grades achieved during construction. The survey should at least include the following.

- One or more construction baselines.
- The edges of all surface breaks (ex. toes, crests, ridges and valleys).
- All structures.
- Invert elevation of and location of all HDPE piping at each lateral intersection and endpoint, and at least every 50 feet between the intersections and endpoints.
- Inverts of sumps, manholes and other appurtenances.
- Top/toe of all berms, roads, and channels.
- Location of edge of liner, anchor trenches tie-in seam to adjacent existing liner system (as applicable).
- Major patches of HDPE liner.

Laser planes or GPS systems are highly recommended for achieving the correct lines and grades during construction of each surface.

9.7 Thickness Measurements

The CQC surveyor as a representative of the Contractor shall obtain top and bottom elevations of the soil liner and other components as required by the project specifications. Thickness verification may be done with a table or by electronic comparison of drawing files. The procedure for obtaining top and bottom elevations of the soil liner shall be agreed to by the CQA Consultant and Engineer prior to construction. The CQC surveyor shall review the survey information with the Contractor to ensure that the survey demonstrates compliance with the project technical specifications. The Contractor is responsible for identifying and reporting to the CQA Consultant any areas of non-compliance evidenced by the survey, and for repairing such areas. The CQA Consultant and Contractor shall review the thickness measurements of the soil liner component prior to placement of the geomembrane liner. The CQA consultant should notify the Project Manager of areas the need to be corrected.

9.7.1 Tabular verification

If allowed by Engineer, a thickness verification table may be compiled containing the following information for each point.

- Proposed subgrade elevation.
- Actual subgrade elevation.
- Subgrade deviation.
- Proposed soil liner elevation.
- Actual soil liner elevation.
- Soil liner thickness.
- Elevation deviation.
- Proposed cover elevation.
- Actual cover elevation.
- Cover Thickness.
- Cover Elevation deviation.

Any deviations in elevation or thickness outside the tolerances allowed by specification shall be corrected.

9.7.2 Drawing verification

Electronically compare the surfaces for thickness verification. Supply the Engineer and/or the CQA Consultant with electronic files in agreed upon common format for comparison for review. These files may be for all or a portion of the work. The reviewer shall generate a drawing illustrating the areas of noncompliance and provide it to the Contractor for acquisition of additional data points or corrective action.

9.8 Tolerances

Except for liner components where no minus tolerances are acceptable, the following are maximum tolerances for survey points.

- On surfaces: the maximum tolerances shall be 0.25 foot. This tolerance must be set to the record elevation of the surface below it and not the design elevation.
- On piping for leachate collection/detection lines: the maximum tolerance shall be 0.02 foot. This tolerance must be set to the record elevation of the surface below it and not the design elevation.
- On cleanout risers: the tolerance shall be 0.25 foot. This tolerance must be set to the record elevation of the surface below it and not the design elevation.

9.9 Documentation

All field survey notes will be retained by the senior surveyor. The results from the field surveys will be documented on a set of survey record (as-built) drawings by the Contractor for submittal to the CQA Consultant. The Contractor shall certify to the CQA Consultant and Engineer that the results of the survey demonstrates compliance with the contract documents. Sealed surveys depicting the information gathered shall be supplied to the Engineer and CQA Consultant in

sufficient quantities. The surveys shall depict the information in a topographic format and illustrate actual data points.

10 Documentation

An effective CQA plan depends largely on recognition of all construction activities that should be monitored and on assigning responsibilities for the monitoring of each activity. This is most effectively accomplished and verified by the documentation of quality assurance activities. The CQA Consultant will document that all quality assurance requirements have been addressed and satisfied.

This CQA plan integrates the testing and inspection performed by the CQC Consultant in accordance with the project specifications with the CQA overview and conformance testing performed by the CQA Consultant in accordance with this CQA Plan.

The CQA Consultant will provide the Project Manager with the CQC Consultant's daily and weekly reports including signed descriptive remarks, data sheets, and logs to verify that all CQC monitoring activities have been carried out. The CQA Consultant will also provide the Project Manager with a weekly report summarizing CQA activities and identifying potential quality assurance problems. The CQA Consultant will also maintain a copy of this CQA plan and a complete file of plans, reports, project specifications, checklists, test procedures, daily logs, and other pertinent documents at the job site.

10.1 Recordkeeping

The CQC Consultant's reporting procedures will include preparation of a daily report which, at a minimum, will consist of: a) field notes, including memoranda of meetings and/or discussions with the Contractor; b) observation logs and testing data sheets; and c) construction problem and solution data sheets. The daily report must be completed at the end of each CQC Consultant's shift, prior to leaving the site. This information will be submitted weekly to and reviewed by the CQA Consultant.

The CQC Consultant's weekly reports must summarize the major events that occurred during that week. Critical problems that occur shall be communicated verbally to the Project Manager or CQA Consultant immediately as well as being included in the weekly reports. The CQC Consultant's weekly report must be submitted to the CQA Consultant no later than the Monday following the week reported.

The CQA Consultant's weekly report must summarize the CQC Consultant's weekly and daily reports, CQA conformance testing activities, construction problems that occurred, and the resolution of construction problems. The CQA Consultant's weekly report should identify all potential or actual compliance problems outstanding. The CQA Consultant's weekly report must be submitted to the Project Manager on the Wednesday following the week reported.

10.1.1 Memorandum of Discussion with CQC Consultant or Geosynthetic Installer

A report will be prepared summarizing each critical discussion between the CQA Consultant and the CQC Consultant or Geosynthetic Installer. At a minimum, the report will include the following information.

- Date, project name, location, and other identification.
- Name of parties to discussion at the time.
- Relevant subject matter or issues.
- Activities planned and schedule.
- Signature of the CQA Consultant.

10.1.2 CQA Observation Logs and Testing Data Sheets

CQA observation logs and conformance testing data sheets will be prepared by the CQA Consultant on a weekly basis. At a minimum, these logs and data sheets will include the following information.

- An identifying sheet number for cross referencing and document control.
- Date, project name, location, and other identifying information.
- Data on weather conditions.
- A scale site plan showing all proposed work areas and test locations.
- Descriptions and locations of ongoing construction.
- Descriptions and specific locations of areas, or units, of work being tested and/or observed and documented.
- Locations where tests and samples were taken.
- A summary of test results.
- Calibrations of test equipment, and actions taken as a result of recalibration.
- Offsite materials received, including quality verification documentation.
- Decisions made regarding acceptance of units of work, and/or corrective actions to be taken in instances of substandard quality.
- The CQA Consultant's signature.

10.1.3 CQA Construction Problem and Solution Data Sheets

CQA sheets describing special construction situations will be cross-referenced with specific CQA observation logs and testing data sheets, and must include the following information, where available.

- An identifying sheet number for cross referencing and document control.
- A detailed description of the situation or deficiency.
- The location and probable cause of the situation or deficiency.
- How and when the situation or deficiency was found or located.
- Documentation of the response to the situation or deficiency.
- Final results of any responses.
- Any measures taken to prevent a similar situation from occurring in the future.

- The signature of the CQA Consultant, and signature of the Project Manager indicating concurrence if required by this CQA Plan.

The Project Manager will be made aware of any significant recurring nonconformance with the project specifications. The Project Manager will then determine the cause of the non-conformance and recommend appropriate changes in procedures or specification. When this type of evaluation is made, the results will be documented, and any revision to procedures or project specifications will be approved by the Owner and Engineer.

10.2 CQA Photographic Reporting Data Sheets

Photographic reporting data sheets, where used, will be cross-referenced with CQA observation logs and testing data sheets and/or CQA construction problem and solution data sheets. Digital ~~P~~photographs shall be taken at regular intervals during the construction process and in all areas deemed critical.

These photographs will serve as a pictorial record of work progress, problems, and mitigation activities~~. The basic file will contain color prints; negatives will also be stored in a separate file in chronological order.~~ The file name for the digital photographs will contain the date and a description of the photograph (i.e. 20150712 Liner Installation Cell 1). These records will be presented to the Project Manager upon completion of the project.

In lieu of photographic documentation, digital video may be used to record work progress, problems, and mitigation activities. The Project Manager may require that a portion of the documentation be recorded by photographic means in conjunction with video.

10.3 Design and/or Project Technical Specification Changes

Design and/or project specification changes may be required during construction. In such cases, the CQA Consultant will notify the Project Manager and the Engineer. The Project Manager will then notify the appropriate agency, if necessary.

Design and/or project specification changes will be made only with the written agreement of the Project Manager and the Engineer, and will take the form of an addendum to the project specifications. All design changes shall include a detail (if necessary) and state which detail it replaces in the plans.

10.4 CQA Progress Reports

The CQA Consultant will prepare a summary progress report each week, or at time intervals established at the pre-construction meeting. As a minimum, this report will include the following information.

- A unique identifying sheet number for cross-referencing and document control.
- The date, project name, location, and other identifying information.
- A summary of work activities during progress reporting period.
- A summary of construction situations, deficiencies, and/or defects occurring during the progress reporting period.

- Summary of all test results, failures and retests, and signature of the CQA Consultant.

10.5 Signature and Final Report

At the completion of each major construction activity at the structural fill unit, the CQA Consultant will certify all required forms, observation logs, field and laboratory testing data sheets including sample location plans, construction problems and solution data sheets. The CQA Consultant will also provide a final report which will certify that the work has been performed in compliance with the plans and project technical specifications, and that the supporting documents provide the necessary information.

The CQA Consultant will also provide summaries of all the data listed above with the report. The Record Drawings will include scale drawings depicting the location of the construction and details pertaining to the extent of construction (e.g., depths, plan dimensions, elevations, soil component thicknesses, etc.). All surveying and base maps required for development of the record drawings will be done by the construction surveyor. These documents will be certified by the Contractor and CQC Consultant and delivered to the CQA Consultant and included as part of the CQA documentation (Certification) report.

It may be necessary to prepare interim certifications, as allowed by the regulatory agency to expedite completion and review.

10.6 Storage of Records

All handwritten data sheet originals, especially those containing signatures, will be stored by the Project Manager in a safe repository on site. Other reports may be stored by any standard method which will allow for easy access. All written documents will become property of the Owner.

Technical Specifications

Colon Mine Site Structural Fill

Charah, Inc.

Sanford, NC

November 2014
Revised ~~December 2014~~ January 2015

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Table of Contents

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SECTION 01060
SPECIAL CONDITIONS

PART 1 - GENERAL

1.1 CONDITIONS SPECIFIC TO THIS PROJECT

A. CQC/CQA Duties: In general, the CQC Consultant will perform all testing related to earthwork and soil liner work and provide documentation to the CQA Consultant. The CQA Consultant will conduct the destructive geosynthetic testing and provide geosynthetic documentation as per these documents. CQC and CQA documentation will be used by the CQA Consultant to prepare and submit final certification to NCDENR. Refer to the CQA Plan.

B. The CONTRACTOR is responsible for construction/maintenance of any additional access/haul roads as approved by the OWNER.

C. The CONTRACTOR is responsible for maintaining the Erosion and Sediment Control measures.

D. CONTRACTOR is to obtain all soil material from on-site. Stockpiling of soil material shall be within the limits of disturbance as shown on the Drawings.

E. Limits of Disturbance:
   1. As defined on the Drawings.

F. Site Access:
   1. The only access to the site available to the CONTRACTOR is entering through the existing entrance on Colon Road.

G. Hours of Construction shall be as agreed by the OWNER. Construction may occur on Legal Holidays with permission from the OWNER. The OWNER may allow the CONTRACTOR to extend the Hours of Construction provided there are not complaints from the community and the OWNER approves of the extension. If the OWNER receives any complaints, then the OWNER may revoke the extended hours of construction.

1.2 PROJECT MEETINGS

A. A preconstruction conference shall be held at the site with the ENGINEER, CONTRACTOR's Project Manager and Project Superintendent and CONTRACTOR's Subcontractor Representatives. The purpose is to review sequence of work and communication procedures.

B. Pre-Installation Conferences:
   1. Coordinate and schedule with Resident Project Representative and ENGINEER for each material, product or system specified. Conferences to be held prior to initiating installation, but not more than two (2) weeks before scheduled initiation of installation.
      a. Conferences may be combined if installation schedule of multiple components occurs within the same two (2) week interval.
      b. Review manufacturers recommendations and Contract Documents Specifications.
   2. CONTRACTOR's Superintendent and individual who will actually act as foreman of the installation crew (installer), if other than the Superintendent, shall attend.

C. Construction Meetings:
   1. The ENGINEER will conduct construction meetings involving:
      a. CONTRACTOR's project manager.
      b. CONTRACTOR's project superintendent.
      c. OWNER's designated representative(s).
      d. ENGINEER's designated representative(s).
      e. CONTRACTOR's subcontractors as appropriate to the work in progress.
      f. OWNER's Construction Quality Control Consultant.

2. Frequency of meetings to be as agreed upon at the Pre-Construction Meeting.
3. The ENGINEER will take meeting minutes and submit copies of meeting minutes to participants and designated recipients identified at the Preconstruction Conference. Corrections, additions or deletions to the minutes shall be noted and addressed at the following meeting.
4. The CONTRACTOR shall have available at each meeting up-to-date record drawings

1.3 DATA AND MEASUREMENTS

A. The data given in the Specifications and shown on the Drawings is believed to be accurate but the accuracy is not guaranteed. The Contractor must take all levels, locations, measurements, and verify all dimensions of the job site prior to construction and must adapt his work into the exact construction. Larger scale Drawings take precedence over smaller scale Drawings, and approved shop drawings take precedence over all others.

B. All survey's shall be sealed by a North Carolina registered land surveyor and submitted to the Engineer. The Contractor shall provide the Engineer with an electronic version of the sealed survey in AutoCAD readable format. Provide unique layers for 1 FT contours, index contours, text, water, vegetation, buildings, roads, etc. Utilize North Carolina grid coordinate system and locate all features in x, y, and z dimensions.

C. Initial survey shall include the following:
   1. Topography of the cell area
   2. Topography of the stockpile areas.
   3. Topography within limits of construction including:
      a. Topography of all sediment basins.
      b. Location of existing channels.
      c. Location of structures.
      d. Inverts of pipe, size, and pipe location.

D. Final as-built survey shall include the following, for example:
   1. Topography of the entire area within limits of construction.
   2. Limits of liner placement.
   3. Topography of the stockpile areas and all other disturbed areas.
   4. Location of roads.
   5. Location of channels.
   6. Topography of all sediment basins and associated outlet structures.
   7. Culverts (invert, size, locations).
   8. Location of utility poles on the property.
   9. Other areas or items that were a part of the Work as directed by the Engineer.
   10. Locations of leachate pipes, valves, sumps, and subcell divider berms.

E. During construction, the contractor shall submit to the Engineer for review preliminary surveys that depict thickness verification of the soil layers.

F. Thickness verification may be done with a table or by electronic comparison of drawing files. The method shall be agreed to by the CQA and ENGINEER prior to construction. If the table method is selected, the same point on each soil layer must be used. The thickness is to be measured perpendicular to the slope. Refer to the soil specifications for frequency of points.

G. Contractor shall preserve and protect all reference points and pay for replacement of any destroyed referenced points.

H. Additional requirements are set forth in Section 9.0 of the CQA Plan.

1.4 SPECIAL CONSIDERATIONS

A. CONTRACTOR shall be responsible for negotiations of any waivers or alternate arrangements required to enable transportation of materials to the site.

B. Maintain conditions of access road to site such that access is not hindered as the result of construction related deterioration.

C. Safety:
   1. The CONTRACTOR alone shall be solely and completely responsible for conditions of the job site in connection with his work, including safety of all personas and property, preparatory to and during performance of the work. This requirement shall apply continuously and not be limited to normal working hours.
   2. The Construction Documents and the construction hereby contemplated, are to be governed, at all times, by applicable provisions of local and state laws and regulations, and federal laws, including, but not limited to, the latest amendments of the following: Department of Labor, Bureau of Labor Standards Safety and Health Regulations for Construction, and Williams and Steiger Occupational Safety and Health Act of 1970, including rules and regulations pursuant thereto, applicable to the Work and performance of the Contract. (OSHA).
   3. The duty of the ENGINEER to conduct construction review of the CONTRACTOR's performance is not intended to include review of the adequacy of the CONTRACTOR's safety measures in, on, or near the construction site.
   4. All explosives shall be stored in a secure manner and all storage places shall be marked clearly "DANGEROUS EXPLOSIVES," and shall be in the care of competent watchmen at all times.

D. Inspections by Federal and State Agencies: Authorized representative and agents of the state and federal government shall be permitted to inspect all work, materials, records of personnel, invoices of materials, and other relevant data and records.

E. Water:
   1. CONTRACTOR is responsible for all water necessary for the completion of the Work. Water used on the project shall be fresh and of drinkable quality. The CONTRACTOR shall make arrangements to obtain fresh water for his drinking.
   2. Water for other uses such as dust control and moisture control of fill may be obtained from storm water basins as approved by the CQC and CQA Consultants. The CONTRACTOR shall obtain any required permits.
   3. CONTRACTOR is responsible for coordinating use of, and all costs associated with use of, water from local sources.

F. The CONTRACTOR shall provide sanitary facilities during construction.

G. Order of Construction: The CONTRACTOR will schedule construction operations to allow the other contractors access to the site.

1.5 HISTORICAL AND ARCHAEOLOGICAL

A. If during the course of construction, evidence of deposits of historical or archeological interest is found, the CONTRACTOR shall cease operations affecting the find and shall notify OWNER. No further disturbance of the deposits shall ensue until the CONTRACTOR has been notified by OWNER that CONTRACTOR may proceed. OWNER will issue a notice to proceed after appropriate authorities have surveyed the find and made a determination to OWNER. Compensation to the CONTRACTOR, if any, for lost time or changes in construction resulting from the find, shall be determined in accordance with changed or extra work provisions of the Contract Documents. The site has been previously investigated and has no known history of historical or archaeological finds.

PART 2 - PRODUCTS

2.1 INTERFACE FRICTION TESTS

A. Laboratory friction tests shall be conducted, on behalf of the OWNER by the CQA Consultant, with representative samples of the materials selected by the CONTRACTOR for use in the

Work. The CQA Consultant must approve the testing laboratory used for these tests. The CONTRACTOR is responsible for shipping materials to the testing laboratory. The initial set of testing and subsequent conformance tests (if any) shall be paid for by the CQA Consultant. If any interface doesn't meet the requirements, or if the CONTRACTOR changes geosynthetic materials, then the additional cost to qualify those materials shall be borne by the CONTRACTOR.

B. Base Liner
   1. Testing will include the interfaces between the following adjacent materials with a minimum peak friction angle of 26 degrees is required for each interface.

MATERIAL	SPECIFICATION SECTION
Ash	----
Drainage Composite	02777
60 Mil HDPE (textured)	02775
Geosynthetic Clay Liner (GCL)	02776
Soil liner	02276

C. Cap System
   1. The CONTRACTOR may select one of the following cap systems. Testing will include the interfaces between the following adjacent materials with a minimum peak friction angle of 26 degrees is required for each interface.
      a. Option 1

MATERIAL	SPECIFICATION SECTION
Drainage Soil	N/A
40 Mil (textured HDPE or textured LLDPE)	02775 or 02774
Ash	---

      b. Option 2

MATERIAL	SPECIFICATION SECTION
Unclassified Soil	N/A
Drainage Composite	02777
40 Mil (textured HDPE or textured LLDPE)	02775 or 02774
Ash	----

D. Testing shall be performed in accordance with ASTM D6243. The materials shall be tested at normal stressed of 500, 1,000, and 1,500 psf. Displacement rates shall be in accordance with ASTM D6243 Procedure A for geosynthetic to geosynthetic interfaces and Procedure B for soil to geosynthetic interfaces. Soil components shall be compacted to the same moisture-density requirements specified for full-scale field placement and saturated prior to shear for 24 hours. All geosynthetic interfaces shall be tested in a wet condition. Geosynthetics shall be oriented such that the shear force is parallel to the downslope orientation of these components in the field. The testing laboratory shall confirm these criteria with the CQA firm prior to performing the tests.

E. Test results must be satisfactory for material shop drawings to be approved.

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 02220
EARTHWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Earthwork.

B. Related Sections include but are not necessarily limited to:
   ~~1. Section 01400 – Quality Control.~~
   ~~2.~~1. Section 02270 – Soil Erosion and Sediment Control.
   ~~3.~~2. Section 02276 - Soil Liner System ~~(Alternate Liner)~~.
   ~~4.~~3. Construction Quality Assurance Plan.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Society for Testing and Materials (ASTM):
      a. C33, Standard Specification for Concrete Aggregates.
      b. D698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft3).
      c. D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/f (2,700 kN-m/m)).
      d. D1586, Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils.
      e. D2487, Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
      f. D4253, Standard Test Methods for Maximum Index Density of Soils Using a Vibratory Table.
      g. D4254, Test Methods for Minimum Index Density of Soils and Calculation of Relative Density.
   2. North Carolina Erosion and Sediment Control Planning and Design Manual, current edition.
   3. North Carolina Department of Transportation Standard Specification for Roads and Structures, current edition.

B. Employ a Geotech Engineer and laboratory to conduct the specified tests to assure that all work complies with this Specification.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Product technical data including:
      a. Acknowledgement that products submitted meet requirements of standards referenced.
      b. Manufacturer's installation instructions.
   2. Certifications.
   3. Test reports:
      a. Soils inspection and testing results.

B. Samples:
   1. Submit samples and source of fill and backfill materials proposed for use.
   2. Submit samples and source of borrow materials proposed for use.
   3. Submit soil samples directly to soils laboratory with notification to the Engineer.

1.4 SOILS/GEOTECHNICAL

A. The Soils Engineer will selectively test materials and monitor compliance with the requirements of these Specifications.

B. The Contractor will afford these representatives access to the job site for the performance of their duties as described in the Contract Documents.

C. General Duties and Responsibilities of the Contractor's Geotech Engineer: Under the direction of a qualified registered engineer or geologist:
   1. Perform stockpile and in-place testing of all soil and rock materials used in the work in conformance with these Specifications and the CQA Plan.
   2. Inspect subgrades and excavations and evaluate/determine suitability of materials encountered. Determine extent of any overexcavation required to remove unsuitable materials under roadways, structures, or other areas of construction.
   3. Document placement of fill materials and perform testing to confirm compliance with these Specifications.
   4. Evaluate the suitability of existing on-site materials for use in construction of embankments and fills within the proposed grading shown on the Contract Drawings.
   5. Measure quantity of unsuitable materials under contract provisions for authorized overexcavation and backfill.

D. General Duties and Responsibilities of the Engineer:
   1. Approve materials proposed for incorporation into the work by the Geotech Engineer.
   2. Review subgrades and excavations and approve suitability of materials encountered as proposed by the Geotech Engineer. Approve extent of any overexcavation required to remove unsuitable materials under roadways, structures, or other areas of construction, as proposed by the Geotech Engineer.
   3. Review placement of fill materials and testing by Geotech Engineer for compliance with these specifications.
   4. Review/approve the suitability of existing on-site materials for use in construction of embankments and fills.
   5. Review construction operations and monitor for compliance with Contract Documents.
   6. Review/approve Geotech Engineer quantity of unsuitable materials for payment on a unit price basis under contract provisions for authorized overexcavation and backfill.

E. Available Subsurface Information: Data provided in these specifications on subsurface soil conditions are not intended as representations or warranties of the continuity of such conditions between borings or indicated sampling locations. It shall be expressly understood that neither the Owner nor the Engineer will be responsible for any interpretation or conclusion drawn therefrom by the Contractor. Data is made available for the convenience of the Contractor.

F. Additional or supplementary soil borings or other exploratory operations may be made by the Contractor. The Contractor shall provide a copy of any data obtained/developed during such work. Such additional work shall be performed in a timely manner in accordance with and not impacting or changing the project schedule set forth in the Contract Documents.

1.5 TOLERANCES

A. Grading shall be to a tolerance of + 0.25 FT unless otherwise noted in the construction documents and then the stricter criteria shall be used.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Fill and Backfill: Selected material approved by Engineer and Owner from site excavation or other approved source.

B. The Contractor shall conduct his own quantity and quality investigations and testing to determine availability and suitability of (on-site and/or off-site) borrow materials, as allowed by the Owner.

C. All earth materials proposed for use in the Work shall be adequately characterized prior to the Work by the Geotech Engineer.

PART 3 - EXECUTION

3.1 PROTECTION

A. Protect existing surface and subsurface features on-site and adjacent to site as follows:
   1. Provide barricades, coverings, or other types of protection necessary to prevent damage to existing items indicated to remain in place.
   2. Protect and maintain benchmarks, monitoring wells, existing structures, monuments, or other established reference points and property corners. If disturbed or destroyed, replace at own expense to full satisfaction of controlling agency.
   3. Verify location of utilities. Omission or inclusion of utility items does not constitute non-existence or definite location. Secure and examine local utility records for location data.
      a. Take necessary precautions to protect existing utilities from damage due to any construction activity.
      b. Repair damages to utility items at own expense.
      c. In case of damage, notify Engineer at once so required protective measures may be taken.
   4. Maintain stockpiles and excavations in such a manner to prevent inconvenience or damage to structures on-site or on adjoining property.
   5. Avoid surcharge or excavation procedures which can result in heaving, caving, or slides.

B. Construct erosion and sedimentation controls prior to beginning earthwork.

3.2 SITE EXCAVATION AND GRADING

A. The Work includes all operations in connection with excavation, borrow, construction of fills and embankments, rough grading, and disposal of excess materials in connection with the preparation of the site(s) for construction of the proposed facilities.

B. Excavation and Grading: Perform as required by the Contract Drawings.
   1. Contract Drawings may indicate both existing grade and finished grade required for construction of Project. Stake all units, structures, piping, roads, parking areas and walks and establish their elevations. Perform other layout work required. Replace property corner markers to original location if disturbed or destroyed.
   2. Preparation of ground surface for embankments or fills: Before fill is started, scarify to a minimum depth of 6 IN in all proposed embankment and fill areas. Where ground surface is steeper than one vertical to four horizontal, plow surface in a manner to bench and break up surface so that fill material will bind with existing surface.
   3. Protection of finish grade: During construction, shape and drain embankment and excavations. Maintain ditches and drains to provide drainage at all times. Protect graded areas against action of elements prior to acceptance of work. Re-establish grade where settlement or erosion occurs.

C. Borrow: Provide necessary amount of approved fill compacted to density equal to that indicated in this Specification. Fill material to be approved by Soils Engineer prior to placement.

D. ~~Construct e~~Embankments and ~~f~~Fills ~~as required by the Contract Drawings~~:
   1. Construct embankments and fills at locations and to lines of grade indicated. Completed fill shall correspond to shape of typical cross section or contour indicated regardless of method used to show shape, size, and extent of line and grade of completed work.

2. Provide approved fill material which is free from roots, organic matter, trash, frozen material, and stones having maximum dimension greater than 6 IN. Ensure that stones larger than 3 IN are not placed in upper 6 IN of fill or embankment.

~~2.~~3. ~~Do not p~~Place material in layers no greater than 8 IN loose thickness. However, thicker lifts may be allowed if it can be demonstrated that compaction requirements are met and approved by the Engineer. Place layers horizontally and compact each layer prior to placing additional fill. Perform testing as indicated in Part 3.6 of this Section.

~~3.~~4. Compact by sheepsfoot, pneumatic rollers, vibrators, or by other equipment as required to obtain specified density. Control moisture for each layer necessary to meet requirements of compaction.

E. Upon reaching subgrade elevations shown, proofroll subgrade soils and obtain the Geotech Engineer's review/recommendation and approval. If unsuitable materials are encountered at the subgrade elevation, repair as directed by the Geotech Engineer to remove unsuitable materials. Excavation of 1 cy or greater should be preapproved by the Geotech Engineer.

F. Proofrolling shall be conducted with a pneumatic-tired vehicle of at least 20 tons Gross Vehicle Weight (GVW), approved by the Geotech Engineer. An alternate method may be approved by the Geotech Engineer may be used in constricted areas.

G. Where subgrade materials are determined to be unsuitable, such materials shall be removed to the lengths, widths, and depths directed by the Geotech Engineer and backfilled with suitable material unless further excavation or earthwork is required. No additional payment will be made for such excavation and backfill 6 IN or less than the finished subgrade. Payment for unsuitable material excavation greater than 6 IN beneath the finished subgrade shall be negotiated.

H. The subgrade of areas to receive fill shall be smooth and free of all vegetation, sticks, roots, rocks, and debris.

I. Dewatering (as required): Provide and maintain dewatering of all surface water and/or groundwater as required for excavation.

J. Do not place fill when the subgrade is frozen, wet, loose, or soft.

K. Moisture control:
1. Moisture content of materials prior to, and during compaction, shall be uniform throughout each layer of material.
2. Granular materials shall be thoroughly wetted during or immediately prior to compaction.
3. Supplementary water shall be added as required to materials by sprinkling and mixing uniformly throughout layer.
4. Materials too wet for placing shall be temporarily spread or aerated until moisture content is acceptable. If these materials cannot be processed in time to use, the Contractor shall find alternatives acceptable to the Geotech Engineer.

3.3 USE OF EXPLOSIVES

A. Blasting with any type of explosive must be in compliance with 3.4 of this Section.

3.4 ROCK EXCAVATION

A. Rock is defined as natural material that cannot be moved or ripped with a Caterpillar D8N (or newer version) equipped with a single tooth ripper or approved equal. A demonstration is required. The Contractor shall not remove rock until authorized by the Engineer.

B. All rock excavation shall be under one classification. This classification shall include solid ledge rock in its natural location that requires systematic quarrying, drilling, and/or blasting for its removal and also boulders that exceed 1 CY in volume.

C. The use of explosives shall be limited to the magnitude and location of the charge that will not cause damage to adjacent existing construction and utilities through shock vibrations or other stress loadings. Provide adequate blanket protection to ensure that there will not be fragments of

rock or other debris flying through the air when discharging explosives. Any damage to existing construction or other features caused by blasting operations to be repaired and paid for by Contractor.

1. Explosive permits shall be obtained from the appropriate local authorities.

D. Where explosives and blasting are used, comply with all laws and ordinances of municipal, state and Federal agencies relating to the use of explosives. Use qualified personnel for blasting and take proper precautions to protect persons, property or the work from damage or injury from blast or explosion. Conduct preblast survey in the company of the Geotech Engineer to aid in determining any damage caused by blasting.

3.5 FIELD QUALITY CONTROL

A. Moisture density relations, to be established by the Geotech Engineer are required for all materials to be compacted.

B. Extent of compaction testing will be as necessary to assure compliance with Specifications.

C. Give minimum of 24 HR advance notice to Geotech Engineer when ready for compaction or subgrade testing and inspection.

D. Should any compaction density test or subgrade inspection fail to meet Specification requirements, perform corrective work as necessary.

E. Pay for all costs associated with corrective work and retesting resulting from failing compaction density tests.

3.6 COMPACTION DENSITY REQUIREMENTS

A. Obtain approval from Soils Engineer with regard to suitability of soils and acceptable subgrade prior to subsequent operations.

B. Provide dewatering system necessary to successfully complete compaction and construction requirements.

C. Remove frozen, loose, wet, or soft, material and replace with approved material as directed by Soils Engineer.

D. Stabilize subgrade with well graded granular materials as directed by Soils Engineer.

E. Assure by results of testing that compaction densities comply with the following requirements:

1. Sitework:

SOIL TYPE	COMPACTION DENSITY
Cohesive Soils	95 percent, ASTM D698
Cohesionless Soils	75 percent relative density per ASTM D4253 and D4254
Structural Fill Under Slabs-On-Grade	75 percent relative density per ASTM D4253 and D4254
Stockpile Material	90 percent, ASTM D698

2. Perform testing at a minimum frequency of 1 test per lift per 10,000 square feet for structural fill.

~~2.~~3. Test locations shall be selected to be representative of conditions encountered.

3.7 SPECIAL REQUIREMENTS

A. Erosion Control: Conduct work to minimize erosion of site. Construct stilling areas to settle and detain eroded material. Remove eroded material washed off site. Clean streets daily of any spillage of dirt, rocks, or debris from equipment entering or leaving site.

END OF SECTION

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SECTION 02240
LEACHATE COLLECTION STONE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Operational Cover.
2. Leachate collection stone.

B. Related Sections Include But Are Not Necessarily Limited To:
~~1. Section 01400 – Quality Control.~~
1. Section 01060 – Special Conditions.
2. Section 02220 – Earthwork.
3. Section 02275 – Soil Liner System ~~(Standard Liner)~~.
~~4. Section 02276 – Soil Liner System (Alternate Liner).~~
~~5.~~4. Section 02775 – HDPE Geomembrane Liner System.
~~6.~~5. Section 02778 – Geotextiles.
~~7.~~6. Section 15067 – Pipe: High Density Polyethylene (HDPE).
~~8.~~7. Construction Quality Assurance Plan.

1.2 QUALITY STANDARDS

A. Referenced Standards
1. American Society for Testing and Materials:
   a. C117 or C136 - Particle Size Analysis.
   b. D2434 - Permeability of Granular Soils.
   c. D4373 - Calcium Carbonate Content of Soils.
   d. D5084 - Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.
2. North Carolina Department of Transportation (NCDOT), Standard Specifications for Roads and Structures current edition.

1.3 SUBMITTALS

A. Shop Drawings:
1. At least four weeks prior to construction of the leachate collection layer, submit a bulk sample of each material from each source to the Geotech Engineeer for testing and forward results to Engineer for approval.

B. Miscellaneous Submittals.

C. Submit all required laboratory test data as required by Subparts 2.1 and 3.2 for materials used in the construction.
1. Submit periodic surveys of each layer during construction for thickness verification. Frequency of survey submittals to be established between Contractor and Engineer prior to placement. Follow the CQA plan for surveying requirements.

1.4 JOB CONDITIONS

A. Take necessary precautions to protect synthetic liner from damage due to any construction activity. Repair damages to liner at own expense. Assess no cost to Engineer or auxiliary party for any damages to liner system or pipe resulting from placement of stone or activities of equipment operating on stone.

B. Protect and maintain benchmarks, monuments, or other established points and reference points and if disturbed or destroyed, replace items to full satisfaction of Owner and controlling agency.

1.5 TOLERANCES

A. Materials shall be placed to the lines and grades as shown on the ~~Contract~~ Drawings.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Material: Submit source test data to the Engineer prior to delivery to the site.
   1. Free of roots, sod or other organic matter, and frozen material.
   2. Materials must meet acceptance criteria presented in 3.2 of this Specification.
   3. Materials may be natural or manufactured.

B. Interface Friction Tests:
   1. Test materials using ASTM ~~D 5321~~D6243. Section 01060-Special Conditions, ~~paragraph 2.1,~~ outlines the conditions under which this material shall be tested ~~at Contractor's expense~~.
   2. This material is part of a system. The system shall meet the requirements before the component materials can be deemed acceptable.

PART 3 - EXECUTION

3.1 GENERAL

A. The leachate collection stone is placed directly over the liner system; thus, extreme caution shall be exercised by the Contractor to prevent damage to the liner system materials.

B. Placement of these materials within the cell shall be conducted only when the Geotech Engineer or his representative is present at the site and informed in advance of the intent to complete this work.

C. Exercise care in maintaining a true line and grade an all piping during placement and spreading of the material.

D. Place materials over the Geomembrane only after areas have been released by the Geomembrane Installer and the CQA/CQC Consultants. The materials shall be placed as specified below.
   1. All materials shall be placed and spread with low ground pressure equipment (6 psi ground pressure or less) as approved by the Engineer to reduce potential damage to the Geomembrane. The Geomembrane surface shall be off limits to construction traffic. Hard turning of tracked equipment on the stone must be avoided.
   2. At least 24 IN of separation between the Geomembrane and all low ground pressure equipment shall be maintained.
   3. Material shall not be placed over standing water or ice.
   4. Material shall not be compacted within the cell limits.
   5. Material on slope shall be placed from the bottom to top of the slope.

E. The leachate collection stone shall be spread in a manner that minimizes development of folds in the Geosynthetics. Any portions of the Geosynthetics that develop a fold shall be repaired by the Contractor.
   1. If during spreading, excessive wrinkles develop, the Contractor shall adjust placement and spreading methods, or cease until the Geomembrane cools and wrinkles decrease in size.
   2. Wrinkles that exceed approximately 6 IN in height and cannot be eliminated by amended placement and spreading methods shall be cut and repaired by the Geomembrane Installer in a method approved by the CQA/CQC Consultants.

F. Any damage to the underlying soil, Geomembrane liners or Geotextiles shall be repaired in accordance with the applicable Section of these Specifications.

G. Stockpiling of materials within the limits of the cell shall be subject to advanced approval by the CQA/CQC Consultants. Any hauling equipment (dump trucks, etc.) operating within the cell limits, including access ramps, shall have a minimum of 3 FT. of separation between the vehicle wheels and the Geomembrane.

H. Any areas where unauthorized or tracked equipment has operated over the leachate collection system shall be subject to investigation for potential Geomembrane damage. Such investigations may include removal of overlying materials in the affected areas and visual inspection of the Geomembrane. These activities shall be conducted under direction by the CQA/CQC Consultants .

3.2 QUALITY CONTROL

A. The CQC Consultant shall perform testing of the materials.

B. Ensure CQA Consultant has at all times immediate access for the testing of all related work.

C. Assure by results of CQC testing that materials and installation comply with the following requirements:

Required Test	Minimum Frequency	Leachate Collection Stone
1. Gradation – ASTM D422	1 per 3,000 CY or portion thereof	NCDOT #57
2. Permeability, K – ASTM D5084 or D2434	1 per 3,000 CY or portion thereof	$K \geq 1$ cm/sec
3. Carbonate Content – ASTM D3042	1 per material source	15% by weight
4. Thickness	Minimum need for sealed survey	As specified

D. Permeability testing shall be performed for all materials listed above.

END OF SECTION

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SECTION 02276
SOIL LINER SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Soil used within structural fill footprint.

B. Related Sections include but are not necessarily limited to:
   1. Section 02110 - Site Clearing.
   2. Section 02220 - Earthwork.
   3. Section 02775 - HDPE Geomembrane Liner System.
   4. Section 02800 - Geosynthetic Clay Liner.
   5. Construction Quality Assurance Plan.

1.2 QUALITY STANDARDS

A. Reference Standards:
   1. ASTM - American Society for Testing and Materials:
      a. ASTM D-422 - Particle Size Analysis.
      b. ASTM D-698 - Standard Proctor.
      c. ASTM D-854 - Specific Gravity.
      d. ASTM D-1140 - Fines Content in Soils.
      e. ASTM D-1556 - In-situ Density Measurement Using the Sand Cone.
      f. ASTM D-1557 - Modified Proctor.
      g. ASTM D-2166 - Unconfined Compressive Strength.
      h. ASTM D-2216 - Moisture Content Using Over-Dry Method.
      i. ASTM D-2487 - Soils Classification.
      j. ASTM D-2573 - Field Vane Shear Test.
      k. ASTM D-2922 - In-situ Density Using Nuclear Methods.
      l. ASTM D-3017 - In-situ Moisture Content Using Nuclear Methods.
      m. ASTM D-4318 - Atterberg Limits.
      n. ASTM D-5084 - Flexible Wall permeameter.
   2. USEPA - United States Environmental Protection Agency
      a. EPA/600/R-93/182 -"Quality Assurance and Quality Control for Waste Containment Facilities," September, 1993.
   3. ASCE – American Society of Civil Engineers.
      a. ASCE Paper No. 25333 – Water Content – Density Criteria for Compacted Soil Liners (Daniel et at, 1998).
      b. ASCE Paper No. 23827 – In-Site Hydraulic Conductivity for Compacted Clay (Daniel et at, 1989).
   4. Construction Quality Assurance (CQA) Plan.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Borrow Source Characterization Study (BSCS).

B. Miscellaneous Submittals:
   1. Soil Liner Test Strip Report sealed by a professional engineer licensed in North Carolina, within 14 days of obtaining the last sample.
   2. Submit periodic surveys during construction for thickness verification. Schedule of survey to be established between Contractor and Engineer prior to placement.

3. Periodic reports of field and lab tests prior to placement of any HDPE in a given area. All applicable reports must be submitted for review.
4. As-built survey with thickness verification table. Refer to Section 01060 for survey requirements.
5. Comprehensive report of field and laboratory tests sealed by a professional engineer licensed in North Carolina, within 14 calendar days of completion of HDPE liner placement. Typed report to include:
    a. Method and equipment used to install the material.
    b. Confirmation the material delivered to the site meets the requirements of this specification.
    c. Daily field logs.
    d. Number of test required, performed, and failed.
    e. Date test performed.
    f. Remedy for failed tests.
    g. Site plan with location of tests.
    h. Field test results with summary log.
    i. Laboratory test results with summary log.
6. Certify the Work is constructed to the specified tolerances with sealed surveys to support the certification.
7. Certify that borrow material is not contaminated with hazardous materials or hazardous wastes.

1.4 JOB CONDITIONS

A. Verify conditions of subgrade prior to commencing work.

B. In accordance with these Specifications, the Contractor is responsible for conducting a borrow soil characterization study (BSCS).

C. Contractor shall provide the CQA Consultant and Owner access to information about the borrow source of the low permeability soil.

1.5 TOLERANCES

A. The soil liner system must meet the following tolerances:
1. The saturated hydraulic permeability of the soil liner must be equal to or less than 1.0×10^{-5} cm/sec, as determined by ASTM D5084.
2. The thickness of the soil liner must be equal to or greater than 18 inches. Any excess shall be below the elevation defined by the finished grade tolerance.
3. The work should be constructed to lines, grades, as defined by the control points indicated on the Drawings. Laser based grading systems are recommended.
4. Finished grade tolerance; design proposed grade to plus 0.25 FT.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Low Permeability Soil - General:
1. Contractor shall provide natural, fine-grained soil or bentonite amended soil that is capable of being worked to produce a soil layer of thickness shown on the Drawings that meets the hydraulic conductivity requirements.
2. The soil shall be relatively homogeneous in color and texture and shall be free from roots, stones, foreign objects, and other deleterious materials.

3. Some soils not meeting the requirements of B.1. and B.4. below, may be acceptable for use in the Work at the sole discretion of the Engineer. The contractor may submit data on soils for the Engineer's review. For the Engineer to approve the materials, the submittal should contain: a statement signed by a qualified professional Engineer that the proposed soils will meet the hydraulic conductivity requirement and are otherwise suitable for use in the Work; and, supporting geotechnical test results and data.
4. All soils must be approved for use by the Engineer prior to use in the Work.

B. Natural Fine-Grained Soil
1. Classification: Natural fine-grained soil shall have a classification of SC, SM, CH, CL, MH, or ML as determined by ASTM D2488.
2. Grain sizes shall be within the following gradation:

Sieve Size	Percent Passing by Weight
3/4 IN	100
No. 4	> 90
No. 200	> 30

3. Hydraulic Conductivity: The saturated hydraulic conductivity of the natural fine-grained soil shall meet the stated tolerances, when compacted in accordance with requirements established by the CQC Consultant and Contractor on the basis of the soil liner test strip as specified herein.
4. Other Soil Liner Properties:
   a. The liquid limit shall be at least 25 as measured by ASTM D4318.
   b. The plasticity index shall be at least 10 and less than 30 as measured by ASTM D4318.

C. Bentonite Amended Soil (where applicable):
1. Hydraulic conductivity of constructed bentonite amended soil shall meet the tolerances when compacted in accordance with requirements established by the CQC Consultant on the basis of test results from the soil liner test strip and the borrow soil characterization study.
2. Soil used in the bentonite amended soil shall be free from roots, organic matter, debris, particles larger than 3/4 IN, and other deleterious material. All soil used in the bentonite amended soil shall be taken from a borrow area approved by the CQA Consultant and Engineer.
3. Unless approved otherwise by the CQA Consultant, the soil used in the bentonite amended soil shall meet the following washed sieve gradation:

Sieve Size	Percent Passing by Weight
¾ IN	100
No. 4	55-100
No. 20	45-75
No. 200	10-40

4. Bentonite:
   a. Bentonite shall be free-flowing, powdered, high-swelling, sodium montmorillonite clay (bentonite) free of additives.
   b. Acceptable bentonite manufacturers are:
      1) American Colloid Co., (800) 276-2737.
      2) Bentonite Performance Minerals, LLC (281) 871-7900.
      3) WYO-BEN, Inc. (800) 548-7055.
      4) Approved equal.
   c. The Contractor may propose a bentonite supplier other than those listed above if it is demonstrated that its use in the amended soil satisfies the requirements of these Specifications.

D. Permeability Test
   1. Laboratory permeability tests (ASTM D-5084) shall be conducted in constant head, triaxial type permeameters. The specimens shall be consolidated under an isotropic effective consolidation stress not to exceed 10 psi for base liner. The inflow to and outflow from the specimens shall be monitored with time and the coefficient of permeability calculated for each recorded flow increment. The test shall continue until steady state flow is achieved and relatively constant values of coefficient of permeability are measured.

E. Interface Friction Tests.
   1. Test materials using ASTM D 6243. ~~Consult with the Design Engineer to determine the required interface friction and the conditions under which this material shall be tested.~~ Section 01060-Special Conditions, outlines the conditions under which this material shall be tested.
   2. This material is part of a system. The system shall meet the requirements before the component material can be deemed acceptable.

2.2 SOIL LINER MATERIAL ACCEPTANCE

A. General: All imported, on-site, and processed materials specified in this Section are subject to the following requirements:
   1. All tests necessary for the Contractor to locate and define acceptable sources of materials shall be made by the CQC Consultant. Certification that the material conforms to the Specification requirements along with copies of the test results from a qualified commercial testing laboratory shall be submitted to the CQA Consultant for approval at least 10 days before the material is required for use. All material samples shall be furnished by the Contractor at the Contractor's sole expense.
   2. All samples required in this Section shall be representative and be clearly marked to show the source of the material and the intended use on the project. Sampling of the material source shall be done by the CQC Consultant in accordance with ASTM D75.
   3. Notify the CQA Consultant at least 24 hours prior to sampling so that they may observe the sampling procedures.
   4. Tentative acceptance of the material source shall be based on an inspection of the source by the CQA Consultant and the certified test results of the Borrow Source Characterization Study (BSCS) as submitted by the CQA Consultant to the Engineer. No imported materials shall be delivered to the site until the proposed source and materials tests have been accepted in writing by the Engineer.
   5. Final acceptance of any material will be based on results of tests made on material samples taken from the completed soil liner test strip, combined with the results of the BSCS. If tests conducted by the CQA/CQC Consultant indicate that the material does not meet Specification requirements, material placement will be terminated until corrective measures are taken. Material which does not conform to the Specification requirements and is placed in the work shall be removed and replaced.
   6. Contractor shall be solely responsible for obtaining all permits required to obtain acceptable sources of materials for use in the work.

B. Sampling and testing required herein shall be done at the Contractor's sole expense.

C. Borrow Source Characterization Study:
   1. The Contractor will be responsible for all processing and screening of the soil liner material at his own cost to meet the requirements of the Specifications. The Contractor will be responsible for the erosion protection of the stockpile and borrow area during his operation. The Contractor shall coordinate all aspects of this operation with the CQA/CQC Consultants and Engineer.
   2. CQC Consultant shall complete a BSCS of natural fine-grained soils or of soil that will be used in bentonite amended soils.
   3. Contractor shall conduct tests, including particle size, Atterberg limits, moisture-density, and hydraulic conductivity tests, as necessary to locate an acceptable source of material.

4. Once a potential source of material has been located, the CQC Consultant shall develop and undertake a testing program to demonstrate the acceptability of the proposed material. Certified results of all tests shall be submitted to the Engineer upon completion of tests. Tentative acceptance of the borrow source by the Engineer will be based upon the results of the study. The testing program shall include the following elements, at a minimum:
   a. An excavation plan for the borrow source indicating proposed surface mining limits and depths of samples to be taken for testing.
   b. Test pits for borrow source sampling shall be appropriately spaced to reflect site geomorphology and sampled at depth intervals appropriate to the proposed excavation methods.
   c. A minimum of one (1) sample shall be collected per 15,000 cy and tested for the parameters required as described in the following paragraphs.
5. Test Parameters and Reporting for Natural Fine-Grained Soils: All samples collected from the proposed borrow area for natural fine-grained soils shall be tested for the following parameters:

Parameter	Test Method
Particle Size (sieve plus hydrometer)	ASTM D422
Atterberg Limits	ASTM D4318
Standard Proctor	ASTM D698
Hydraulic Conductivity(1)	ASTM D5084

   (1) Hydraulic conductivity tests shall be performed on recompacted samples of the proposed material, compacted according to criteria developed by the Geotech Engineer using data from tests conducted in accordance with ASTM D698.

6. Test Parameter for Soil to be Used in Bentonite Amended Soil:
   a. Parameters and reporting for soils to be used in bentonite amended soil shall be the same as for natural fine-grained soil.
   b. Tests required under this paragraph are part of the BSCS. Additional tests on the bentonite amended soil product are required for soil liner acceptance. See 2.1E.

D. Bentonite Amended Soil Conformance Testing (where applicable):
1. Following acceptance of a source for soils to be used in bentonite amended soils, the Geotech Engineer shall perform a Design Mix Analysis and submit certifications for the imported bentonite material as described below.
2. Design Mix Analysis:
   a. Collect two of the coarsest samples of the soil taken from the approved borrow area (based on percent retained on #200 sieve). Soil samples for testing shall be at least 100 pounds each.
   b. Trial mix samples shall be prepared by mixing each soil sample with three trial application rates of bentonite. Compact each trial mix sample to a dry density equal to 95 percent relative compaction and at a moisture content within the range of optimum to optimum plus 3 percent (ASTM D-698) for the unamended soil.
   c. Test the hydraulic conductivity of the trial mix samples using ASTM D5084 and report all data to Engineer. Graph measured hydraulic conductivity vs. percent bentonite.
   d. Contractor shall select a minimum bentonite content needed to consistently achieve the required in-place hydraulic conductivity.
3. After mix design and initial testing, Geotech Engineer shall conduct tests of the mixed bentonite amended soil, after it has been discharged from the pugmill and before this is placed in the work using the following methods and at the following frequencies.

Test	Method	Minimum Frequency
Standard Proctor	ASTM D698	1 per 10,000 cu yd

4. Bentonite: Submit certifications from the supplier of the bentonite material that it meets the specified requirements.

E. Fine-Grained Material Dewatering, Mixing, and Staging
   1. Dewatering of soil liner borrow excavations, if required, shall be solely at the Contractor's expense.
   2. Drying, blending, or wetting required to maintain the soil liner soil at a suitable moisture content shall be solely at the Contractor's expense.

2.3 EQUIPMENT

A. Compaction Equipment:
   1. The compaction equipment shall be of a suitable type, adequate to obtain the permeability specified, that provides a kneading action, such as a wobble-wheeled roller or a sheepsfoot roller having tines as long as the maximum loose lift thickness to ensure proper lift interface compaction free of voids.
   2. The CQC Consultant shall confirm compaction equipment adequacy, and recommend changes if required, based on the soil liner test strip.
   3. The compaction equipment shall be maintained and operated in a condition that will deliver manufacturer's rated compactive effort.
   4. Hand-operated equipment shall be capable of achieving specified soil densities.
   5. The finished surface of the final lift shall be rolled with a smooth steel drum roller or rubber-tired roller to eliminate tine or roller marks and provide a smooth, dense surface for geomembrane placement.

B. Moisture Control Equipment:
   1. Equipment for applying water shall be of a type and quality adequate for the work, shall not leak, and shall be equipped with a distributor bar or other approved device to assure uniform application.
   2. Equipment for mixing and drying out material shall consist of blades, discs, or other equipment defined by the CQC Consultant and approved by the CQA Consultant.
   3. Mixing of natural fine-grained soils may also be required to get even distribution of moisture.
   4. Soil liner material must not be compacted within 24 hours of the adjustment of water content by the addition of water.

C. Bentonite Amended Soil Mixing Equipment (where applicable):
   1. Contractor shall mix, process, and condition the bentonite amended soil in a pugmill prior to placing and compacting the mixture.
   2. The pugmill shall have the capability to break up soil clumps and mix material to form a homogeneous blend. The pugmill shall have controls that allow a variable rate of discharge from it, to control the degree of mixing. The pugmill shall have automated controls to control the rate of feed of each material to within an accuracy of 2 percent by weight.
   3. The pugmill discharge shall be equipped with a batching bin having a drop outlet for loading hauling vehicles directly from the pugmill. Pugmill shall be positioned to allow direct discharge to hauling vehicles.
   4. Contractor shall not store amended soil in a manner or for a length of time that will cause any degradation of the project or amended soil.

PART 3 - EXECUTION

3.1 SOIL LINER TEST STRIP

A. Test Strip Installation:
   1. Prior to actual soil liner installation, a soil liner test strip of a dimension no less than 100 FT long by 30 FT wide by 1.5 FT thick shall be constructed by the Contractor over a compacted subgrade within the liner construction site.
   2. The soil liner test strip shall initially be constructed in 6 IN lifts. The lift thickness may be increased if it can be demonstrated to meet the acceptance criteria in Part 3.4 of this specification and approved by the Engineer. The final compacted thickness of each lift shall be a maximum of 6 IN. Prior to placement of successive lifts, the surface of the lift in place shall be scarified or otherwise conditioned to eliminate lift interfaces.

3. The soil liner test strip shall be constructed using the same equipment and construction procedures that are anticipated for use during actual liner installation.
4. During test strip installation, the Contractor in coordination with the Engineer shall determine the field procedures that are best suited for his construction equipment to achieve the requirements specified herein.
5. If the test strip fails to achieve the desired results, the soil material of the strip shall be completely removed, and additional test strip(s) shall be constructed until the requirements are met.
6. Document that the subgrade of the test strip liner is properly compacted to at least 95 percent of the maximum dry density, as determined using the Standard Proctor test (ASTM D-698). Field density tests on the subgrade shall be performed by the Geotech Engineer and documented at a minimum of three test locations within the test strip area.
7. Perform at least five field density measurements on each lift of the liner test strip. The field density tests shall be conducted using a nuclear gauge (ASTM D-2922) or other method, as approved by the Engineer. Corresponding tests for moisture content to determine dry density shall likewise be performed by using a nuclear gauge (ASTM D-3017), or other approved method. On the test pad, the density measurement if performed by a nuclear gauge shall be verified through performance of one sand cone test (ASTM D-1556) or drive tube test (ASTM D-2937) at a location selected by the Engineer. The moisture content measurement, if performed by a nuclear gauge shall be verified by recovering at least five samples for oven-dry testing (ASTM D-2216) from the test location.
8. A composite sample will be taken from each lift for recompacted lab permeability (ASTM D-5084).
9. Measure the thickness of the test strip at a minimum of five random locations upon completion of the soil liner test strip.
10. Test a minimum of five random samples of the liner construction materials delivered to the site during test strip installation for moisture content (ASTM D-2216), sieve analyses (ASTM D-421, D-422) and Atterberg limits (ASTM D-4318).
11. Conduct at least one standard Proctor (ASTM D-698) and one modified Proctor (ASTM D-1557) compaction test on bag samples of the test strip material to determine the moisture-density relationships.
12. Take a minimum of one undisturbed sample from each lift of the test strip for laboratory hydraulic conductivity testing. The samples shall be taken within a 2 FT radius of the in-situ density and moisture tests. The Engineer may also conduct confirmatory in-situ hydraulic conductivity testing.
13. The data gathered from the test strip sampling (i.e., field density, moisture, undisturbed samples, and in-situ hydraulic conductivity) shall be used along with the Proctor curve for the soil to develop a range of acceptable moisture and density test values which are likely to be consistent with the required maximum permeability. Establish the range of moisture/density values to be utilized as a means to establish Pass/Fail Criteria for the area to be lined by the subject material.
14. The test strip will be considered acceptable if the measured hydraulic conductivity of the test strip as determined by ASTM D-5084 meets the requirements of the Specifications.
15. If field and laboratory test data indicate that the installed test strip meets the requirements of this Specification, it may be used as part of the liner provided that it is adequately protected by the Installer from drying and equipment damage after installation. The Installer shall scarify the liner material along the edge of the test strip. A minimum 2 FT overlap per lift is required for mixing and compaction between the test strip and the liner.
16. If the test strip fails to meet Specifications, additional mix designs (if bentonite amended) and/or test strips will be constructed until a test strip meets the requirements. No soil liner may be placed until a test strip has been accepted by the CQA Consultant.
17. Upon receipt of the test data from the CQA Consultant, the Engineer shall inform the Contractor if the test strip can remain in-place as part of the liner.

3.2 INSTALLATION

A. The subgrade to be lined shall be smooth and free of vegetation, sticks, roots, foreign objects, and debris. It shall be the responsibility of the Contractor to keep the receiving surfaces in the accepted condition until complete installation of the liner is accomplished.

B. The subgrade shall be proofrolled with a pneumatic tired vehicle of at least 20 tons GVW, making passes across the area as directed by the CQA/CQC Consultants. The soil liner shall not be placed over areas deemed unacceptable by CQA/CQC Consultants based on proofroll observations or inadequate test results.

C. The soil liner shall be installed in ~~6 IN~~ compacted lifts as determined by the test strip results. The material shall be placed consistent with criteria developed from construction of a satisfactory test strip.

D. When particles exceeding ¾ IN are observed at the final lift surface, they shall be removed by the Contractor prior to final rolling of the surface.

E. Equipment shall be used such that bonding of the lifts will occur. Equipment shall have cleats or other protrusions of such length necessary to completely penetrate into the loose lift. Compaction shall be performed using appropriately heavy, properly ballasted, penetrating foot compactor making a minimum number of passes as approved by the CQA/CQC Consultants based on the soil liner test strip.

F. If desiccation and crusting of the lift surface occurs prior to placement of the next lift, this area shall be scarified to a minimum depth of 2 IN or until sufficiently moist materials are encountered, whichever is greater. After scarification, the superficial material should be reworked to obtain ~~a~~ moisture content at least 2 percent above optimum moisture content. Alternately, the drier superficial soil may be stripped and mixed with additional moist soil to achieve a moisture content satisfying the project requirements.

G. No frozen material shall be placed.

H. Material shall not be placed on a previous lift which is frozen. Frozen in-place material shall be removed prior to placement of additional soil material.

I. Material which has been subjected to a freeze/thaw cycle(s) shall be disked and recompacted prior to placement of subsequent lifts.

J. During construction, exposed finished lifts of the soil liner material should be sprinkled with water to minimize desiccation, as necessary. The Contractor is responsible to protect the soil liner from rain, drying, desiccation, erosion and freezing. All defective areas shall be repaired by the Contractor to the satisfaction of the CQA/CQC Consultants.

K. At the end of each day's construction activities, completed lifts or sections of the compacted soil liner should be sealed. Common sealing methods include rolling with a rubber tired or smooth-drum roller, back dragging with a bulldozer, or placement of temporary cover soil over the compacted soil liner. The compacted soil liner should be sprinkled with water, as needed.

~~L. If testing shows that a lift is significantly thicker than 6 IN, the top of the lift will be shaved off so that the lift is approximately 6 IN thick.~~

3.3 INSITU MATERIAL

A. Insitu materials meeting the hydraulic conductivity requirements may be left in place and incorporated into the soil liner system if the following conditions are met.
   1. Undisturbed Shelby samples are taken at locations as directed by a geotechnical engineer or geologist and tested at a frequency of 1 test for each 6 inch layer of soil liner per acre.
   2. Material is consistent for the full depth of soil liner material measured in the field and confirmed with the UD samples in the lab.
   3. Thickness verification must be conducted at a minimum of 8 locations per acre.
   4. Test holes are backfilled with powder bentonite.

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5. A licensed geotechnical engineer or geologist certifies the test results are representative of the insitu materials to remain, and fulfill the intent of the specifications for soil liner.

~~3.3~~3.4 FIELD QUALITY CONTROL AND QUALITY ASSURANCE

A. Refer to the CQA Plan.

B. Perform the following field and laboratory quality control tests during soil liner construction:

Test	Method	Minimum Frequency	Acceptable Criteria
1. Field Density	ASTM D2937	1/10,000 SF/lift	≥ 95%
	or		
	ASTM D2937 and	1/5 D3017 tests	≥ 95%
	ASTM D3017	1/10,000 SF/lift	≥ 95%
2. Thickness	Surveyor	8 locations/acre	≥ 18 IN
3. Atterberg Limits	ASTM D4318	1/acre/lift	BSCS Criteria
4. Fines Content	ASTM D1140	1/acre/lift	BSCS Criteria
5. Hydraulic Conductivity	ASTM D5084	1/acre/lift	≤ 1.0×10^{-5} cm/sec
6. Laboratory Moisture Density Relationship	ASTM D698	1/5,000 CY of placed liner material	NA

C. Test methods shall also conform to criteria set forth in Paragraph 3.1, Soil Liner Test Strip.

D. Test frequencies may be modified by the Engineer. If there are indications of declining or failing test results, frequencies may be increased. If hydraulic conductivity test results are well above acceptable, the frequency for Atterberg limit and fine content testing may be waived by the Engineer.

E. The acceptable criteria may be modified if supported by the test strip results and approved by the Engineer.

F. Holes in the compacted soil liner created as a result of destructive testing (e.g., thin-walled Shelby tube sampling and nuclear gauge, field density determinations) shall be backfilled and tamped by rod uniformly in 2 IN thick lifts. The backfill material shall be the same liner construction material or hydrated bentonite powder, if approved by the CQA Consultant. On the surface, the backfill material shall extend slightly beyond the holes to make sure that a good tie-in with the surrounding liner is achieved. Repaired areas shall be observed and documented by the CQC Consultant.

G. Give minimum of 24 HR advance notice to CQA Consultant when ready for soil testing and inspection in completed area of the soil liner.

H. For areas not meeting field and laboratory testing criteria, the Contractor shall scarify the full depth of the lift or replace the material as needed. The material shall be reshaped, rewetted as needed, rehomogenized and recompacted to the specified density. Areas not meeting the thickness requirements shall be augmented with additional materials. The added materials shall be reworked with the soil layer to ensure homogeneity and proper bonding. This may be done by scarification of the surface prior to addition of new material. The repaired area shall be properly documented, and field and laboratory quality control testing shall be performed to ensure the repaired liner section meets the requirements specified herein.

I. The Contractor shall pay for all costs associated with corrective work and retesting resulting from failing tests. The Engineer shall be informed immediately of all failing tests.

END OF SECTION

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SECTION 02774
LLDPE GEOMEMBRANE

PART 1 - GENERAL

1.1 SUMMARY

A. This specification is for material used for the cap system.

~~A.~~B. Section Includes:

1. Furnish all labor, materials, tools, and equipment, and perform all work and services necessary for or incidental to the furnishing and installation, complete, of an impermeable, LLDPE geomembrane as shown on Drawings for closure of the structural fill.
2. Completely coordinate work with that of all other trades.
3. Work items in project include, but are not necessarily limited to, the liner for the structural fill.
4. Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, complete, and compatible installation shall be furnished and installed as part of this work.
5. Furnish CQC Consultant to monitor work of Geomembrane Installer and to perform CQC testing in accordance with provisions of the Contract Documents.
6. The Contractor, Geomembrane Installer, and CQC Consultant are required to attend the CQA/CQC Resolution Meeting and the CQA/CQC Preconstruction Meeting.

~~B.~~C. Related Sections include but are not necessarily limited to:

1. Section 01060 – Special Conditions
~~1.~~2. Section 02220 – Earthwork.
~~2.~~3. Construction Quality Assurance Plan.

1.2 QUALITY STANDARDS

A. Referenced Standards:

1. ASTM International (ASTM):
   a. D792, Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
   b. D1004, Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
   c. D1238 Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.
   d. D1603 Standard Test Method for Carbon Black in Olefin Plastics.
   e. D3015 Standard Practice for Microscopic Examination of Pigment Dispersion in Plastic Compounds. Refer to Subpart 2.2 for property to be tested.
   f. D3895 Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis.
   g. D4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.
   h. D4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
   i. D5199 Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
   j. D5397 Procedure to Perform a Single Point Notched Constant Tensile Load – Appendix (SP-NCTL) Test.
   k. D5596 Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
   l. D5721 Practice for Air-Oven Aging of Polyolefin Geomembranes.
   m. D520 Pressured Air Channel Evaluation of Dual Seamed Geomembranes

n. D5885 Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry.
o. D5994 Test Method for Measuring the Core Thickness of Textured Geomembranes.
p. D6392 Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.
q. D6693 Test Method for Determining Tensile Properties.
r. D7238 Standard Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane.
s. D7466 Standard Test Method for Measuring the Asperity Height of Textured Geomembrane.

2. The Geosynthetic Research Institute (GRI).
a. GM6 Pressurized Air Channel Test for Dual Seam Geomembranes.
b. GM10 Specification for the Stress Crack Resistance of Geomembrane Sheet.
c. GM11 Accelerated Weathering of Geomembranes Using a Fluorescent UVA-Condensation Exposure Device.
d. GM17 Test Methods, Test Properties, and Testing Frequency for HDPE Smooth and Textural Geomembrane.

B. Qualifications:
1. Each geomembrane manufacturing or installation firm shall demonstrate 5 years continuous experience, including a minimum of 10,000,000 SF of LLDPE geomembrane manufacture or installation.
2. Geomembrane Installer Personnel Qualifications:
a. Installation Superintendent shall have worked in a similar capacity on at least five LLDPE geomembrane liner jobs similar in size and complexity to the project described in the Contract Documents.
b. The Master Welder shall have completed a minimum of 5,000,000 sf of LLDPE geomembrane seaming work using the type of seaming apparatus proposed for use on this Project.
c. Other welders shall have seamed a minimum of 1,000,000 sf of LLDPE geomembrane.

C. CQA Plan Implementation: Construction Quality Assurance for the LLDPE geomembrane installation will be performed for the Owner in accordance with the CQA Plan prepared for this project. The Contractor, CQC Consultant and Geomembrane Installer, however, should familiarize themselves with the CQA Plan and are responsible for providing reasonable notice of and access to work elements that the Geotech Engineer is required by the CQA Plan to overview.

1.3 SUBMITTALS

A. Shop Drawings: Submit for Engineer's approval prior to placement of geomembrane liner:
1. Manufacturer's Submittals.
a. Manufacturer's Quality Control (MQC) Program: Submit certification that program complies with GM17.
b. Manufacturer's Field Installation Procedures Manual: Submit complete geomembrane manufacturer's specifications, descriptive drawings, and literature for the recommended installation of the LLDPE geomembrane liner system, including recommended methods for handling and storage of all materials prior to installation, and field installation guidelines that the manufacturer feels are relevant and important to the success of this project. The manual clearly identifies any exceptions taken by the manufacturer in the specified execution of the Work. Unless excepted and approved by the Engineer, the procedures herein shall be considered part of the manual.
c. Manufacturer's Material Data: Submit statement of planned production date(s) for the geosynthetics to be provided for this Project. Prior to shipment of geomembrane, submit quality control certificates for each roll demonstrating conformance with the requirements of these Specifications. Submit statement of production dates for the resin and the LLDPE geomembrane for this work.

d. Manufacturer's written acceptance of Geomembrane Installer's qualifications for installation of the LLDPE geomembrane.

2. Geomembrane Installer's Submittals.
   a. The Geomembrane Installer will submit written documentation that their personnel satisfy the qualifications of 1.2 B.
   b. Geomembrane Installer's Construction Quality Control Program: Submit for review a complete description of the Geomembrane Installer's formal construction quality control programs to include, but not be limited to, product acceptance testing, installation testing, including both nondestructive and destructive quality control field testing of the sheets and seams during installation of the geomembrane, proposed methods of testing geosynthetic joints and connections at appurtenances for continuity, documentation and changes, alterations, repairs, retests, and acceptance.
   c. Geomembrane Installer's Installation Procedures Manual: Submit for approval the Installer's installation manual to include: ambient temperature at which the seams are made, control of panel lift up by wind, acceptable condition of the subsurface beneath the geomembrane, quality and consistency of the welding material, proper preparation of the liner surfaces to be joined, cleanliness of the seam interface (e.g., the amount of airborne dust and debris present), and proposed details for connecting the LLDPE liner to appurtenances, i.e. penetrations of the containment facilities. The document shall include a complete description of seaming by extrusion welding and hot-wedge welding. The Geomembrane Installer's Installation Manual will by reference include requirements of the Manufacturer's Installation Manual unless exceptions are noted and approved by the Engineer. After this manual has been approved by the Engineer, the Geomembrane Installer shall not deviate from the procedures included in the manual.
   d. Geomembrane panel layout with proposed size, number, position, and sequencing of panels and showing the location and direction of all field joints. Joints shall be perpendicular to flow direction where possible, unless approved otherwise.
   e. Warranty: The Geomembrane Installer shall agree in writing to warranty the geomembrane system. See Part 1.6 of this Section.
3. Installer's Submittals:
   a. Installer shall submit written documentation that their personnel satisfy the qualifications of ~~Section 01400~~Part 1.2.B of this Section.
   b. Installer's Geomembrane Manual: Submit CQA/CQC written program for meeting the geomembrane material conformance and CQA/CQC requirements of these Specifications.
4. Provide all submittals in a single coordinated transmittal. Partial submittals will not be accepted. All submittals must be approved prior to the Geomembrane Preconstruction Meeting.

B. Miscellaneous Submittals:
   1. Geomembrane Installer's Submittals.
      a. Warranty: Submit a warranty signed by the Geomembrane Installer that the installed geomembrane liner, attachments, and appurtenances are free of defects in material, manufacturing, and workmanship. See Part 1.6 of this Section.
      b. Record Drawings: Submit reproducible drawings of record showing changes from the approved installation drawings. The record drawings shall include the identity and location of each repair, cap strip, penetration, boot, and sample taken from the installed geosynthetic for testing. The record drawings shall show locations of each type of material anchor trenches and the construction baseline.
      c. Welder Certification: Submit certification for each welder and performance records that include linear feet of weld completed, number of samples tested, and test failure rate for each welder. Submit field notes with daily equipment reports.
      d. Certification: Submit written certification that the geomembrane liner was installed in accordance with this Specification and with the approved shop drawings.

e. CQA/CQC Records: Submit copies of all material and seam test results. Each test shall be identified by date of sample, date of test, sample location, name of individual who performed the test, and standard test method used.

f. CQA/CQC Weld Test Summary Report: The CQA/CQC Consultant shall submit a report showing normal distribution of all CQC seam test results, identifying the high, low, and average of the five coupon samples in each test.

2. Provide all submittals in a single coordinated transmittal. Partial submittals will not be accepted.

1.4 PROJECT CONDITIONS

A. When the weather is of such a nature as to endanger the integrity and quality of the installation, whether this is due to rain, high winds, cold temperatures, or other weather elements, the installation of the geomembrane shall be halted at the direction of, or with the concurrence of, the Engineer until the weather conditions are satisfactory.

B. The Contractor shall ensure that adequate dust control methods are in effect to prevent the unnecessary accumulation of dust and dirt on geosynthetic surfaces which hamper the efficient field seaming of geosynthetic panels.

C. The Contractor shall maintain natural surface water drainage diversions around the work area and provide for the disposal of water which may collect in the work area directly from precipitation falling within the area or from inadequate diversion structures or practices.

D. The Contractor shall be responsible to coordinate the installation of the leachate collection system which shall be in accordance with Geomembrane Installer's Installation Manual and as specified in these Specifications and shown on the Contract Drawings.

E. Vehicles will not be allowed on the liner area unless at least 24 inches of cover has been placed over the liner except as noted in these Specifications.

F. Vehicles larger than one and one-half ton pickup trucks are prohibited on the exterior berms. Contractor shall repair any damage to exterior berms prior to final payment.

1.5 DEFINITIONS AND RESPONSIBILITIES

A. Geomembrane Manufacturer: Manufacturer of geomembranes producing geomembrane sheets from resin and additives. The manufacturer is responsible for producing geomembrane sheet which complies with these Specifications. These responsibilities include but are not limited to:

1. Acceptance of the resin and additives from chemical formulators. Testing of the raw resin and additives to ensure compliance with the manufacturer's specifications and with this Specification.
2. Formulation of the resin and additives into geomembrane sheeting using mixing and extrusion equipment.
3. Testing of the geomembrane sheet to ensure compliance with manufacturer's specification and this Specification.
4. Shipping of the geomembrane sheet to installer designated facilities.
5. Certification of the raw materials and finished geomembrane sheet to comply with this Specification.
6. Certification of installer's training, experience, and methods for welding and inspection of geomembrane installations in compliance with manufacturer's standards.

B. Geomembrane Installer. Installer of geomembranes is responsible for handling, fitting, welding, and testing of geomembrane sheets or blankets in the field. These responsibilities include but are not limited to:

1. Acceptance (in writing) of the geomembrane from the manufacturer.

2. Acceptance (in writing) of the CSL surface which will serve as a base for the geomembrane. This acceptance shall precede installation of the geomembrane, and shall state that the installer has inspected the surface, and reviewed the Specifications for material and placement, and finds all conditions acceptable for placement of geomembrane liners. The written acceptance shall explicitly state any and all exceptions to acceptance.
3. Handling, welding, testing, and repair geomembrane liners in compliance with this Specification and the Geomembrane Installer's Installation Procedures Manual.
4. Performance of QA/QC testing and record keeping as required by the approved Geomembrane Installer's Field Installation Procedures Manual.
5. Repair or replacement of defects in the geomembrane as required by the CQA/CQC Consultant.

C. Engineer: Responsible for approval of submittals from the Contractor.

D. CQA/CQC Consultant: Responsible for observing field installation of the geomembrane and performance of material conformance and CQC testing to provide the Contractor with verbal and written documentation of the compliance of the installation with these Specifications. The CQA/CQC Consultant reports to the Contractor and is part of this contract.

E. Engineer: Responsible for implementing CQA Plan including overviewing material conformance testing, field installation of the geomembrane, and CQC activities, and to perform limited CQA conformance testing to provide Owner with verbal and written documentation of the compliance of the installation with these Specifications. The Engineer will use the written results of the CQA/CQC program in the preparation of the facility Certification Document.

F. Refer to the accompanying CQA Plan for additional definitions.

1.6 WARRANTIES

A. The Installer's warranty shall be against defects in the system installed for a period of two years from the date of final acceptance of the Work by the Owner.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS AND/OR GEOMEMBRANE INSTALLERS

A. Subject to compliance with the Contract Documents, the following manufacturers and installers are acceptable:
1. LLDPE Geomembrane liners manufacturers:
   a. GSE, Inc., 19103 Gundle Road, Houston, Texas 77073.
   b. Raven Industries, 205 E. 6th Street, Sioux Falls, SD, 37104
   ~~c. Sol Max International, Inc.~~
   ~~d.~~c. Agru/America, Inc., 500 Garrison Road, Georgetown, SC 29440.
2. LLDPE Geomembrane Liner Installers:
   a. Authorized installers of approved manufacturers.
   b. Other installers may qualify for approval by providing references for a minimum of 10,000,000 SF of liner installations.

2.2 MATERIALS

A. LLDPE Geomembrane:
1. Geomembrane shall consist of unsupported polyethylene in thickness as shown on Drawings and manufactured from virgin, first quality resin designed and formulated specifically for liquid containment in hydraulic structures. Reclaimed polymer shall not be added to the resin; except use of polymer recycled during the manufacturing process shall be allowed provided that recycled polymer shall be clean and shall not exceed 2 percent by weight.

2. The geomembrane shall be manufactured to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter. Any such defects shall be cause for rejection of the defective geomembrane material. Minor defects may be repaired in accordance with manufacturer's recommendations if this repair is approved by the Engineer.
3. The geomembrane liner shall be manufactured as seamless rolls or as prefabricated panels with a minimum width of 22 FT as delivered to the site. All factory seams shall be inspected and tested for strength and continuity prior to delivery to the site.
4. No additives or fillers may be added to the resin prior to or during manufacture of the geomembrane.
5. Prior to shipment, the geomembrane manufacturer will provide the Engineer and the Geotech Engineer with a quality control certificate for each roll of geomembrane provided. The quality control certificate will be signed by a responsible party employed by the geomembrane manufacturer and will include:
   a. Roll numbers and identification; and
   b. The results of quality control tests performed under the MQC program.
6. The CQA/CQC Consultant will verify that a control certificate has been received for each roll and that the certified roll properties meet the requirements of these Specifications.
7. Textured LLDPE sheet (both sides) shall be used on all lined slopes.
8. The geomembrane liner material shall consist of **40 MIL NOMINAL TEXTURED LLDPE** and meet or exceed GRI GM17 and the following requirements:

PROPERTY	TEST METHOD	TEST VALUE
a. Sheet Thickness, Mils	ASTM D5994 (textured)	
• Minimum Average		nominal - 5%
• Lowest Individual 8 of 10		nominal - 10%
• Lowest Individual 10 of 10		nominal - 15%
b. Sheet Density (g/cc)	ASTM D792 or D1505	0.920
c. Minimum Tensile Properties	ASTM D6693	
• Strength at Break		60 ppi
• Elongation at Break		250%
d. Min. Tear Resistance Initiation	ASTM D1004, Die C	22 lbs
e. Carbon Black	ASTM D1603 or ASTM D4218	2.0-3.0%
f. Carbon Black Dispersion	ASTM D5596	Category
• 10 of 10		1 or 2
g. Puncture Resistance, Minimum Average	ASTM D4833	44 lbs
h. Oxidative Induction Time, Minimum Average	ASTM D3895 or ASTM D5885	100 min. 400 min.
i. Asperity height, Minimum average	GRI GM17	10 mil

B. Extrusion rod shall be manufactured from identical resin to that used in geomembrane manufacture. Manufactured extrusion rod shall be tested for carbon black content and dispersion, specific gravity, and melt index at a frequency of not less than one test per batch.

2.3 INTERFACE FRICTION TESTS

A. Interface Friction Tests.
   1. Test both materials using ASTM D 6243. ~~Consult the Design Engineer for the required interface friction and the conditions under which this material shall be tested~~ Section 01060-Special Conditions, outlines the conditions under which this material shall be tested.
   2. This material is part of a system. The system shall meet the requirements before the component material can be deemed acceptable.
   ~~3. The costs associated with this testing shall be included in the Bid price for Construction Quality Control. Any retesting or other additional testing required to meet the Specification shall be at no additional cost to the Owner.~~

2.4 EQUIPMENT

A. Welding Equipment: Extrusion welding equipment shall be provided with thermocouples and temperature readout devices which continuously monitor the temperature of the extrudate. Radiant wedge welding equipment shall be provided with thermocouples and temperature readout devices which continuously monitor the temperature of the wedge. Equipment shall be maintained in adequate number to avoid delaying work, and shall be supplied by a power source capable of providing constant voltage under a combined-line load. Use a rub sheet, sand bags, or other method approved by the Geotech Engineer to separate the electric generators from the geomembrane.

B. Field Tensiometer: The Geomembrane Installer shall provide a tensiometer for on-site shear and peel testing of geomembrane seams. The tensiometer shall be in good working order, built to ASTM D6693 specifications, and accompanied by evidence of recent calibration. The tensiometer shall be motor driven and be equipped with a gauge that measures the force in unit pounds exerted between the jaws as displayed on a digital readout.

C. Vacuum Box: The Geomembrane Installer shall provide a minimum of 2 vacuum box assemblies consisting of a rigid housing, a transparent viewing window, a soft closed cell neoprene gasket attached to the bottom, a port hole or valve assembly, a vacuum gauge, a vacuum pump assembly equipped with a pressure control, a rubber pressure/vacuum hose with fittings and connections, and a soapy solution and an applicator. The equipment shall be capable of inducing and holding a minimum vacuum of 5 psi.

D. Air Pressure Test: The Geomembrane Installer shall provide the necessary air pump and fittings required to perform the GRI GM6 air pressure test on dual seams.

E. Roll Handling Equipment: The Geomembrane Installer shall provide handling equipment that is adequate and does not pose a risk to the geomembrane rolls. The Geotech Engineer shall inspect the equipment and confirm its adequacy.

PART 3 - EXECUTION

3.1 LINER SYSTEM CONSTRUCTION

A. Cap System Component
   1. Prior to placement of the geomembrane over the CCP, the CCP must be prepared as follows:
      a. The surface must be uniform.
      b. The surface must be graded to promote positive drainage.
      c. Aggregates larger than 0.75IN must be removed.

~~A. Compacted Soil Liner (CSL) Component:~~

~~1. The CSL component shall be constructed in accordance with Section 02276 and the Contractor shall protect the CSL from freezing, desiccation, flooding with water, and freezing.~~

~~2. Prior to placement of the geomembrane, the CSL must be prepared as follows:~~

~~a. Lines and grade must be verified by a Licensed Land Surveyor.~~

~~b. The surface must be proofrolled to verify the supporting soil condition.~~

~~c. The surface must be inspected for rocks larger than 0.75 IN.~~

~~d. Steel drum rolled in preparation for the geomembrane.~~

~~e. Thickness shall be verified by an approved method.~~

~~3. CSL acceptance: Geomembrane liner materials shall not be placed until the required CSL preparation has been completed and the CSL has been accepted and certified in writing by the Geomembrane Installer and approved by the Engineer.~~

B. Geomembrane Liner:

1. The geomembrane liner shall be manufactured in accordance with the approved MQC program. The manufacturer shall not deviate from the program without written approval of the Engineer.
2. Transportation and handling of the geomembrane shall meet the following requirements:
   a. Transportation of the geomembrane is the responsibility of the Geomembrane Installer, Contractor, or other party as agreed upon.
   b. All handling on site is the responsibility of the Geomembrane Installer.
   c. The CQA/CQC Consultants will verify that the handling equipment used on the site is adequate and will not damage the geomembrane.
   d. Upon delivery to the site, the Geomembrane Installer and the CQA/CQC Consultants will conduct a surface examination of all rolls for defects or damage. This inspection will be conducted without unrolling rolls. The CQA/CQC Consultants will ensure that defective rolls are rejected and removed from the site.
   e. The Geomembrane Installer will be responsible for the storage of the geomembrane on site. The Project Manager will provide a storage location on site. The Geomembrane Installer shall ensure that the storage space is adequate to protect the geomembrane from theft, vandalism, vehicular damage, etc.
3. Field Panel Identification: The CQA/CQC Consultants will document that the Geomembrane Installer labels each field panel with an "identification code" consistent with the approved panel layout plan. The location of the label and the color of marker used must be as agreed to in the QA/QC Preconstruction Meeting.
4. Geomembrane Installation: Geomembrane liner shall be installed in accordance with the approved Geomembrane Installer's Field Installation Procedure Manual and panel layout drawing. The Geomembrane Installer shall maintain a weekly updated as-built drawing showing the location of all field panels.
   a. Geomembrane shall not be placed upon standing water or other conditions which will result in deterioration of the soil liner.
   b. The Geomembrane Installer shall remove any ~~materials~~ intermediate cover soil placed to protect the ~~soil liner~~CCP prior to placement of the geomembrane liner.
   c. Geomembrane liner shall be handled and placed in a manner which minimizes wrinkles, scratches, and crimps.
   d. Test seams shall be made upon each start of work for each seaming crew, upon every four hours of continuous seaming, every time seaming equipment is changed, or if significant changes in geomembrane temperature and weather conditions are observed. These test welds shall be tested using daily record that summarizes panels deployed, seams completed, seam testing, seam repair, personnel on site, and equipment on site using field tensiometer and, at a minimum, exhibit the required seam strength.
   e. Surfaces to be welded shall be clean and dry at the time of welding. Geomembrane shall not be welded when ambient temperatures are below 40 Deg F (5 Deg C) or above 104 Deg F (40 Deg C) unless the Geomembrane Installer can demonstrate that the seam quality is not compromised.

f. Geomembrane liners shall be welded continuously without fishmouths or breaks in the weld. Where fishmouths are unavoidable, the geomembrane sheet shall be slit to a point such that the sheet lies flat and with no remaining wrinkle. The two edges of the slit shall be welded together provided that the overlap for this weld shall be a minimum of 3 IN. Areas of the slit which do not achieve an overlap of 3 IN, including the terminus of the slit, shall be provided with a patch as discussed below.

g. Defects in and damage to geomembrane sheets shall be repaired by welding a patch over the defect using extrusion welding equipment. The patch material shall consist of an undamaged piece of geomembrane cut to provide a minimum of 3 IN of overlap in all directions from the defect. Torn or permanently twisted geomembrane shall be replaced. Defects in and damage to double hot wedge welded seams are not to be repaired by welding a patch over the defect using extrusion welding equipment. Defective double hot wedge welded seams shall be cut out and reconstructed.

h. Defects in and damage to double hot wedge welded seams are not to be repaired by welding over the defect using extrusion welding equipment. Defective double hot wedge welded seams shall be cut out and reconstructed or a cap strip placed over the area and extrusion welded. The repair shall be tested in accordance with the type of weld used.

~~h.~~i. Personnel walking on the geosynthetic shall not engage in activities or wear types of shoes that could damage the geosynthetic. Smoking shall not be permitted while working on the geomembrane.

~~i.~~j. Vehicular traffic directly on the geosynthetic shall not be permitted. Equipment shall not damage the geosynthetic materials by handling, trafficking, leakage of hydrocarbons, or any other means. The unprotected geomembrane surface shall not be used as a work area, for preparing patches, storing tools and supplies, or other uses.

C. Geomembrane Testing (Nondestructive): The Geomembrane Installer shall test and document all seam welds continuously using one of the following nondestructive seam tests:

a. Vacuum testing shall conform to the following procedure: Brush soapy solution on geomembrane. Place vacuum box over the wetted seam area. Ensure that a leak-tight seal is created. Apply a pressure of approximately five (5) psi. Examine the geomembrane through the viewing window for the presence of soap bubbles for not less than 15 seconds. All areas where soap bubbles appear shall be marked and repaired as described in this Section.

b. Air Pressure Testing (for double seam with an enclosed space) shall conform to GRI GM6 requirements. Seams shall be pressurized to 20 psig and held for 5 minutes with no more than 4 psig loss. Seams with more than 4 psig loss shall be marked and repaired as described in this Section.

D. Destructive Seam Testing:

1. Test and evaluate in accordance with GRI Test Method GM19.
2. A minimum of one destructive test per 500 LF of seam, and as many other samples as CQA/CQC Consultant determines appropriate, shall be obtained at locations specified by the CQA/CQC Consultant.
   a. Sample locations shall not be identified prior to seaming.
   b. The samples shall be a minimum of 12 IN wide by 48 IN long with the seam centered lengthwise.
   c. Each sample shall be cut into three equal pieces with one piece retained by the Installer, one piece given to an Independent Testing Laboratory, and the remaining piece given to the CQA/CQC Consultant for quality assurance testing and/or permanent record.
   d. Each sample shall be numbered and recorded on the final panel layout record drawing, and cross-referenced to a field log which identifies:
      1) Panel/sheet number.
      2) Seam number.
      3) Top sheet.
      4) Date and time cut.
      5) Ambient temperature.

6) Seaming unit designation.
7) Name of seamer.
8) Seaming apparatus temperature and pressures (where applicable).

3. A minimum of four 1 IN wide replicate specimens shall be cut from the Installer's sample.
   a. A minimum of 2 specimens shall be tested for shear strength and 2 for peel adhesion using an approved field quantitative tensiometer. Jaw separation speed shall be 2 IN per minute.
   b. To be acceptable, all replicate test specimens must meet the specified seam strength requirements and fail as Film Tear Bond.
   c. If the field tests pass, 5 specimens shall be tested at the Independent Testing Laboratory for shear strength and 5 for peel adhesion in accordance with ASTM D4437.
   d. To be acceptable, 4 out of 5 replicate test specimens must meet the specified seam strength requirements and fail as Film Tear Bond.
4. The minimum required seam strengths:

DESCRIPTION	TEST METHOD	HOT WEDGE (LBS/IN WIDTH)	EXTRUSION (LBS/IN WIDTH)
LLDPE Peel	ASTM D46392	50	44
LLDPE Shear	ASTM D6392	60	60

5. If the field tests pass, 5 specimens shall be tested at the Independent Testing Laboratory for shear strength and 5 for peel adhesion in accordance with ASTM D6592.
   a. To be acceptable, 4 out of 5 replicate test specimens must meet the specified seam strength requirements and fail as Film Tear Bond.
   b. If the field or laboratory tests fail, the seam shall be repaired in accordance with the Manufacturer's Quality Control manual.
   c. In addition, all destructive seam sample holes shall be repaired the same day as cut.
   d. Certified test results on all field seams shall be submitted to and approved by the CQA/CQC Consultants prior to acceptance of the seam.
6. Ten percent of all repaired areas shall be destructively tested.
   a. All repaired areas shall be non-destructively tested.
7. Destructive testing shall be performed by an Independent Testing Laboratory employed by the Contractor, not the Installer.
   a. The CQA Consultant may separately conduct destructive testing for quality assurance.
   b. If samples tested by CQA Consultant fail, based on above criteria, seam will be classified as failed.
8. A map showing the locations, number and type of all patches shall be prepared and provided to the Owner.
9. Documentation: The following documentation must be maintained at the project site for review by the Engineer or CQA Consultant:
   a. Geomembrane Installer's Documentation:
      1) Daily Log: daily record that summarizes panels deployed, seams completed, seam testing, seam repair, personnel on site, and equipment on site.
      2) Panel Log: provides geomembrane roll number used and subgrade acceptance for each panel deployed.
      3) Seam Testing Log: provides a complete record of all nondestructive and destructive seam tests performed as part of the Geomembrane Installer's QC program.
      4) Seam/Panel Repair Log: provides a complete record of all repairs and vacuum box testing of repairs made to defective seams or panels.
      5) As-Built Drawing: maintain an as-built drawing updated on a weekly basis.
   b. CQC Consultant's Documentation:

1) Daily Log: daily record that summarizes panels deployed, seams completed, CQC seam testing, seam repair, personnel on site, equipment on site, weather conditions, etc.
2) CQA/CQC Testing Log: record of all seam destructive tests and material conformance tests performed by the CQC Geosynthetics Laboratory.
3) Material Conformance: maintain original conformance certificate(s) from geomembrane manufacturer.
4) Subgrade Acceptance Log: maintained originals of subgrade acceptance forms for each panel and signed by the Geomembrane Installer.

3.2 GEOMEMBRANE ACCEPTANCE

A. The Geomembrane Installer shall retain all Ownership and responsibility for the geomembrane liner system until final acceptance of the Work by the Owner. Owner will accept the geosynthetic installation when the installation is finished and all required submittals from the Geomembrane Installer and Geotech Engineer have been received, approved, and verification of the adequacy of all field seams and repairs, including associated testing, is complete.

END OF SECTION

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SECTION 02775
HDPE GEOMEMBRANE

PART 1 - GENERAL

1.1 SUMMARY

A. This specification is for material used for the base liner (compacted soil liner) and the cap system.

~~A.~~B. Section Includes:

1. Furnish all labor, materials, tools, and equipment, and perform all work and services necessary for or incidental to the furnishing and installation, complete, of an impermeable, HDPE geomembrane liner as shown on Drawings and specified in accordance with provisions of the Contract Documents.
2. Completely coordinate work with that of all other trades.
3. Work items in project include, but are not necessarily limited to, the liner for the structural fill.
4. Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, complete, and compatible installation shall be furnished and installed as part of this work.
5. Furnish CQA/CQC Consultant to monitor work of Geomembrane Installer and to perform CQA/CQC testing in accordance with provisions of the Contract Documents.
6. The Contractor, Geomembrane Installer, Geotech Engineer, and Engineer are required to attend the CQA/CQC Resolution Meeting and the CQA/CQC Preconstruction Meeting.

~~B.~~C. Related Sections include but are not necessarily limited to:

1. Section 1060 – Special Conditions
~~1.~~2. Section 02220 - Earthwork
~~2.~~3. Section 02240 - Leachate Collection Stone.
~~3.~~4. Section 02276 - Soil Liner System
~~4.~~5. Section 02777 – Drainage Composite.
~~5.~~6. Construction Quality Assurance Plan.

1.2 QUALITY STANDARDS

A. Referenced Standards:

1. ASTM International (ASTM):
   a. D792, Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
   b. D1004, Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
   c. D1238 Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.
   d. D1603 Standard Test Method for Carbon Black in Olefin Plastics.
   e. D3015 Standard Practice for Microscopic Examination of Pigment Dispersion in Plastic Compounds. Refer to Subpart 2.2 for property to be tested.
   f. D3895 Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis.
   g. D4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.
   h. D4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
   i. D5199 Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
   j. D5397 Procedure to Perform a Single Point Notched Constant Tensile Load – Appendix (SP-NCTL) Test.

k. D5596 Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
l. D5721 Practice for Air-Oven Aging of Polyolefin Geomembranes.
m. D520 Pressured Air Channel Evaluation of Dual Seamed Geomembranes
n. D5885 Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry.
o. D5994 Test Method for Measuring the Core Thickness of Textured Geomembranes.
p. D6392, Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
q. D6693, Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
r. D7238 Standard Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane.
s. D7466 Standard Test Method for Measuring the Asperity Height of Textured Geomembrane.

2. The Geosynthetic Research Institute (GRI).
a. GM6 Pressurized Air Channel Test for Dual Seam Geomembranes.
b. GM10 Specification for the Stress Crack Resistance of Geomembrane Sheet.
c. GM11 Accelerated Weathering of Geomembranes Using a Fluorescent UVA-Condensation Exposure Device.
d. GM13 Standard Specification for Test Properties, Testing Frequency, and Recommended

B. Qualifications:
1. Each geomembrane manufacturing or installation firm shall demonstrate 5 years continuous experience, including a minimum of 10,000,000 SF of HDPE geomembrane manufacture or installation.
2. Geomembrane Installer Personnel Qualifications:
a. Installation Superintendent shall have worked in a similar capacity on at least five HDPE geomembrane liner jobs similar in size and complexity to the project described in the Contract Documents.
b. The Master Welder shall have completed a minimum of 5,000,000 sf of HDPE geomembrane seaming work using the type of seaming apparatus proposed for use on this Project.
c. Other welders shall have seamed a minimum of 1,000,000 sf of HDPE geomembrane.

C. CQA Plan Implementation: Construction Quality Assurance for the HDPE geomembrane installation will be performed for the Owner in accordance with the CQA Plan prepared for this project. The Owner, CQC Consultant , and Geomembrane Installer, however, should familiarize themselves with the CQA Plan and are responsible for providing reasonable notice of and access to work elements that is required by the CQA Plan to overview.

1.3 SUBMITTALS

A. Shop Drawings: Submit for Engineer's approval prior to placement of geomembrane liner.

B. Manufacturer's Submittals.
1. Manufacturer's Quality Control (MQC) Program: Submit certification that the MQC program at a minimum conforms to GRI GM13 standards.
2. Manufacturer's Field Installation Procedures Manual: Submit complete geomembrane manufacturer's specifications, descriptive drawings, and literature for the recommended installation of the HDPE geomembrane liner system, including recommended methods for handling and storage of all materials prior to installation, and field installation guidelines that the manufacturer feels are relevant and important to the success of this project. The manual clearly identifies any exceptions taken by the manufacturer in the specified execution of the Work. Unless excepted and approved by the Engineer, the procedures herein shall be considered part of the manual.

3. Manufacturer's Material Data: Submit statement of planned production date(s) for the geosynthetics to be provided for this Project. Prior to shipment of geomembrane, submit quality control certificates for each roll demonstrating conformance with the requirements of these Specifications. Submit statement of production dates for the resin and the HDPE geomembrane for this work.
4. Manufacturer's written acceptance of Geomembrane Installer's qualifications for installation of the HDPE geomembrane.

C. Geomembrane Installer's Submittals.
1. The Geomembrane Installer will submit written documentation that their personnel satisfy the qualifications of 1.2 B.
2. Geomembrane Installer's Construction Quality Control Program: Submit for review a complete description of the Geomembrane Installer's formal construction quality control programs to include, but not be limited to, product acceptance testing, installation testing, including both nondestructive and destructive quality control field testing of the sheets and seams during installation of the geomembrane, proposed methods of testing geosynthetic joints and connections at appurtenances for continuity, documentation and changes, alterations, repairs, retests, and acceptance.
3. Geomembrane Installer's Installation Procedures Manual: Submit for approval the Installer's installation manual to include: ambient temperature at which the seams are made, control of panel lift up by wind, acceptable condition of the subsurface beneath the geomembrane, quality and consistency of the welding material, proper preparation of the liner surfaces to be joined, cleanliness of the seam interface (e.g., the amount of airborne dust and debris present), and proposed details for connecting the HDPE liner to appurtenances, i.e. penetrations of the containment facilities. The document shall include a complete description of seaming by extrusion welding and hot-wedge welding. The Geomembrane Installer's Installation Manual will by reference include requirements of the Manufacturer's Installation Manual unless exceptions are noted and approved by the Engineer. After this manual has been approved by the Engineer, the Geomembrane Installer shall not deviate from the procedures included in the manual.
4. Geomembrane panel layout with proposed size, number, position, and sequencing of panels and showing the location and direction of all field joints. Joints shall be perpendicular to flow direction where possible, unless approved otherwise.
5. Warranty: Submit a sample warranty in accordance with Paragraph 1.6 Warranties.

D. Installer Submittals:
1. Installer shall submit written documentation that their personnel satisfy the project qualifications.
2. Installer Geomembrane Manual: Submit Installer's written program for meeting the geomembrane material conformance and CQA/CQC requirements of these Specifications.

E. Provide all submittals in a single coordinated transmittal. Partial submittals will not be accepted. All submittals must be submitted prior to the Geomembrane Preconstruction Meeting~~, Section 01200~~.

F. Miscellaneous submittals for Engineer's Approval Required for Final Acceptance of HDPE Geomembrane Liner System:
1. Geomembrane Installer's Submittals.
a. Warranty: Submit a warranty signed by the Geomembrane Installer that the installed geomembrane liner, attachments, and appurtenances are free of defects in material, manufacturing, and workmanship.
b. Record Drawings: Submit reproducible drawings of record showing changes from the approved installation drawings. The record drawings shall include the identity and location of each repair, cap strip, penetration, boot, and sample taken from the installed geosynthetic for testing. The record drawings shall show locations of each type of material anchor trenches and the construction baseline.

c. Welder Certification: Submit certification for each welder and performance records that include linear feet of weld completed, number of samples tested, and test failure rate for each welder. Submit field notes with daily equipment reports.

d. Certification: Submit written certification that the geomembrane liner was installed in accordance with this Specification and with the approved shop drawings.

e. CQA/CQC Records: Submit copies of all material and seam test results. Each test shall be identified by date of sample, date of test, sample location, name of individual who performed the test, and standard test method used.

f. CQA/CQC Weld Test Summary Report: The Geotech Engineer shall submit a report showing normal distribution of all CQA/CQC seam test results, identifying the high, low, and average of the five coupon samples in each test.

2. Provide all submittals in a single coordinated transmittal. Partial submittals will not be accepted.

1.4 PROJECT CONDITIONS

A. When the weather is of such a nature as to endanger the integrity and quality of the installation, whether this is due to rain, high winds, cold temperatures, or other weather elements, the installation of the geomembrane shall be halted at the direction of, or with the concurrence of, the Engineer until the weather conditions are satisfactory.

B. The Contractor shall ensure that adequate dust control methods are in effect to prevent the unnecessary accumulation of dust and dirt on geosynthetic surfaces which hamper the efficient field seaming of geosynthetic panels.

C. The Contractor shall maintain natural surface water drainage diversions around the work area and provide for the disposal of water which may collect in the work area directly from precipitation falling within the area or from inadequate diversion structures or practices.

D. The Contractor shall be responsible to coordinate the installation of the leachate collection system which shall be in accordance with Geomembrane Installer's Installation Manual and as specified in these Specifications and shown on the Contract Drawings.

E. Vehicles will not be allowed on the liner area unless at least 24 inches of cover has been placed over the liner except as noted in these Specifications.

F. Vehicles larger than one and one-half ton pickup trucks are prohibited on the exterior berms. Contractor shall repair any damage to exterior berms prior to final payment.

1.5 DEFINITIONS AND RESPONSIBILITIES

A. Geomembrane Manufacturer: Manufacturer of geomembranes producing geomembrane sheets from resin and additives. The manufacturer is responsible for producing geomembrane sheet which complies with these Specifications. These responsibilities include but are not limited to:

1. Acceptance of the resin and additives from chemical formulators. Testing of the raw resin and additives to ensure compliance with the manufacturer's specifications and with this Specification.
2. Formulation of the resin and additives into geomembrane sheeting using mixing and extrusion equipment.
3. Testing of the geomembrane sheet to ensure compliance with manufacturer's specification and this Specification.
4. Shipping of the geomembrane sheet to installer designated facilities.
5. Certification of the raw materials and finished geomembrane sheet to comply with this Specification.
6. Certification of installer's training, experience, and methods for welding and inspection of geomembrane installations in compliance with manufacturer's standards.

B. Geomembrane Installer. Installer of geomembranes is responsible for handling, fitting, welding, and testing of geomembrane sheets or blankets in the field. These responsibilities include but are not limited to:
   1. Acceptance (in writing) of the geomembrane from the manufacturer.
   2. Acceptance (in writing) of the CSL surface which will serve as a base for the geomembrane. This acceptance shall precede installation of the geomembrane, and shall state that the installer has inspected the surface, and reviewed the Specifications for material and placement, and finds all conditions acceptable for placement of geomembrane liners. The written acceptance shall explicitly state any and all exceptions to acceptance.
   3. Handling, welding, testing, and repair geomembrane liners in compliance with this Specification and the Geomembrane Installer's Installation Procedures Manual.
   4. Performance of QA/QC testing and record keeping as required by the approved Geomembrane Installer's Field Installation Procedures Manual.
   5. Repair or replacement of defects in the geomembrane as required by the Geotech Engineer.

C. Engineer: Responsible for approval of submittals from the Contractor.

D. CQC Consultant/Geotech Engineer: Responsible for observing field installation of the geomembrane and performance of material conformance and CQC testing to provide the Contractor with verbal and written documentation of the compliance of the installation with these Specifications.

E. Engineer: Responsible for implementing CQA Plan including overviewing material conformance testing, field installation of the geomembrane, and CQC activities, and to perform limited CQA conformance testing to provide Owner with verbal and written documentation of the compliance of the installation with these Specifications. The Engineer will use the written results of the CQA/CQC program in the preparation of the facility Certification Document.

F. Refer to the accompanying CQA Plan for additional definitions.

1.6 WARRANTIES

A. The Installer's warranty shall be against defects in the system installed for a period of two years from the date of final acceptance of the Work. .

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS AND/OR GEOMEMBRANE INSTALLERS

A. Subject to compliance with the Contract Documents, the following manufacturers and installers are acceptable:
   1. HDPE Geomembrane liners manufacturers:
      a. GSE, Inc., 19103 Gundle Road, Houston, Texas 77073.
      b. Agru/America, Inc., 500 Garrison Road, Georgetown, SC 29440.
      ~~c. Solmax International Inc., 2801 Marie-Victorin Blvd., Varennes, Quebec, Canada J3X 1P7~~
   2. HDPE Geomembrane Liner Installers:
      a. Authorized installers of approved manufacturers.
      b. Other installers may qualify for approval by providing references for a minimum of 10,000,000 SF of liner installations.

2.2 MATERIALS

A. HDPE Geomembrane:
   1. Geomembrane shall consist of unsupported polyethylene in thickness as shown on Drawings and manufactured from virgin, first quality resin designed and formulated specifically for liquid containment in hydraulic structures. Reclaimed polymer shall not be added to the resin; except use of polymer recycled during the manufacturing process shall be allowed provided that recycled polymer shall be clean and shall not exceed 2 percent by weight.

2. The geomembrane shall be manufactured to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter. Any such defects shall be cause for rejection of the defective geomembrane material. Minor defects may be repaired in accordance with manufacturer's recommendations if this repair is approved by the Engineer.
3. The geomembrane liner shall be manufactured as seamless rolls or as prefabricated panels with a minimum width of 22 FT as delivered to the site. All factory seams shall be inspected and tested for strength and continuity prior to delivery to the site.
4. No additives or fillers may be added to the resin prior to or during manufacture of the geomembrane.
5. Prior to shipment, the geomembrane manufacturer will provide the Engineer and the Geotech Engineer with a quality control certificate for each roll of geomembrane provided. The quality control certificate will be signed by a responsible party employed by the geomembrane manufacturer and will include:
   a. Roll numbers and identification; and
   b. The results of quality control tests performed under the MQC program.
6. The Geotech Engineer will verify that a control certificate has been received for each roll and that the certified roll properties meet the requirements of these Specifications.
7. Textured HDPE sheet (both sides) shall be used on all lined surfaces. Minimum 6 feet run out from toe of slope, of textured HDPE liner.
8. The geomembrane liner material shall consist of **HDPE** that meets or exceeds GRI GM13 and the following requirements:

PROPERTY	TEST METHOD	TEST VALUE	
a. Sheet Thickness, Mils	ASTM D5994	40	60
• Minimum Average		nominal -5%	-5%
• Lowest Individual 8 of 10		nominal -10%	-10%
• Lowest Individual 10 of 10		nominal -15%	-15%
b. Sheet Density (g/cc)	ASTM D792 or D1505	0.940	0.940
c. Minimum Tensile Properties	ASTM D6693		
• Yield Stress		84 ppi	126 ppi
• Break Stress		60 ppi	90 ppi
• Elongation at Yield		12%	12%
• Elongation at Break (2-inch gage length)		100%	100%
d. Min. Tear Resistance Initiation	ASTM D1004, Die C	28 lbs	42 lbs
e. Carbon Black	ASTM D1603 or ASTM D4218	2.0-3.0%	2.0-3.0%
f. Carbon Black Dispersion	ASTM D5596	Category	Category
• 8 of 10		1 or 2	1 or 2
• 10 of 10		1, 2, or 3	1, 2, or 3
g. Puncture Resistance, Minimum Average	ASTM D4833	60 lbs	90 lbs
h. Oxidative Induction Time, Minimum Average	ASTM D3895 or ASTM D5885	100 min. 400 min.	100 min. 400 min.
i. Asperity Height, Minimum Average	GRI GM12	10 mil	10 mil

B. Extrusion rod shall be manufactured from identical resin to that used in geomembrane manufacture. Manufactured extrusion rod shall be tested for carbon black content and dispersion, specific gravity, and melt index at a frequency of not less than one test per batch.

2.3 INTERFACE FRICTION TESTS

A. Interface Friction Tests.
   1. Test both materials using ASTM D 6243. ~~Consult the Design Engineer for the required interface friction and conditions under which this material shall be tested~~. Section 01060-Special Conditions, outlines the conditions under which this material shall be tested.
   2. This material is part of a system. The system shall meet the requirements before the component material can be deemed acceptable.

2.4 EQUIPMENT

A. Welding Equipment: Extrusion welding equipment shall be provided with thermocouples and temperature readout devices which continuously monitor the temperature of the extrudate. Radiant wedge welding equipment shall be provided with thermocouples and temperature readout devices which continuously monitor the temperature of the wedge. Equipment shall be maintained in adequate number to avoid delaying work, and shall be supplied by a power source capable of providing constant voltage under a combined-line load. Use a rub sheet, sand bags, or other method approved by the Geotech Engineer to separate the electric generators from the geomembrane.

B. Field Tensiometer: The Geomembrane Installer shall provide a tensiometer for on-site shear and peel testing of geomembrane seams. The tensiometer shall be in good working order, built to ASTM D6693 specifications, and accompanied by evidence of recent calibration. The tensiometer shall be motor driven and be equipped with a gauge that measures the force in unit pounds exerted between the jaws as displayed on a digital readout.

C. Vacuum Box: The Geomembrane Installer shall provide a minimum of 2 vacuum box assemblies consisting of a rigid housing, a transparent viewing window, a soft closed cell neoprene gasket attached to the bottom, a port hole or valve assembly, a vacuum gauge, a vacuum pump assembly equipped with a pressure control, a rubber pressure/vacuum hose with fittings and connections, and a soapy solution and an applicator. The equipment shall be capable of inducing and holding a minimum vacuum of 5 psi.

D. Air Pressure Test: The Geomembrane Installer shall provide the necessary air pump and fittings required to perform the GRI GM6 air pressure test on dual seams.

E. Roll Handling Equipment: The Geomembrane Installer shall provide handling equipment that is adequate and does not pose a risk to the geomembrane rolls. The Geotech Engineer shall inspect the equipment and confirm its adequacy.

PART 3 - EXECUTION

3.1 LINER SYSTEM CONSTRUCTION

A. Compacted Soil Liner (CSL) Component:
   1. The CSL component for the base liner shall be constructed in accordance with Section 02276 and the Contractor shall protect the CSL from freezing, desiccation, flooding with water, and freezing.
   2. Prior to placement of the geomembrane over the CSL, the CSL must be prepared as follows:
      a. Lines and grade must be verified by a Licensed Land Surveyor.
      b. The surface must be proofrolled to verify the supporting soil condition.
      c. The surface must be inspected for rocks larger than 0.75 IN.
      d. Steel drum rolled in preparation for the geomembrane.
      e. Thickness must be verified by an approved method. Refer to Specification 01060 and the CQA Plan

3. CSL acceptance: Geomembrane liner materials shall not be placed until the following have been completed. ~~required CSL preparation has been completed and the CSL has been accepted and certified in writing by the Geomembrane Installer and approved by the Engineer.~~
   a. The thickness of the CSL has been verified by the CQA.
   b. A sealed survey of the CSL has been submitted to the CQA.
   c. The required CSL preparations have been completed.
   d. The CSL has been accepted in writing by the Geomembrane installer.

B. Cap System Component
1. Prior to placement of the geomembrane over the CCP, the CCP must be prepared as follows:
   a. The surface must be uniform.
   b. Graded to promote positive drainage.
   c. Aggregates larger than 0.75 IN must be removed.

~~B.~~C. Geomembrane Liner:

1. The geomembrane liner shall be manufactured in accordance with the approved MQC program. The manufacturer shall not deviate from the program without written approval of the Engineer.
2. Transportation and handling of the geomembrane shall meet the following requirements:
   a. Transportation of the geomembrane is the responsibility of the Geomembrane Installer, Contractor, or other party as agreed upon.
   b. All handling on site is the responsibility of the Geomembrane Installer.
   c. The Geotech Engineer will verify that the handling equipment used on the site is adequate and will not damage the geomembrane.
   d. Upon delivery to the site, the Geomembrane Installer and the Geotech Engineer will conduct a surface examination of all rolls for defects or damage. This inspection will be conducted without unrolling rolls. The Geotech Engineer will ensure that defective rolls are rejected and removed from the site.
   e. The Geomembrane Installer will be responsible for the storage of the geomembrane on site. The Project Manager will provide a storage location on site. The Geomembrane Installer shall ensure that the storage space is adequate to protect the geomembrane from theft, vandalism, vehicular damage, etc.
3. Field Panel Identification: The Geotech Engineer will document that the Geomembrane Installer labels each field panel with an "identification code" consistent with the approved panel layout plan. The location of the label and the color of marker used must be as agreed to in the QA/QC Preconstruction Meeting.
4. Geomembrane Installation: Geomembrane liner shall be installed in accordance with the approved Geomembrane Installer's Field Installation Procedure Manual and panel layout drawing. The Geomembrane Installer shall maintain a weekly updated as-built drawing showing the location of all field panels.
   a. Geomembrane shall not be placed upon standing water or other conditions which will result in deterioration of the soil liner.
   b. The Geomembrane Installer shall remove any materials placed to protect the soil liner prior to placement of the geomembrane liner.
   c. Geomembrane liner shall be handled and placed in a manner which minimizes wrinkles, scratches, and crimps.
   d. Test seams shall be made upon each start of work for each seaming crew, upon every four hours of continuous seaming, every time seaming equipment is changed, or if significant changes in geomembrane temperature and weather conditions are observed. These test welds shall be tested using daily record that summarizes panels deployed, seams completed, seam testing, seam repair, personnel on site, and equipment on site using field tensiometer and, at a minimum, exhibit the required seam strength.

e. Surfaces to be welded shall be clean and dry at the time of welding. Geomembrane shall not be welded when ambient temperatures are below 40 Deg F (5 Deg C) or above 104 Deg F (40 Deg C) unless the Geomembrane Installer can demonstrate that the seam quality is not compromised.

f. Geomembrane liners shall be welded continuously without fishmouths or breaks in the weld. Where fishmouths are unavoidable, the geomembrane sheet shall be slit to a point such that the sheet lies flat and with no remaining wrinkle. The two edges of the slit shall be welded together provided that the overlap for this weld shall be a minimum of 3 IN. Areas of the slit which do not achieve an overlap of 3 IN, including the terminus of the slit, shall be provided with a patch as discussed below.

g. Defects in and damage to geomembrane sheets shall be repaired by welding a patch over the defect using extrusion welding equipment. The patch material shall consist of an undamaged piece of geomembrane cut to provide a minimum of 3 IN of overlap in all directions from the defect. Torn or permanently twisted geomembrane shall be replaced.

h. Defects in and damage to double hot wedge welded seams are not to be repaired by welding ~~a patch~~ over the defect using extrusion welding equipment. Defective double hot wedge welded seams shall be cut out and reconstructed or a cap strip placed over the area and extrusion welded. The repair shall be tested in accordance with the type of weld used.

i. Personnel walking on the geosynthetic shall not engage in activities or wear types of shoes that could damage the geosynthetic. Smoking shall not be permitted while working on the geomembrane.

j. Vehicular traffic directly on the geosynthetic shall not be permitted. Equipment shall not damage the geosynthetic materials by handling, trafficking, leakage of hydrocarbons, or any other means. The unprotected geomembrane surface shall not be used as a work area, for preparing patches, storing tools and supplies, or other uses.

C. Geomembrane Testing (Nondestructive): The Geomembrane Installer shall test and document all seam welds continuously using one of the following nondestructive seam tests:

a. Vacuum testing shall conform to the following procedure: Brush soapy solution on geomembrane. Place vacuum box over the wetted seam area. Ensure that a leak-tight seal is created. Apply a pressure of approximately five (5) psi. Examine the geomembrane through the viewing window for the presence of soap bubbles for not less than 15 seconds. All areas where soap bubbles appear shall be marked and repaired as described in this Section.

b. Air Pressure Testing (for double seam with an enclosed space) shall conform to GRI GM6 requirements. Seams shall be pressurized to 30 psig and held for 5 minutes with no more than 3 psig loss. Seams with more than 3 psig loss shall be marked and repaired as described in this Section.

D. Destructive Seam Testing:

1. Test and evaluate in accordance with GRI Test Method GM19.
2. A minimum of one destructive test per 500 LF of seam, and as many other samples as Geotech Engineer determines appropriate, shall be obtained at locations specified by the Geotech Engineer.
   a. Sample locations shall not be identified prior to seaming.
   b. The samples shall be a minimum of 12 IN wide by 48 IN long with the seam centered lengthwise.
   c. Each sample shall be cut into three equal pieces with one piece retained by the Installer, one piece given to an Independent Testing Laboratory, and the remaining piece given to the Geotech Engineer for quality assurance testing and/or permanent record.
   d. Each sample shall be numbered and recorded on the final panel layout record drawing, and cross-referenced to a field log which identifies:
      1) Panel/sheet number.
      2) Seam number.
      3) Top sheet.

4) Date and time cut.
5) Ambient temperature.
6) Seaming unit designation.
7) Name of seamer.
8) Seaming apparatus temperature and pressures (where applicable).

3. A minimum of four 1 IN wide replicate specimens shall be cut from the Installer's sample.
   a. A minimum of 2 specimens shall be tested for shear strength and 2 for peel adhesion using an approved field quantitative tensiometer. Jaw separation speed shall be 2 IN per minute.
   b. To be acceptable, all replicate test specimens must meet the specified seam strength requirements and fail as Film Tear Bond.
   c. If the field tests pass, 5 specimens shall be tested at the Independent Testing Laboratory for shear strength and 5 for peel adhesion in accordance with ASTM D4437.
   d. To be acceptable, 4 out of 5 replicate test specimens must meet the specified seam strength requirements and fail as Film Tear Bond.

   The minimum required seam strengths:

		40 mil		60 mil	
Description	Test Method	Hot Wedge (lbs/in width)	Extrusion (lbs/in width)	Hot Wedge (lbs/in width)	Extrusion (lbs/in width)
HDPE Peel	ASTM D6392	60	52	91	78
HDPE Shear	ASTM D6392	80	80	120	120

4. If the field tests pass, 5 specimens shall be tested at the Independent Testing Laboratory for shear strength and 5 for peel adhesion in accordance with ASTM D6392.
   a. To be acceptable, 4 out of 5 replicate test specimens must meet the specified seam strength requirements and fail as Film Tear Bond.
   b. If the field or laboratory tests fail, the seam shall be repaired in accordance with the Manufacturer's Quality Control manual.
   c. In addition, all destructive seam sample holes shall be repaired the same day as cut.
   d. Certified test results on all field seams shall be submitted to and approved by the Geotech Engineer prior to acceptance of the seam.
5. Ten percent of all repaired areas shall be destructively tested.
   a. All repaired areas shall be non-destructively tested.
6. Destructive testing shall be performed by an Independent Testing Laboratory employed by the Contractor, not the Installer.
   a. The Geotech Engineer may separately conduct destructive testing for quality assurance.
   b. If samples tested by Geotech Engineer fail, based on above criteria, seam will be classified as failed.
7. A map showing the locations, number and type of all patches shall be prepared and provided to the Owner.
8. Documentation: The following documentation must be maintained at the project site for review by the Engineer:
   a. Geomembrane Installer's Documentation:
      1) Daily Log: daily record that summarizes panels deployed, seams completed, seam testing, seam repair, personnel on site, and equipment on site.
      2) Panel Log: provides geomembrane roll number used and subgrade acceptance for each panel deployed.
      3) Seam Testing Log: provides a complete record of all nondestructive and destructive seam tests performed as part of the Geomembrane Installer's QC program.
      4) Seam/Panel Repair Log: provides a complete record of all repairs and vacuum box testing of repairs made to defective seams or panels.
      5) As-Built Drawing: maintain an as-built drawing updated on a weekly basis.
   b. CQC Consultant’s Documentation:

1) Daily Log: daily record that summarizes panels deployed, seams completed, CQC seam testing, seam repair, personnel on site, equipment on site, weather conditions, etc.
2) CQA/CQC Testing Log: record of all seam destructive tests and material conformance tests performed by the CQA/CQC Geosynthetics Laboratory.
3) Material Conformance: maintain original conformance certificate(s) from geomembrane manufacturer.
4) Subgrade Acceptance Log: maintained originals of subgrade acceptance forms for each panel and signed by the Geomembrane Installer.

3.2 GEOMEMBRANE ACCEPTANCE

A. The Geomembrane Installer shall retain all Ownership and responsibility for the geomembrane liner system until final acceptance by the Owner. Owner will accept the geosynthetic installation when the installation is finished and all required submittals from the Geomembrane Installer and CQA/CQC Consultant have been received, approved, and verification of the adequacy of all field seams and repairs, including associated testing, is complete.

END OF SECTION

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SECTION 02777
DRAINAGE COMPOSITE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Bonded geotextile-geonet drainage composite.

B. Related sections include but are not necessarily limited to:
   1. Section 02774 – LLDPE Geomembrane.
   ~~1.~~ 2. Section 02775 – HDPE Geomembrane.
   ~~2.~~ 3. Section 02778 - Geotextiles.
   ~~3.~~ 4. Construction Quality Assurance Plan.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. ASTM International (ASTM):
      a. D413, Rubber Property - Adhesion to Flexible Substrate.
      b. D792, Standard Test Methods for Density and Specific Gravity of Plastic by Displacement.
      c. D1238, Flow Rates of Thermoplastics by Extrusion Plastometer.
      d. D1505, Density of Plastics by the Density-Gradient Technique.
      e. D1603, Carbon Black in Olefin Plastics.
      f. D4716, Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextile Related Products.
      g. D4873, Identification, Storage and Handling of Geosynthetic Rolls.
      h. D5199, Standard Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
      i. D5321, Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
      j. D7005, Standard Test Method for Determining the Bond Strength (Ply Adhesion) of Geocomposites.

B. Qualifications:
   1. Each manufacturing and fabricating firm shall demonstrate 5 years continuous experience, including a minimum of 5,000,000 SF of drainage composite production in the past 3 years.
   2. Installer shall attend pre-installation conference.

1.3 DEFINITIONS:

A. Manufacturer: Manufacturer producing drainage composites from geonet cores and geotextiles.

B. Installer: The Installers are the individuals actually performing the hands-on work in the field.

C. MARV: Minimum average roll value.

1.4 SUBMITTALS

A. Shop Drawings:
   1. Manufacturer's documentation that raw materials and roll materials comply with required drainage composite physical properties.
   2. Manufacturer and Installer quality control manuals.
   3. Original test results for resins and roll material at frequency specified in respective quality control manuals. Include or bracket the rolls delivered for use in the Work.

4. Layout plan with proposed size, number, position and sequencing of drainage composite rolls and direction of all field seams.
5. Proposed details of anchor trench if different than included in Contract Documents.

B. Miscellaneous Submittals:
1. Qualification documentation specified in Article 1.2.

1.5 DELIVERY, STORAGE AND HANDLING

A. Label, handle, and store drainage composites in accordance with ASTM D4873 and as specified herein.

B. Wrap each roll in an opaque and waterproof layer of plastic during shipment and storage. Do not remove the plastic wrapping until deployment.

C. Label each roll with the manufacturer's name, drainage composite type, lot number, roll number, and roll dimensions (length, width, gross weight).

D. Repair or replace, as directed by the Engineer, drainage composite or plastic wrapping damaged as a result of storage or handling.

E. Do not expose drainage composite to temperatures in excess of 71 DegC (160 DegF) or below 0 DegC (32 DegF) unless recommended by the Manufacturer.

F. Do not use hooks, tongs or other sharp instruments for handling the drainage composite.

G. Do not lift rolls by use of cables or chains in contact with the drainage composite.

H. Do not drag drainage composite along the ground or across textured geomembranes.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
1. GSE Environmental.
2. Agru-American, Inc.
3. Engineer approved equal.

2.2 MATERIALS AND MANUFACTURE

A. Geonet Core:
1. Use nonthermally degraded polyethylene polymer which is clean and free of any foreign contaminants.
2. Manufactured geonet to conform to the property requirements listed in Table 1 and be free of defects including tears, nodules or other manufacturing defects which may affect its serviceability.

TABLE 1 - GEONET PROPERTIES

PROPERTY	TEST METHOD	TEST VALUE
Polymer Density	ASTM D1505	>0.93 g/cc
Polymer Melt Index	ASTM D1238	<1.1 g/10 min.
Carbon Black Content	ASTM D1603	2-3 percent
Thickness	ASTM D5199	≥0.300 in.

B. Geotextile:
1. Cover geonet core on both sides with a geotextile complying with requirements specified in Section 02778: Geotextiles, Separator.

C. Drainage Composite:

1. Create a composite by heat bonding geotextiles to the geonet. The bond between the geotextile and the geonet shall exhibit a MARV ply adhesion of 1 LBS/IN when tested in accordance with ASTM D7005
2. Effective Transmissivity MARV of $3.3x10^{-3}$ square meters per second @ 100 hrs.

2.3 SOURCE QUALITY CONTROL

A. Transmissivity Testing:
   1. Measure in place flow rate using water at 68 DegF with a normal compressive load of ~~10,000~~6,250 psf, a hydraulic gradient of ~~0.3~~0.2, and 100-hour loading.
   2. Attach geotextiles to the geonet in the same configuration as will be used in the field.
   3. Boundary conditions are ~~soil interface on the upper geotextile and HDPE geomembrane against the lower geotextile~~shall match the upper and lower interfaces to be used in the field.
   4. Testing frequency: 1 test for every 50,000 SF of installed product.
   5. Report shall include:
      a. Graph of flow rate vs. hydraulic gradient.
      b. Calculate transmissivity under laminer flow conditions.
      c. Calculated effective transmissivity at hydraulic gradient of 0.3.

B. Interface Friction Tests.
   1. Test materials using ASTM D 6243. ~~Consult the Design Engineer for the required interface friction and the conditions under which this material must be tested.~~ Section 01060-Special Conditions, outlines the conditions under which this material shall be tested.
   2. This material is part of a system. The system shall meet the requirements before the component material can be deemed acceptable.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Prior to placement of the drainage composite, clean the substrate of all soil, rock, and other materials which could damage the composite.

B. The geocomponent drainage media shall be placed only on geomembrane that has been approved by the Geomembrane Installer and accepted by the Geotech Engineer.

3.2 INSTALLATION

A. Install geocomposite drain in accordance with manufacturer's written recommendations.

B. Deploy the drainage composite ensuring that the drainage composite and underlying materials are not damaged. Replace or repair faulty or damaged drainage composite as directed by Engineer.

C. Unroll drainage composite downslope keeping in slight tension to minimize wrinkles and folds.

D. Maintain free of dirt, mud, or any other foreign materials at all times during construction. Clean or replace rolls which are contaminated.

E. Place adequate ballast to prevent uplift by wind.

F. Overlap adjacent rolls a minimum of 6 IN. Overlap new drainage composite over existing as shown on the drawings.

G. Use manufacturer's fasteners to join adjacent rolls. Metallic fasteners will not be allowed. Space fasteners a maximum of 5 FT along downslope roll overlaps and a maximum of 1 FT along cross slope roll overlaps. Use fasteners of contrasting color from the drainage composite to facilitate visual inspection. Do not weld drainage composite to geomembranes.

H. Heat tack overlap of the upper geotextile to the upper geotextile of the adjacent rolls.

I. Repairs holes or tears in the drainage composite by placing a patch of drainage composite extending a minimum of 2 FT beyond the edges of the hole or tear. Use approved fasteners, spaced every 6 IN around the patch, to fasten the patch to the original roll.

J. Penetration details shall be as recommended by the Manufacturer and as approved by the Engineer.

3.3 FIELD QUALITY CONTROL

A. Provide as-constructed drawing showing roll number; layout; joint locations; and repair and patch locations.

B. Prior to installation of the drainage composite, provide the Engineer quality control certificates signed by the manufacturer's quality assurance manager for every 50,000 SF of geocomposite drainage media to be installed.

~~B.~~C. Refer to Section 02778 for exposure limits of the geotextile. If the specifications in Section 02778 are exceeded, the drainage composite shall be replaced.

END OF SECTION

SECTION 02778
GEOTEXTILES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Non-woven geotextile material.
   2. Woven geotextile material.

B. Related Sections:
   1. Section 02220 - Earthwork.
   2. Section 02777 - Drainage Geocomposite.
   3. Construction Quality Assurance Plan.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Association of State Highway Transportation Officials (AASHTO):
      a. M288, Standard Specification for Geotextile Specification for Highway Application.
   2. ASTM International (ASTM):
      a. D1987, Biological Clogging of Geotextile or Soil/Geotextile Filters.
      b. D3766, Standard Terminology Relating to Catalysts and Catalysis.
      c. D3776, Test Method for Mass Per Unit Area of Woven Fabric.
      d. D3786, Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics - Diaphragm Bursting Strength Tester Method.
      e. D4354, Sampling of Geosynthetics for Testing.
      f. D4355, Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).
      g. D4491, Water Permeability of Geotextiles by Permittivity.
      h. D4533, Trapezoid Tearing Strength of Geotextiles.
      i. D4595, Tensile Properties of Geotextiles by the Wide-Width Strip Method.
      j. D4632, Grab Breaking Load and Elongation of Geotextiles.
      k. D4751, Determining Apparent Opening Size of A Geotextile.
      l. D4759, Determining the Specification Conformance of Geosynthetics.
      m. D4833, Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
      n. D4873, Identification, Storage, and Handling of Geosynthetic Rolls.
      o. D5261, Test Method for Measuring Mass Per Unit Area of Geotextiles.
      p. D6193, Standard Practice for Stitches and Seams.
      q. D7238, Standard Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus.

B. Qualifications:
   1. Each manufacturing, fabricating firm shall demonstrate 5 years continuous experience, including a minimum of 10,000,000 SF of geotextile installation in the past 3 years.
   2. Installing firm shall demonstrate that the site Superintendent or Foreman has had responsible charge for installation of a minimum of 1,000,000 SF of geotextile.
   3. Installer shall attend pre-installation conference.

1.3 DEFINITIONS:

A. Manufacturer: Manufacturer producing geotextile sheets from resin and additives.

B. Installer: The Installers are the individuals actually performing the hands-on work in the field.

C. MARV: Minimum Average Roll Value

1.4 SUBMITTALS

A. Shop Drawings:
   1. Manufacturer's documentation that raw materials and roll materials comply with required geotextile physical properties.
   2. Manufacturer and Installer quality control manuals.
   3. Original test results for resins, roll material and factory seam tests at frequency specified in respective quality control manuals. Results shall include or bracket the rolls delivered for use in the Work.
   4. Proposed details of anchoring and overlapping if different than included in Contract Documents.

B. Miscellaneous Submittals:
   1. For needle punched geotextiles, the Manufacturer shall certify that the geotextile has been continuously inspected using permanent on-line full-width metal detectors and does not contain any needles which could damage other geosynthetic layers.
   2. Qualification documentation specified in Article 1.2.

1.5 DELIVERY, STORAGE AND HANDLING

A. Label, handle, and store geotextiles in accordance with ASTM D4873 and as specified herein.

B. Wrap each roll in an opaque and waterproof layer of plastic during shipment and storage. Do not remove the plastic wrapping until deployment.

C. Label each roll with the manufacturer's name, geotextile type, lot number, roll number, and roll dimensions (length, width, gross weight).

D. Repair or replace geotextile or plastic wrapping damaged as a result of storage or handling, as directed.

E. Do not expose geotextile to temperatures in excess of 71 DegC (160 DegF) or less than 0 DegC (32 DegF) unless recommended by the manufacturer.

F. Do not use hooks, tongs or other sharp instruments for handling geotextile. Do not lift rolls lifted by use of cables or chains in contact with the geotextile. Do not drag geotextile along the ground.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
   1. Agru America, Inc.
   2. Carthage Mills.
   3. TenCate Geosynthetics.
   4. GSE Environmental

2.2 MATERIALS AND MANUFACTURE

A. Geotextile:
   1. Geotextile fibers:
      a. Long-chain synthetic polymer composed of at least 85 percent by weight polyolefins, polyesters, or polyamides.
      b. Filaments resistant to deterioration by ultraviolet light, oxidation, and heat exposure.
      c. Do not add reclaimed or recycled fibers or polymer to the formulation.

2. Form geotextile into a network such that the filaments or yarns retain dimensional stability relative to each other, including the selvages.
3. The geotextile physical properties shall equal or exceed the minimum average roll values listed below. Values shown are for the weaker principal direction. Acceptance of geotextile shall be in accordance with ASTM D4759.

B. ~~Cushion~~ Separator Geotextile: Non-woven, needle punched; polyester or polypropylene; continuous filament or staple fibers; conforming to the following properties:

1. For base liner top of geocomposite only:

Property	Test Method	Minimum Average Roll Value
Composite mass per Unit Area, oz/yd^2	ASTM D5261	14
Grab Tensile Strength, lb	ASTM D4632	200
Puncture Strength, lb	ASTM D4833	100
Trapezoidal Tear Strength, lb	ASTM D4533	85
Apparent Opening Size, US Sieve (mm)	ASTM D4751	170 (0.88)
Permittivity, (sec $^{-1}$)	ASTM D4491	0.3
Flow Rate, gpm/ft^2	ASTM D4491	20
UV Resistance, % Retained	ASTM D4355 (after 500 hours)	70

The geotextile intended as the filter shall be a hybrid geotextile consisting of a woven and non-woven needle punched composite geotextile with the two geotextiles bonded together mechanically. The two geotextiles shall form a monolithic filter product with the woven side bonded to the geonet.

~~| Property | Test Method | Minimum Required Value |~~
~~|---|---|---|~~
~~| Unit Weight | ASTM D5261 | 12 oz/sy |~~
~~| Grab Tensile Strength | ASTM D4632 | 300 lb |~~
~~| Puncture Strength | ASTM D4833 | 180 lb |~~

~~Separator Geotextile: Non-woven, needle punched; polyester or polypropylene; continuous filament or staple fibers; conforming to the following properties:~~

2. For all other locations:

Property	Test Method	Minimum Required Value
Unit Weight	ASTM D5261	8 oz/sy
Grab Tensile Strength	ASTM D4632	210 lb
Elongation	ASTM D4632	50%
Puncture Strength	ASTM D4833	95 lb
Maximum Apparent Opening Size	ASTM D4751	#70 US Sieve
Permittivity	ASTM D4491	0.5 sec-1

Roadbed Geotextile Fabric: The geotextile shall be composed of synthetic fibers formed into a woven fabric. Fibers used in the manufacture of the geotextile shall be polyolefins, polyesters or polyamides and conform to the following properties.

Property	Test Method	Minimum Required Value
Grab Tensile	ASTM D4632	200 lbs
Grab Elongation	ASTM D4632	15 %
Puncture Strength	ASTM D4833	100 lbs
Trapezoidal Tear	ASTM D4533	75
UV Resistance	ASTM D4355 or D7238	90 %

C. Thread:
   1. High-strength polyester, nylon, or other approved thread type.
   2. Equivalent chemical compatibility and ultraviolet light stability as the geotextile.
   3. Contrasting color with the geotextile.

D. The geotextile shall be able to withstand direct exposure to ultraviolet radiation from the sun for up to 90 days without noticeable effect on index or performance properties.

PART 3 - EXECUTION

3.1 PREPARATION

A. Construct the surface underlying the geotextiles smooth and free of ruts or protrusions which could damage the geotextiles.

3.2 INSTALLATION

A. Install geotextiles in accordance with manufacturer's written recommendations.

B. Hand place geotextile. No equipment will be permitted to traffic in direct contact with the geotextile.

C. Lay geotextile smooth so as to be free of tensile stresses, folds, and wrinkles.

D. Seam Construction:
   1. Geotextile seams may be sewn or overlapped. Construct overlapped seams in accordance with manufacturer's recommendations or as shown on Drawings.
   2. Sew seams continuously using an SSA flat seam with one row of a two-thread 401 chain stitch unless otherwise recommended by the manufacturer.
   3. Minimum distance from the geotextile edge to the stitch line nearest to that edge: 2 IN unless otherwise recommended by the manufacturer.
   4. Test seams at the frequency specified in Article 3.3.
   5. Tie off thread at the end of each seam to prevent unraveling.
   6. Construct seams on the top side of the geotextile to allow inspection.
   7. Sew skipped stitches or discontinuities with an extra line of stitching with 18 IN of overlap.
   8. Heat tack the geotextile overlaps as shown on the Drawings.
   9. Overlap adjacent panels a minimum of 4 IN. Heat bond seam must develop a minimum of 60% of the tensile strength of the parent geotextile as measured in ASTM D4632.

E. Protect geotextiles from clogging, tears, and other damage during installation.

F. Geotextile Repair:
   1. Place a patch of the same type of geotextile which extends a minimum of 12 inches beyond the edge of the damage or defect.
   2. Fasten patches continuously using a sewn seam or other approved method.
   3. Align machine direction of the patch with the machine direction of the geotextile being repaired.
   4. Replace geotextile which cannot be repaired.

G. Use adequate ballast (e.g. sand bags) to prevent uplift by wind.

H. Do not use staples or pins to hold the geotextile in place.

I. Geotextile left uncovered for more than 90 days shall be replaced unless otherwise allowed by Engineer.

END OF SECTION

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SECTION 02800
GEOSYNTHETIC CLAY LINER (GCL)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Furnish all labor, material, and equipment to complete installation of the GCL in accordance with the Contract Drawings and these Specifications.
   2. Completely coordinate work with that of other trades.
   3. Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, complete, and compatible installation shall be furnished and installed as part of this work.
   4. Furnish CQC Consultant to monitor the work of GCL Installer and to perform CQA/CQC testing in accordance with provisions of the Contract Documents.

B. Related Sections include but are not necessarily limited to:
   1. Section 01060 – Special Conditions
   2. Section 02220 - Earthwork.
   3. Section 02775 - HDPE Geomembrane Liner System.

1.2 QUALITY STANDARDS

A. Referenced Standards:
   1. ASTM International (ASTM):
      a. D4632, Test Method for Grab Breaking Load and Elongation of Geotextiles.
      b. D4643, Determination of Water Content of Soil by Microwave Oven Method.
      c. D4833, Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
      d. D4873, Identification, Storage and Handling of Geosynthetic Rolls.
      e. D5261, Measuring Mass Per Unit Area of Geotextiles.
      f. D5321, Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
      g. D5887, Test Method for Measurement of Index Flux through Saturated GCL Specimens Using a Flexible Wall Permeameter.
      h. D5888, Guide for Storage and Handling of Geosynthetic Clay Liners.
      i. D5889, Quality Control of GCL.
      j. D5890, Swell Index of Clay Mineral Component of Geosynthetic Clay Liners.
      k. D5891, Fluid Loss of Clay Component of Geosynthetic Clay Liners.
      l. D5993, Test Method for Measuring Mass Per Unit Area of Geosynthetic Clay Liners.
      m. D6072, Practice for Obtaining Samples of GCL
      n. D6102, Guide for Installation of Geosynthetic Clay Liners.
      o. D6243, Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method.
      p. D6496, Determining Average Bonding Peel Strength Between Top and Bottom Layers of Needle Punched GCLs.
      q. D6766, Test Method for Evaluation of Hydraulic Properties of Geosynthetic Clay Liners Permeated with Potentially Incompatible Aqueous Solutions.
      r. D6768, Test Method for Tensile Strength of Geosynthetic Clay Liner.

2. Geosynthetic Research Institute (GRI):
    a. GCL-3, Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners (GCLs).

B. Quality Assurance:
1. The OWNER's representative will conduct independent testing to support construction quality assurance program and to provide documentation of such to appropriate regulatory agencies. Facilitate and provide opportunities as OWNER's representative require.
2. Manufacture, store, place, seam, test and protect GCL as described in ASTM D4873, D5888 and D6102.

C. Qualifications:
1. Each manufacturing firm shall demonstrate 5 years continuous experience, including a minimum of 5,000,000 SF of the material for use in similar projects..

D. CQA Plan Implementation: Construction Quality Assurance documentation for the GCL installation will be performed for the Owner in accordance with the CQA Plan prepared for this project. The Owner, CQC Consultant, and GCL Installer, however, should familiarize themselves with the CQA Plan.

1.3 DEFINITIONS:

A. Manufacturer: Manufacturer produces geosynthetic clay liner panels from first quality geotextiles and sodium bentonite. The manufacturer is responsible for producing panels which comply with this Specification. These responsibilities include but are not limited to:
1. Acceptance of the geotextiles, bentonite, and additives from suppliers/manufacturers and testing of these materials to ensure compliance with the manufacturer's specifications and with this Specification.
2. Fabrication of the geotextiles and bentonite into GCL panels using mixing and extrusion equipment.
3. Testing of the GCL to ensure compliance with manufacturer's specification and this Specification.
4. Shipping of the GCL to fabricator/installer designated facilities.
5. Certification of the raw materials and finished GCL to comply with this Specification.
6. Certification of fabricator's and installer's training, experience, and methods for seaming and inspecting GCL installations in compliance with manufacturer's standards and with Quality Assurance requirements of this Specification (Article 1.2).

B. Installer: Installers of GCLs are responsible for storing, handling, fitting, seaming, and testing of GCL panels in the field. These responsibilities include but are not limited to:
1. Acceptance (in writing) of the GCL rolls from the transporter.
2. Acceptance (in writing) of the soil material which will serve as a base for the GCL. This acceptance shall precede installation of the GCL, and shall state that the installer has inspected the surface, and reviewed the Specifications for material and placement, and finds all conditions acceptable for placement of GCL liners. The written acceptance shall explicitly state any and all exceptions to acceptance.
3. Handling, seaming, testing, and repair of GCL liners in compliance with this Specification and with written procedure manuals prepared by the installer or the manufacturer.
4. Repair or replacement of defects in the GCL as required by the Inspector or the Owner.
5. Installer and manufacturer may be the same firm.

C. Inspector: Inspectors of GCL liner are responsible for observing field installation of the GCL and providing the manufacturer, installer, and Owner with verbal and written documentation of the compliance of the installation with this Specification and with written procedures manuals prepared by the manufacturer. Inspector’s responsibilities include, but are not limited to:
1. Inspection of material, handling, and field installation of the GCL liner. Inspection of all seams, repair, and test results.
2. All exceptions to material or installation shall be documented to the Engineer in writing within 48 hours of discovery.

D. Engineer: The Engineer is responsible for design of the geosynthetic liner system.

E. Hydrated GCL is defined as material which has become soft as determined by squeezing the material with finger pressure, material which has exhibited swelling, or material which as a moisture content greater than 100 percent as determined by ASTM D2216.

1.4 SUBMITTALS

A. Shop Drawings:
   1. Product Data and Factory Test Results: Published product properties and specifications for the proposed GCL, as well as factory test results of materials certified by the GCL manufacturer, shall be submitted showing conformance with the requirements of these Specifications. In addition, the Contractor shall submit the manufacturer's certification stating that the material is similar to and of the same formulation as that for which test results are submitted, and by which actual usage has been demonstrated to be satisfactory for the intended application.
   2. Samples: Samples of the GCL sheeting shall be provided to the CQA Consultant. Samples shall have a width of 4.5 IN, and a length of 5 IN.
   3. Delivery, Storage, and Handling Instructions: The manufacturer's recommendations for delivery, storage, and handling shall be submitted to the CQA Consultant for review.
   4. Delivery Date: The CQA Consultant shall be notified of the scheduled delivery date for the materials.
   5. Installation Drawings, Procedures, and Schedules: Installation drawings, procedures, and a schedule for carrying out the work shall be provided by the Contractor to the CQA Consultant for review. Procedures addressed by the Contractor shall include but not be limited to material unloading, storage, installation, repair, and protection to be provided in the event of rain. A schedule showing the order of placement, location of panels, seams, and penetrations shall be submitted for the CQA Consultant's review. Proposed methods of seaming (overlapping) GCL panels. Submit drawings showing the panel layout, seams, and associated details including pipe penetrations. Following review, these drawings will be used for installation of the GCL. Any deviations from these drawings must be approved by the CQA Consultant.

B. Miscellaneous Submittals:
   1. Test results:
      a. Bentonite, geotextile and GCL tests at frequency specified in respective quality control manuals. Results shall include or bracket the rolls delivered for use in the Work.
   2. Qualification documentation specified in Article 1.2.
   3. Submit written certifications that:
      a. The GCL delivered to site meets the requirements of this Specification.
      b. The GCL was received and accepted in undamaged condition from shipper.
      c. The subgrade has been properly prepared and acceptable for the placement of the GCL.
      d. The GCL was installed in accordance with this Specification and with approved shop drawings.
      e. The materials placed on top of the GCL were placed properly and carefully.
   4. Warranties.
   5. Record Drawing Information: Record drawings including but not limited to drawings showing the location of all seams, panels, repairs, patches, anchor trenches, pipe penetrations, and other appurtenances, including measurements and dimensions, shall be prepared by the Contractor and submitted to the Owner following completion of the project.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Do not place GCL rolls directly on the ground.

B. Store and protect GCL from dirt, water, ultraviolet light and other sources of damage.

C. Label, handle, and store GCL in accordance with ASTM D4873 and as specified herein.
   1. Wrap each roll in an opaque and waterproof layer of plastic during shipment and storage.

2. Do not remove the plastic wrapping until deployment.

D. Label each roll with the manufacturers name, lot number, roll number, and roll dimensions (length, width, gross weight).
   1. Repair or replace GCL or plastic wrapping damaged as a result of storage or handling, as directed.
   2. Do not expose GCL to temperatures in excess of 71 Deg C (160 Deg F) or less than 0 Deg C (32 Deg F) unless recommended by the Manufacturer.

E. Do not use hooks, tongs or other sharp instruments for handling the GCL. Do not lift rolls by use of cables or chains in contact with the GCL. Do not drag GCL along the ground.

1.6 WARRANTY

1. The Manufacturer shall provide a warranty to the OWNER against manufacturing defects or failures related to manufacture on a non-prorata basis for five (5) years after date of shipment.
2. GCL Installer's Warranty: The GCL Installer's warranty shall warrant their workmanship to be free of defects on a non-prorata basis for five (5) years after the final acceptance of the Work. This warranty shall include but not be limited to overlapped seams, anchor trenches, attachments to appurtenances, and penetration seals.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
   1. Geosynthetic Clay Liners:
      a. Agru America, Inc.
      b. CETCO.
      c. GSE Environmental.

2.2 MATERIALS

A. General:
   1. The GCL shall be reinforced.
   2. The GCL shall consist of bentonite encased, front and back, with geotextile. The materials supplied under these Specifications shall be first quality products designed and manufactured specifically for the purposes of this work.
   3. The GCL shall be supplied in rolls. The roll length shall be maximized to provide the largest manageable sheet for the fewest overlaps. Labels on the roll shall identify the sheet number, date of fabrication, proper direction of unrolling, and minimum recommended overlap. A quality control certificate shall be supplied with each roll.
   4. The active ingredient of the GCL shall be natural sodium bentonite. Encapsulate bentonite between two geotextiles.
   5. Lock-stitch or heat-seal needle punched geotextile backed GCL with high strength polypropylene thread, if required, to provide internal shear strength reinforcing. The internal shear reinforcing mechanism shall resist failure due to thread pull-out over long-term creep situations.
   6. Continuously adhere the bentonite to both geotextiles to ensure that the bentonite will not be displaced during handling, transportation, storage and installation, including cutting, patching and fitting around penetrations. The bentonite sealing compound or bentonite granules used to seal penetrations and make repairs shall be made of the same natural sodium bentonite as the GCL and shall be as recommended by the GCL manufacturer. The permeability of the GCL overlap seams shall be equal to or less than the permeability of the body of the GCL sheet.

B. Physical Properties: Physical properties of GCL shall be as shown in Table 1 of this Section. The manufacturer shall certify that materials provided meet these criteria according to ASTM D5889 and GRI GCL3 as modified by this Specification.

TABLE 1: REQUIRED GCL PROPERTIES

GCL PROPERTY	TEST METHOD	REQUIRED VALUE
Hydraulic Conductivity	ASTM D5887	$\leq 5x10^{-9}$ cm/s
Bentonite Content (@ 0% moisture)	ASTM D5993	≥ 0.75 lb/sf
Hydrated Internal Shear Strength	ASTM D6243	≥ 500 psf
Free Swell	ASTM D5890	≥ 24 mL
Fluid Loss	ASTM D5891	≤ 18 mL
Peel Strength, MD	ASTM D6496	≥ 3.5 ppi
MARV Tensile Strength, MD	ASTM D6768	≥ 30 ppi

C. The GCL shall be GSE BentoLiner CAR NSL, GSE BentoLiner CAR NWL, or Engineer approved equal.

D. Interface Friction Tests.
1. Test this and adjacent materials using ASTM D 6243. Section 01060-Special Conditions, outlines the conditions under which this material shall be tested.
2. This material is part of a system. The system shall meet the requirements before the component material can be deemed acceptable.

PART 3 - EXECUTION

3.1 CONSTRUCTION

A. Shipping, Handling, and Storage:
1. During periods of shipment and storage, all GCL shall be protected from direct sunlight, water, mud, dirt, dust, and debris. To the extent possible, the GCL shall be maintained wrapped in heavy-duty protective covering until use. GCL delivered to the project site without protective wrapping shall be rejected.
2. The Engineer shall approve the shipping and delivery schedule prior to shipment. The Engineer shall approve the on-site storage area for the GCL. Unloading and storage of GCL shall be the responsibility of the Contractor.
3. GCL that is damaged during shipping, handling, or storage shall be rejected and replaced at Contractor's expense.

B. Installation of GCL:
1. Prior to placement, the surface must be prepared as follows:
   a. Lines and grade must be verified by a Licensed Land Surveyor.
   b. The surface must be proofrolled to verify the supporting soil condition.
   c. The surface must be inspected for rocks larger than 0.75 IN.
   d. Steel drum rolled in preparation for the GCL.

e. Thickness shall be verified by an approved method. Refer to Specification 01060 and the CQA Plan.

2. GCL shall be placed to the lines and grades shown on the Contract Drawings. At the time of installation, GCL shall be rejected by the CQA/CQC Consultant if it has defects, rips, holes, flaws, evidence of deterioration, or other damage.
3. The surface receiving the GCL shall be prepared to a relatively smooth condition, free of obstructions, excessive depressions, debris, and very soft or loose pockets of soil. This surface shall be approved by the CQA Consultant prior to GCL placement.
4. The GCL shall be placed smooth and free of excessive wrinkles.
5. The GCL shall be installed on sideslopes with vertical seams only.
6. When GCL is placed with upslope and downslope portions, the upslope portion shall be lapped such that it is the upper or exposed surface.
7. The GCL shall not be placed in standing water or while raining. Any material that becomes partially/totally hydrated shall be removed and replaced.
8. The GCL seams shall be laid with a minimum overlap equal to 6 IN or the manufacturer's recommendation, whichever is greater. Bentonite powder shall be placed at all GCL seams.
9. GCL shall be temporarily secured in a manner approved by the CQA Consultant prior to placement of overlying materials.
10. Any GCL that is torn or punctured shall be repaired or replaced as directed by the Geotech Engineer, by the Contractor at no additional cost to the Owner. The repair shall consist of a patch of GCL placed over the failed areas and shall overlap the existing GCL a minimum of 12 IN from any point of the rupture.
11. If in-place GCL is not otherwise protected from hydration due to rainfall, the GCL shall be covered with a minimum of 12 IN of the overlying design material within 12 hours of GCL placement.
12. Take necessary precautions to protect underlying soil and geomembrane liners from damage due to any construction activity. Damage to liners shall be repaired at Contractor’s expense.
13. The Contractor shall ensure that adequate dust control methods are in effect to prevent the unnecessary accumulation of dust and dirt on geosynthetic surfaces, which hampers the efficient field seaming of geosynthetic panels.
14. The Contractor shall maintain natural surface water drainage diversions around the work area. The Contractor shall provide for the disposal of water that may collect in the work area, from precipitation falling on the work or from inadequate diversion structures.

3.2 FIELD QUALITY CONTROL

A. The Geotech Engineer shall monitor and document the installation of GCL to ensure that the installation and necessary repairs are made in accordance with these Specifications.

3.3 GCL ACCEPTANCE

A. The GCL Installer shall retain all ownership and responsibility for the GCL until final acceptance by the Owner. The Owner will accept the GCL installation when the installation is finished, all required submittals have been received and approved, and CQC/CQA verification of the adequacy of all field seams and repairs, including associated testing, is complete.

END OF SECTION

Related Documents

Colon Mine Site Structural Fill

Charah, Inc.

Sanford, NC

November 2014
Revised ~~December 2014~~January 2015

Stream & Wetland Delineation Map, January 2015
NPDES Permit NCG020854, December 2014
Riverbend TCLP Report, Sept 2014
Wetlands Determination, August 2014
Threatened/Endangered Study, August 2014
Archeological Study, August 2014
SWPPP, April 2014
Application for Mining Permit, March 2014
Colon Mine Drawings, February 2014
Sutton TCLP Report, June 2012
NCDENR Mine Permit Mod 53-05, April 2005
NCDENR Mine Permit 53-05, March 2004

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Colon Mine (+/- 426 AC)

Legend

- Stream Form
- Wetland Form
- Surveyed Stream-Property Line
- Delineation Boundary
- Stormwater Basin
  Colon Mine Permit # 53-05
  General Mine Information Map - Sheets 1-4 (02.15.14)
- Open Water
- Contours - 2 Ft. Intervals
- Stream
- Linear Wetland
- Culvert
- Wetland

Stream/ Property Line Was Surveyed By WNC Professional Engineers and Surveyors on August 11, 2014.

JD Form #2

JD Form #1

KR, KT, KW, KS, KS, KU, CL, CM, CM, CG, KC, CA, KB, KG, KG, KP, KL, KM, RA, RD, RC, KQ, RB, TP, TE, TF, TM

Basin #16, Basin #15, Basin #14, Basin #12, Basin #11, Basin #11a

Jurisdictional wetlands and waters identified on this map have been located within sub-meter accuracy utilizing a Trimble mapping grade Global Positioning System (GPS) and the subsequent differential correction of that data. GPS points may demonstrate uncorrectable errors due to topography, vegetative cover, and/or multipath signal error.

Note: The illustrated wetland and stream locations are approximate. These areas have been flagged in the field; however, they have not been surveyed. Although ClearWater Environmental Consultants, Inc. (CEC) is confident in our assessment, the US Army Corps of Engineers (Corps) is the only agency that can make final decisions regarding jurisdictional wetland and waters of the US delineations. Therefore, all preliminary determinations are subject to change until written verification is obtained. CEC strongly recommends that written verification be obtained from the Corps prior to closing on the property, beginning any site work, or making any legal reliance on this determination.

This map was prepared by CEC using the best information available to CEC at the time of production. This map is for informational purposes only and should not be used to determine precise boundaries, roadways, property boundary lines, nor legal descriptions. This map shall not be construed to be an official survey of any data depicted.

Source Data: Lee County, General Shale, and Field Collected Data.

N

0 500 1,000 2,000 Feet

Drawn by: RKM 11.11.2014; CEC Project# 765
Updated: RKM 1.8.2015

Lee County,
North Carolina

ClearWater

224 South Grove Street, Suite F
Hendersonville, North Carolina 28792

Figure 5
Stream and Wetland Delineation Map
Delineated: July 21, 22, 23, 24, 30, & 31, 2014 & January 6, 2015.

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Drawings

Colon Mine Site Structural Fill

Charah, Inc.

Sanford, NC

November 2014
Revised ~~December 2014~~ January 2015

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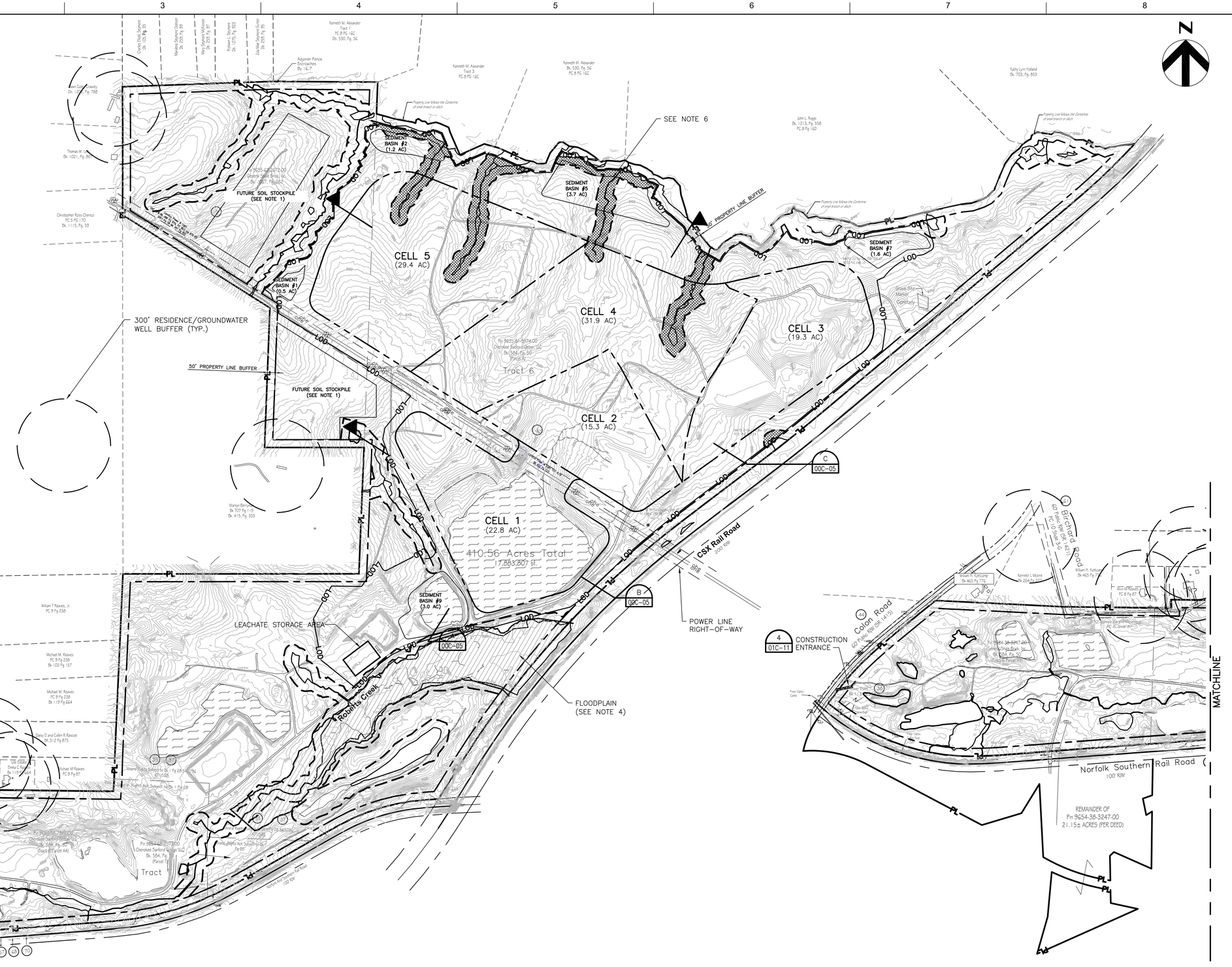
SCOPE:

THE PURPOSE OF THIS PERMIT APPLICATION IS TO OBTAIN A PERMIT FROM NCDENR TO CONSTRUCT A 118.4 ACRE STRUCTURAL FILL OF COAL COMBUSTION PRODUCT (CCP). THIS PROJECT CONSISTS OF EXCAVATING SOIL WITHIN CELLS 1–5 AND INSTALLATION OF A LINER SYSTEM AND LEACHATE COLLECTION SYSTEM PRIOR TO CCP PLACEMENT. AFTER CCP PLACEMENT, A CAP SYSTEM AND STORMWATER DRAINAGE SYSTEM WILL BE INSTALLED. DEVELOPMENT WILL OCCUR IN TWO PHASES TO ALLOW FOR STREAM AND WETLAND MITIGATION. PHASE 1 INCLUDES CELLS 1 AND 2. THE REMAINING CELLS 3–5 WILL BE DEVELOPED IN PHASE 2 AFTER COMPLETION OF STREAM AND WETLAND MITIGATION.

NOTES:

1. TOPOGRAPHIC SURVEY PROVIDED BY AVIO IMAGE MAPPING SERVICES, INC. ALTA SURVEY COMPLETED BY LAWRENCE ASSOCIATES DATED AUGUST 14, 2014. CLEARWATER ENVIRONMENTAL PROVIDED WETLAND LOCATIONS TO LAWRENCE ASSOCIATES FOR INCLUSION INTO THEIR SURVEY.
2. PROPERTY BOUNDARY PROVIDED BY LAWRENCE ASSOCIATES DATED SEPTEMBER 5, 2014.
3. GROUNDWATER WELL LOCATIONS PROVIDED BY LAWRENCE ASSOCIATES DATED SEPTEMBER 5, 2014.
4. FLOODPLAIN LOCATION IS FROM LAWRENCE ASSOCIATES AS IDENTIFIED ON FLOOD INSURANCE RATE MAP FOR LEE COUNTY NORTH CAROLINA, COMMUNITY PANEL NUMBER 3710965400J, DATED SEPTEMBER 6, 2006. LAWRENCE ASSOCIATES CERTIFIES THAT A PORTION OF THIS PROPERTY IS LOCATED IN A SPECIAL FLOOD HAZARD AREA AS DETERMINED BY THE FEDERAL EMERGENCY MANAGEMENT AGENCY.
5. WETLANDS DELINEATED BY CLEARWATER ENVIRONMENTAL ON JULY 21, 22, 23, 24, 30, 31, 2014 AND JANUARY 6, 2015.
6. THE WETLANDS AND STREAMS THAT ARE IMPACTED BY THIS PROJECT WILL BE PERMITTED THROUGH NC DIVISION OF WATER QUALITY AND MITIGATED AS REQUIRED PRIOR TO LAND DISTURBANCE. ESTIMATED IMPACTS INCLUDE:
   - 2,158 LINEAR FEET OF STREAMS
   - 108,510 SQ. FT. (2.49 ACRES) OF WETLANDS
7. ACCORDING TO LAWRENCE ASSOCIATES SURVEY, LEE COUNTY PUBLIC WORKS PROVIDED THE ADDRESSES FOR DRINKING WATER WELL LOCATIONS AND WATER SERVICES TO ADJOINING PARCELS WITHIN 500 FEET OF THE PROPERTY LINE. LEE COUNTY PUBLIC WORKS PROVIDED PARCELS SERVED BY COUNTY WATER. PUBLIC WATER SUPPLY (WATERLINE) IS LOCATED ALONG COLON ROAD.
8. THE LEACHATE STORAGE WILL BE ABOVE GROUND STORAGE TANKS.
9. THE PRIMARY SITE ENTRANCE IS FROM COLON ROAD.
10. SOIL STOCKPILE AREAS TO BE DESIGNED AND PERMITTED AS NEEDED FOR OPERATIONS.



LEGEND

- PL — PROPERTY LINE
- 50' PROPERTY LINE BUFFER
- 50' WETLANDS/STREAM BUFFER
- LOD — LIMITS OF DISTURBANCE
- 300' RESIDENCE/GROUNDWATER WELL BUFFER
- 290 — EXISTING TOPOGRAPHY
- EXISTING ROAD
- IMPACTED WETLANDS/STREAMS
- ohe — OVERHEAD ELECTRIC
- PARCEL BOUNDARIES
- RAILROAD
- CELL BOUNDARIES
- PLANIMETRICS
- OPEN WATER
- STORMWATER BASIN FROM PRIOR MINING ACTIVITIES
- FLOODPLAIN

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N.C.B.E.L.S. License Number F-0116

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B	12/31/14	REVISED PER NCDENR COMMENTS
A	11/2014	ISSUED FOR APPROVAL

PROJECT MANAGER	M.D. PLUMMER, P.E.
DESIGNED BY	P. WESTMORELAND, P.E.
DRAWN BY	J. GAUL
CHECKED BY	J. READLING, P.E.
PROJECT NUMBER	453925-235691-018

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 025495 MICHAEL D. PLUMMER 12/31/14

Charah®

COLON MINE SITE STRUCTURAL FILL
SANFORD, NC

FACILITY PLAN AND BUFFERS

0 1" 2"

FILENAME 00G-02.dwg
SCALE 1"=300'

SHEET 00G-02

NOTES:

1. TOPOGRAPHIC SURVEY AND EXTENT OF WETLANDS PROVIDED BY AVIO IMAGE MAPPING SERVICES, INC. ALTA SURVEY COMPLETED BY LAWRENCE ASSOCIATES DATED AUGUST 14, 2014.
2. PROPERTY BOUNDARY PROVIDED BY LAWRENCE ASSOCIATES DATED SEPTEMBER 5, 2014.

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NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 025495 MICHAEL D. PLUMMER 12/31/14

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SANFORD, NC

EXISTING CONDITIONS

0 1" 2"

FILENAME 00C-01.dwg
SCALE 1" = 300'

SHEET 00C-01

CONSTRUCTION SEQUENCE: PHASE 1

1. OBTAIN AND MAINTAIN ON SITE THE LAND-DISTURBING PERMIT FROM NCDENR.
2. CONTACT THE STATE INSPECTOR TO SCHEDULE AN ON-SITE PRE-CONSTRUCTION CONFERENCE TO DISCUSS EROSION CONTROL MEASURES.
3. INSTALL TREE PROTECTION FENCE, SILT FENCE, AND COMBINATION TREE PROTECTION AND SILT FENCE AS SHOWN ON PLANS, PRIOR TO ANY SITE DISTURBANCE ACTIVITIES (CLEARING, GRUBBING, GRADING, OR EXCAVATION). DEVIATIONS FROM THE APPROVED PLAN MUST BE SUBMITTED TO AND APPROVED BY NCDENR.
4. CONTACT THE INSPECTOR FOR AN ON-SITE INSPECTION OF THE INSTALLED TREE PROTECTION FENCE. WHEN APPROVED, INSTALL REMAINING EROSION CONTROL DEVICES.
5. INSTALL STABILIZED CONSTRUCTION ENTRANCE AND OTHER MEASURES AS INDICATED ON CONSTRUCTION DOCUMENTS, CLEARING ONLY AS NECESSARY TO INSTALL THESE BEST MANAGEMENT PRACTICES (BMPs).
6. INSPECT ALL EROSION CONTROL DEVICES AT WEEKLY INTERVALS AND AFTER EVERY RAINFALL EXCEEDING 1/2" TO VERIFY THAT THEY ARE FUNCTIONING PROPERLY. ANY ACCUMULATED SEDIMENT SHALL BE REMOVED AND PLACED IN A DESIGNATED SPOIL DISPOSAL AREA APPROVED BY THE INSPECTOR. CONDUCT PERIODIC INSPECTIONS OF ALL EROSION AND SEDIMENTATION CONTROLS AND MAKE ANY REPAIRS OR MODIFICATIONS NECESSARY TO ASSURE CONTINUED EFFECTIVE OPERATION OF EACH DEVICE.
7. INSTALL SEDIMENT BASINS AND OTHER MEASURES AS INDICATED ON CONSTRUCTION DOCUMENTS AS SITE IS DEVELOPED. REFER TO THE SPECIFIC CONSTRUCTION SEQUENCE ON SHEET 01C-05 FOR SEDIMENT BASIN #9.
8. BEGIN CLEARING, GRUBBING, DEMOLITION, AND GRADING OF SITE.
9. STABILIZE SITE PER EROSION CONTROL NOTES AS AREAS ARE BROUGHT TO ROUGH GRADES.
10. SEE SHEET 01C-06 FOR PHASE 2 EROSION CONTROL.

PLAN 1
(01C-02)

PLAN 2
(01C-03)

PLAN 3
(01C-04)

PLAN 4
(01C-05)

SITE DATA

RIVER BASIN: CAPE FEAR VIA TRIBUTARIES TO ROBERT'S CREEK

LATITUDE: 35.5348

LONGITUDE: 79.1598

TOTAL DENUDED AREA IS 177.39 ACRES.

THE TOTAL SITE ACREAGE IS 410.56 ACRES.

Morgan Berryman
Bk. 707 Pg. 119
Bk. 415, Pg. 335

Adjoiner Fence Encroaches By 16.7'

BASIN #1

BASIN #2

Property Line follows the Centerline of small branch or ditch.

EMERGENCY SPILLWAY

BASIN #3

BASIN #4

BASIN #5

BASIN #6

BASIN #7

BASIN #8

BASIN #9

50' PROPERTY LINE BUFFER

TIME OF CONCENTRATION (TYP.)

PHASE I DRAINAGE AREA (TYP.)

TO ALLOW PHASING OF FILL ON EACH SIDE OF THE POWERLINE R/W, THIS RIDGE IS TO BE CUT THROUGH TO PROVIDE POSITIVE DRAINAGE RELIEF IN PHASE 1.

NOTE: THIS EXISTING POND HAS NO OUTLET AND IS CURRENTLY PUMPED TO THE SMALLER, ADJACENT, POND TO THE WEST WHICH WILL BE CONVERTED TO SEDIMENT BASIN #9. AS FILL PROGRESSES IN THIS AREA, THE POND WILL BE PUMPED DRY AND SURFACE FLOW DIVERTED AROUND OR PUMPED OUT OF AND INTO BASIN #9. REFER TO SHEET 01C-05 FOR GENERAL CONSTRUCTION SEQUENCE.

CSX Rail Road
200' R/W

Grave Site Marker Cemetary

Tract B

Tract C

1) GROUND STABILIZATION

SITE AREA DISPOSITION	STABILIZATION TIME FRAME	STABILIZATION TIME FRAME EXCEPTIONS
• PERIMETER DIKES, SWALES, DITCHES AND SLOPES	7 DAYS	NONE
• HIGH QUALITY WATER (HQW) ZONES	7 DAYS	NONE
• SLOPES STEEPER THAN 3:1	7 DAYS	IF SLOPES ARE 10' OR LESS IN LENGTH AND ARE NOT STEEPER THAN 2:1, 14 DAYS ARE ALLOWED
• SLOPES 3:1 OR FLATTER	14 DAYS	7-DAYS FOR SLOPES GREATER THAN 50 FEET IN LENGTH
• ALL OTHER AREAS WITH SLOPES FLATTER THAN 4:1	14 DAYS	NONE (EXCEPT FOR PERIMETERS AND HQW ZONES)

GENERAL NOTES

1. ALL EROSION CONTROL MEASURES SHALL BE IN STRICT ACCORDANCE WITH LOCAL AND STATE STANDARDS-SPECIFICALLY THE NC EROSION & SEDIMENT CONTROL MANUAL, AND ORDINANCES.
2. THE CONTRACTOR SHALL DILIGENTLY AND CONTINUOUSLY MAINTAIN ALL EROSION CONTROL BMPs AND STRUCTURES TO ENSURE DEVICES ARE FUNCTIONING PROPERLY TO MINIMIZE EROSION AND SEDIMENT TRANSFER. CONTRACTOR SHALL INSPECT ALL EROSION CONTROL MEASURES AFTER EVERY RAIN EVENT EXCEEDING 1/2" AND AT LEAST ONCE PER WEEK. THE CONTRACTOR SHALL MAINTAIN CLOSE CONTACT WITH INSPECTOR SO THAT PERIODIC INSPECTIONS CAN BE CONDUCTED AT APPROPRIATE STAGES OF CONSTRUCTION.
3. THE SOIL CLASSIFICATION IS PREDOMINANTLY: CrB, CrD (Creedmoor); MfB, MfD, MfE (Mayodan); PfB, PfD, PfF (Pinkston); ToB (Tillery)
4. FINAL LOCATION OF TREE PROTECTION FENCE, SILT FENCE, DIVERSION DITCHES, ETC. SHALL BE ADJUSTED IN THE FIELD BY CONTRACTOR BASED ON SITE CONDITIONS AND INSPECTOR'S RECOMMENDATIONS.
5. ADDITIONAL EROSION CONTROL DEVICES MAY BE REQUIRED DUE TO FIELD CONDITIONS OR AS DIRECTED BY THE INSPECTOR.
6. THE SITE SHALL BE GRADED DURING CONSTRUCTION TO ALLOW ALL RUNOFF TO DRAIN TO STORMWATER AND SEDIMENT CONTROL FEATURES.
7. STABILIZATION IS THE BEST FORM OF EROSION CONTROL. TEMPORARY SEEDING IS NECESSARY TO ACHIEVE EROSION CONTROL ON LARGE DENUDED AREAS AND ESPECIALLY WHEN SPECIFICALLY REQUIRED AS PART OF THE CONSTRUCTION SEQUENCE INDICATED ON THE CONSTRUCTION DOCUMENTS.
8. PER GENERAL PERMIT NCG010000, ALL PERIMETER DIKES, SWALES, DITCHES, PERIMETER SLOPES AND ALL SLOPES STEEPER THAN 3:1 SHALL BE PROVIDED TEMPORARY OR PERMANENT STABILIZATION WITH GROUND COVER AS SOON AS PRACTICABLE BUT IN ANY EVENT WITHIN 7 CALENDAR DAYS FROM THE LAST LAND-DISTURBING ACTIVITY. ALL OTHER DISTURBED AREAS SHALL BE PROVIDED TEMPORARY OR PERMANENT STABILIZATION WITH GROUND COVER AS SOON AS PRACTICABLE BUT IN ANY EVENT WITHIN 14 CALENDAR DAYS FROM THE LAST LAND-DISTURBING ACTIVITY.
9. THE ANGLE FOR GRADED SLOPES AND FILLS SHALL BE NO GREATER THAN THE ANGLE THAT CAN BE RETAINED BY VEGETATIVE COVER OR OTHER ADEQUATE EROSION-CONTROL DEVICES OR STRUCTURES. IN ANY EVENT, SLOPES LEFT EXPOSED WILL, WITHIN 21 CALENDAR DAYS OF COMPLETION OF ANY PHASE OF GRADING, BE PLANTED OR OTHERWISE PROVIDED WITH TEMPORARY OR PERMANENT GROUND COVER, DEVICES, OR STRUCTURES SUFFICIENT TO RESTRAIN EROSION.
10. ALL MATERIALS REQUIRED FOR CONSTRUCTION OF SEDIMENTATION AND EROSION CONTROL MEASURES SHALL BE AVAILABLE ON SITE BEFORE ANY LAND DISTURBING ACTIVITY IS BEGUN.
11. STAGING AREAS AND MATERIAL STOCKPILES FOR THIS PROJECT WILL BE ENCOMPASSED BY SILT FENCE EXCEPT FOR THE POINTS OF ACCESS TO THE STOCKPILE AREA WHICH SHALL BE ON THE HIGH SIDE.
12. SEE DETAIL 2/SHEET 01C-13 FOR SEEDING SPECIFICATIONS AND SEEDBED PREPARATION NOTES.
13. ALL BASINS ARE SEDIMENT BASINS WITH RISERS & SKIMMERS. SEE DETAIL 5/01C-12
14. LINEAR TREE PROTECTION FENCING SHALL BE ORANGE SAFETY FENCE MINIMUM 3' HEIGHT.
15. SILT FENCE SHOULD NOT BE INSTALLED ON DOWNHILL GRADES WHERE THERE IS CONCENTRATED FLOW. SILT FENCE SHOULD NOT BE USED TO DIVERT OR DIRECT FLOW. A DIVERSION SWALE SHOULD BE USED TO DIVERT OR DIRECT FLOW.
16. ROCK OUTLETS IN SILT FENCE MAY BE USED IN LOCATIONS OF MINOR CONCENTRATED FLOW AND IN ISOLATED LOW POINTS OF THE SILT FENCE.

ALL CONSTRUCTION MUST CONFORM TO THE UNDERGROUND UTILITY PROTECTION ACT
BEFORE YOU DIG!
CONTACT ONE-CALL CENTER
1-800-632-4949

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NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 031008 PHILIP A. WESTMORELAND 12-31-14

COLON MINE SITE STRUCTURAL FILL
SANFORD, NC

EROSION AND SEDIMENTATION CONTROL PLAN - PHASE 1 OVERALL

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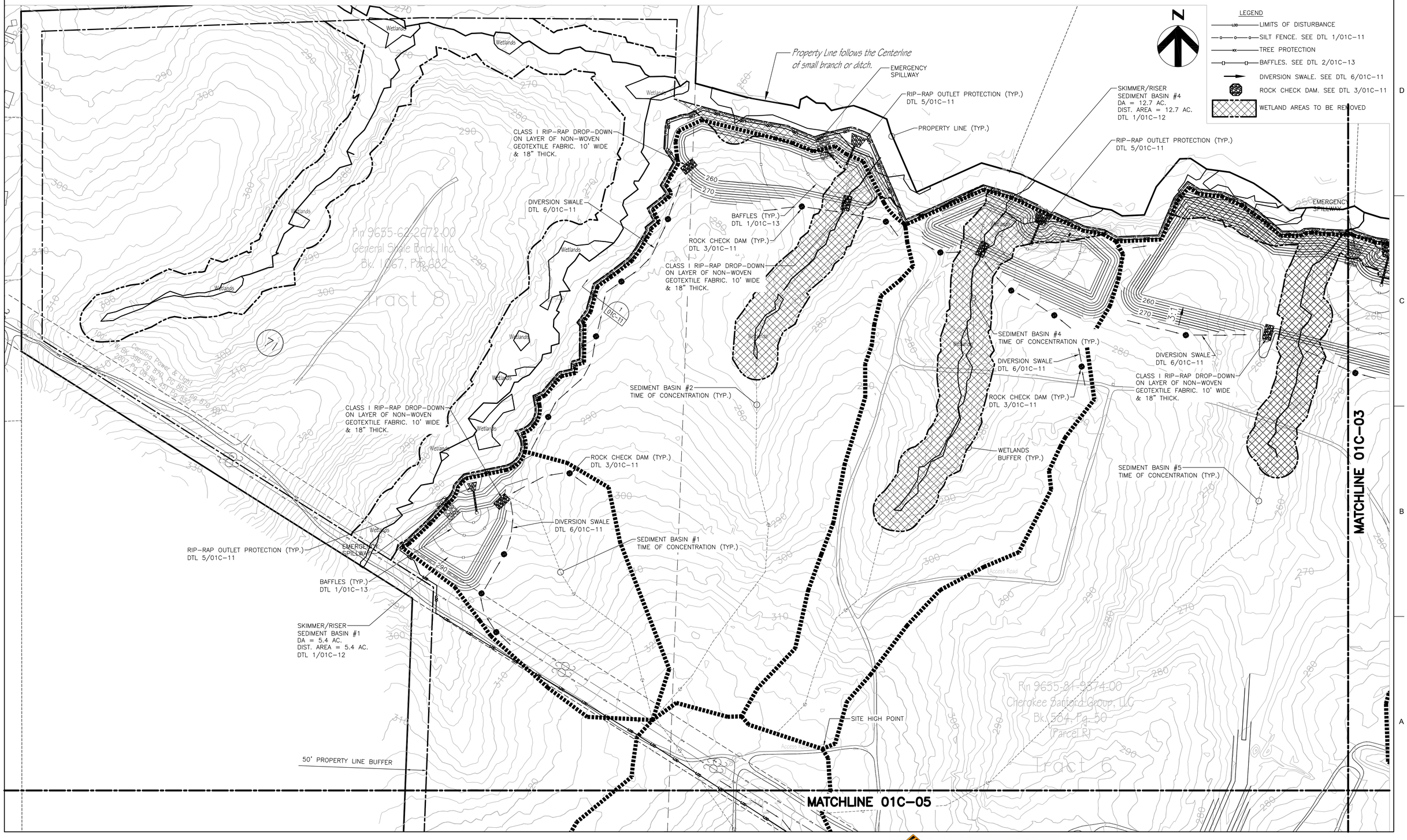
SCALE 1"=200'

SHEET 01C-01



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COLON MINE SITE STRUCTURAL FILL
SANFORD, NC

EROSION AND SEDIMENTATION CONTROL PLAN - PHASE 1 PLAN 1

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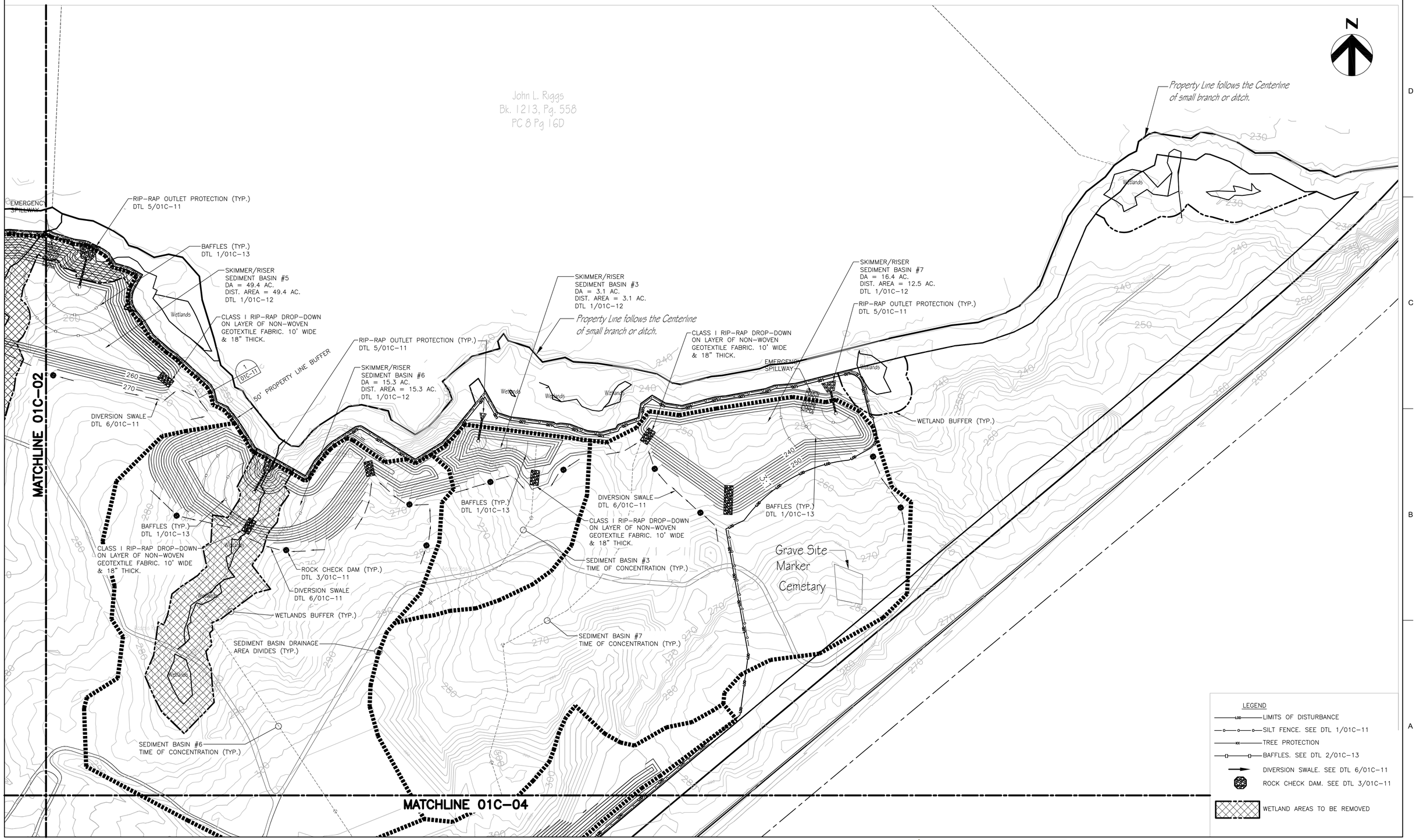
SCALE 1"=100'

SHEET 01C-02



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NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 031008 PHILIP R. WESTMORELAND 12-31-14

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COLON MINE SITE STRUCTURAL FILL
SANFORD, NC

EROSION AND SEDIMENTATION CONTROL PLAN - PHASE 1 PLAN 2

0 1" 2"

FILENAME 01C-03.dwg
SCALE 1"=100'

SHEET 01C-03