April 12, 2008

Mr. Gale L. Baker, P.G.
Municipal Solid Waste Permits Section
Waste Permits Division, MC 124
Texas Commission on Environmental Quality
P.O. Box 13087
Austin, Texas 78711-3087

Re: Angelina County Waste Management Center – Angelina County
Municipal Solid Waste - Permit No. 2105A
Permit Modification – Alternate Final Cover Demonstration
WWC No. 11976665; RN101571131 / CN600833511

Dear Mr. Baker:

On behalf of Angelina County Waste Management Center and in response to your March 13, 2008 letter to The Honorable Wes Suiter, Angelina County Judge, regarding the above referenced, we hereby submit the following response. For your convenience, we have included your site specific comment in italics prior to submitting our response.

Application Form

TCEQ Comment No. 1:

The TCEQ Part I Application (Form TCEQ-0650) indicated that this modification is without public notice, although the modification included the landowners map and mailing list. This form has also been revised from the original. The form needs to be revised, without alteration from the original form, to indicate that this modification requires public notice. An Adobe PDF copy of Form TCEQ-0650 may be obtained at the following URL:

http://www.tceq.state.tx.us/assets/public/permitting/waste/msw/forms/0650.pdf

Response to Comment No. 1:

Part I form has been revised without alteration from the original form and indicates this modification requires public notice.

Final Closure Plan

TCEQ Comment No. 2:

Section 2.1.2 (Alternative Final Cover System) referenced an August 1, 2006 TCEQ rule interpretation of §330.457(d), stating "the infiltration of the standard Subtitle D design must be modeled on the basis of its soil layer and synthetic membrane together." Section 2.1.2 concurs with the referenced rule interpretation. However, this interpretation was a draft and has been subsequently withdrawn from the TCEQ web site. Delete the reference of this rule interpretation from Section 2.1.2.

Response to Comment No. 2:

The reference to the TCEQ rule interpretation of §330.457(d) has been removed.

TCEQ Comment No. 3:

Section 2.2 (MSW Landfill Units With No Synthetic Liner) stated that approximately 6.9 acres are underlain with pre-Subtitle D compacted clay liners with no synthetic bottom liners. Section 2.2 also states in part:

> *"... Prior to initiating final closure of this area, an average of the permeabilities for the underlying compacted clay liner system will be calculated to determine the pre-construction criteria for the final cover system.*
>
> *The final cover system for the MSW landfill unit with no synthetic bottom liner will be constructed with an infiltration layer consisting of a minimum of 18 inches of compacted clay with an average coefficient of permeability less than or equal to the pre-construction permeability criteria as discussed above or $1x10^{-5}$ cm/sec, whichever is less. Additionally, no more than 5% of the measured infiltration layer permeabilities from individual tests will be greater that (sic) $1x10^{-7}$ cm/sec, with no individual results greater than $5.0x10^{-7}$ cm/sec." [emphasis added]*

The rule 30 TAC §330.457(a)(2) states:

> *"For MSW landfill units with no synthetic bottom liner, the clay-rich soil cover layer shall consist of a minimum of 18 inches of earthen material with a coefficient of permeability less than or equal to the permeability of any constructed bottom liner or natural subsoil present. The coefficient of permeability of the infiltration layer shall in no case exceed $1x10^{-5}$ cm/sec, even though the coefficient of permeability of the constructed bottom liner or natural subsoil is greater than $1x10^{-5}$ cm/sec or no data exist for the value(s) of the coefficient of permeability of the constructed bottom liner or natural subsoil."*

It is unclear how the criterion proposed for the coefficient of permeability in Section 2.2 complies with the rule. Clarification is required by revising Section 2.2 to include a detailed explanation (with examples) for the criterion proposed as emphasized above.

Response to Comment No. 3:

The criterion for determining the required coefficient of permeability for pre-Subtle D areas was developed under the guidance and direction of TCEQ MSW Permits Section personnel during preparation of the Final Closure Plan for the BFI Sinton Landfill in 2002. MSW Permits Section personnel, including the section manager at the time, established that the average of the results of permeability tests performed on the clay infiltration layer for final cover systems on pre-Subtitle D areas must be less than or equal to the average of the results of the permeability tests performed on the underlying compacted clay liner systems as reported in historic Soil and Liner Evaluation Reports.

In response to the emphasized portion of your comment, Section 2.2 has been revised to state: "Additionally, no measured infiltration layer permeability from individual tests will be greater that $1x10^{-7}$ cm/sec."

TCEQ Comment No. 4:

Section 2.3 (Erosion Layer) referenced the rule 30 TAC §330.457(a)(3) and stated that the erosion layer must be seeded or sodded to minimize erosion. Please revise Section 2.3 to be consistent with the rule because the erosion layer must be seeded or sodded immediately following the application of final cover in order to minimize erosion.

Response to Comment No. 4:

Section 2.3 has been revised to state, "...must be seeded or sodded immediately following the application of final cover in order to minimize erosion."

TCEQ Comment No.5:

Section 4 (Largest Area Requiring Final Cover) states that 35 acres represents the largest area of the landfill requiring final cover and the executive director will be notified if the largest area requiring final cover exceeds 35 acres.

Please understand that if the largest area ever requiring final cover increases from that stated in the final closure plan, a permit modification application must be prepared and submitted for changes in the final closure plan (pursuant to §305.70(j)(6)) and final closure cost estimate (pursuant to §305.70(j)(30)). Please revise Section 4 to reflect this requirement.

Moreover, the current cost estimate for final closure in Part III, Attachment 8, is based upon 14 acres as the largest area of the landfill ever requiring final cover. The current final closure plan states that there are approximately 610,000 square feet or 14 acres of landfill lacking final cover over a significant portion. Permit Section (§)IV.E (Financial Assurance/Modifications), states:

> *"If the facility's closure or post-closure care plan is modified, the permittee shall provide new cost estimates in current dollars, which meet the requirements of §IV.C. (relating to Closure Financial Assurance), pursuant to 30 TAC §305.70 and shall adjust financial assurance in accordance with any financial assurance regulation that is adopted by the TNRCC subsequent to the issuance of this permit, and in compliance with the provision contained within this permit."*

A permit modification application for changes in the final closure cost estimate must be submitted pursuant to 30 TAC §305.70(j)(30) to reflect the change in the largest area requiring final cover of 35 acres. Please know that a permit modification for changes in the final closure cost estimate must also account for any changes at the facility since the current final closure cost estimate, including changes to the groundwater and landfill gas monitoring system, which might necessitate preparing and submitting a permit modification application for changes in the post-closure care cost estimate. Please address these issues accordingly and in a separate permit modification application(s) as applicable.

Response to Comment No. 5:

The statement regarding notification of the executive director if the largest area requiring final cover exceeds 35 acres has been removed. If a revision to the final closure plan regarding the largest area requiring final cover is needed, a request for a permit modification will be made in accordance with the applicable regulation. Additionally, please note that a permit modification to change the closure/post-closure cost estimates and financial assurance is being prepared and will incorporate necessary changes resulting from this modification.

TCEQ Comment No.6:

Section 5 (Maximum Inventory of Wastes) states:

> *"As detailed in the site development plan, the maximum inventory of waste that will ever be on-site during the active life of the landfill is estimated to be approximately 8,000,000 cubic yards."*

Please include a specific reference in Section 5 as to where this information is detailed in the site development plan. However, please know that §II.E (Facilities and Operations Authorized/Waste Volume Available for Disposal) in the Permit states that the total available waste disposal capacity of the landfill is approximately 9,291,965 cubic yards.

Please explain the difference in the maximum inventory of waste and the total available waste disposal capacity and revise as necessary. Please know that §VII.O (Standard Permit Conditions) in the Permit states "If differences arise between these permit provisions and incorporated Parts I-IV of the Permit Application, these permit provisions shall prevail."

Response to Comment No. 6:

9,291,965 cubic yards, as detailed in §II.E (Facilities and Operations Authorized/Waste Volume Available for Disposal) in the Permit, is the total permitted capacity of landfill including daily and final cover. 8,000,000 cubic yards is the estimated total waste capacity of the facility excluding final cover, therefore this number represents the "maximum inventory of waste" that will ever be on-site during the active life of the landfill.

Section 5 has been revised to state, "The maximum inventory of waste that will ever be on-site during the active life of the landfill is estimated to be approximately 8,000,000 cubic yards. This estimate is based upon the permitted design capacity of the landfill less daily cover and final cover."

TCEQ Comment No. 7:

Section 6 (Implementation of Final Closure Plan) includes documentation describing activities and/or actions to be implemented. Applicable rule citations for these activities and/or actions must be revised to be consistent with the applicable rules in Chapter 330, Subchapter K. The documentation in some instances deviates from the applicable rule, resulting in the proposed final closure plan possibly being less stringent that the rule requirements. One example includes bullet #6 that states in part:

> *"Within 10 days after completion of final closure activities, a certified copy of an 'affidavit to the public' will be..."*

The rule 30 TAC §330.457(g) states in part:

> *"Within ten days after closure..."*

Please revise Section 6 to be consistent with the applicable rules.

Response to Comment No. 7:

Section 6 has been revised to comply with Chapter 330, Subchapter K.

TCEQ Comment No. 8:

Section 7 (Final Contour Map) references Exhibit 4.5, Sheets 1 and 2 of 2 (Final Contour Map). Sheet 2 of 2 is the final contour map for Tract 2 from the current final closure plan. Sheet 1 of 2 is a revision (11/20/07) of the final contour map for Tract 1. Please provide a marked version of this drawing (and all other revised drawings) that clearly shows the proposed changes, in accordance with 30 TAC §305.70(e)(3) and §330.57(g)(6). It is noted that the contour labels (and possibly the contours) on the revised Sheet 1 of 2 have been changed when compared to the current drawing. Please provide an explanation or justification for these changes.

Response to Comment No. 8:

§305.70(e)(3) states:

> *(3) appropriate revisions to all applicable narrative pages and drawings of Attachment A of a permit or a registration (i.e., a site development plan, site operating plan, engineering report, or any other approved plan attached to a permit or a registration document). These revisions shall be marked and include revision dates and notes as necessary in accordance with §330.51(e)(4) of this title (relating to Permit Application for Municipal Solid Waste Facilities) and §330.64(b) and (c) of this title (relating to Additional Standard Permit Conditions for Municipal Solid Waste Facilities).*

§330.57(g)(6) (formerly §330.51(e)(4) of the above rule citation) states:

> *(6) Revisions shall have the revision date and note that the sheet is revised in the header or footer of each revised sheet. The revised text shall be marked to highlight the revision.*

§330.73(a) and (b) (formerly §330.64(b) and (c) of the above rule citation) states:

> *(a) If at any time during the life of the facility the owner or operator becomes aware of any condition in the permit or registration that necessitates a change to accommodate new technology or improved methods or that makes it impractical to keep the facility in compliance, the owner or operator shall submit to the executive director requested changes to the permit or registration in accordance with §305.62 of this title (relating to Amendment) or §305.70 of this title (relating to Municipal Solid Waste Permit and Registration Modifications) and must be approved prior to their implementation.*
>
> *(b) All drawings or other sheets prepared for requested revisions must be submitted following the format in §330.57(g) of this title (relating to Permit and Registration Applications for Municipal Solid Waste Facilities). All revised engineering and geoscientific plans, drawings, and reports shall be signed and sealed by a licensed professional engineer or geoscientist as specified in §330.57(f) of this title.*

In accordance with the rules, all drawings included with the original request were marked with revision dates and notes detailing the revisions and were signed and sealed by a professional engineer. Additionally, all text revisions required as a result of this response are marked in the redline/strikeout copies included with this submittal.

Regarding the justification for the revision to the drawings, we request the revisions to Exhibit 4.4 and Exhibit 4.5, Sheet 1 of 2 to adjust the final contours of Tract 1 and to revise the tie-in details to differentiate between the Subtitle D and pre-Subtitle D areas. As shown on Exhibit 4.4, the final cover system for Subtitle D areas will be 18" lower than the final cover system for the pre-Subtitle D area due to replacing the 18" clay infiltration layer in the Subtitle D final cover system with a geosynthetic clay liner. Additionally, we request revisions to Exhibit 4.1 to remove notes no longer applicable to the site and to Exhibit 4.3 to revise the final cover system details for the Subtitle D areas to represent the alternative final cover system design.

TCEQ Comment No. 9:

Section 8 (Soil Erosion Losses Computations) referenced that the computations can be found in Appendix 5.1. Appendix 5.1 contains a copy of the computations from the current final closure plan (1996). Please revisit the computations to determine if the values/assumptions used in those calculations are still valid based on the proposed final closure plan and current conditions (e.g.., percent (%) slopes, slope lengths, soil erodibility factor, etc.). In addition, a narrative needs to be provided that explains the results of the calculations and compliance with the rule 30 TAC §330.305(d)(2) (relating to Additional Surface Water Drainage Requirements for Landfills). Please revise Appendix 5.1 accordingly.

Response to Comment No. 9:

The Soil Erosion Losses Computations from the current closure plan are still valid as the percent (%) slopes, slope lengths, soil erodibility factor, etc. have not changed and are not being revised as a result of this modification.

Upon completion of the revisions to the permit to comply with 30 TAC §330.305(d)(2) (relating to Additional Surface Water Drainage Requirements for Landfills), Appendix 5.1 will be reviewed and permit modification will be submitted, if required.

TCEQ Comment No.10:

Section 9 (Slope Stability Analysis) referenced that the slope stability analysis for the final cover can be found in Appendix 5.2. Please provide an explanation or reference of how the friction angle (degrees) for each component interface was obtained. Also, please revisit the calculations (e.g., angle of slope (degrees), slope lengths, weight of geocomposites, geomembranes, etc.) to verify if the values used in the calculations are consistent with the final cover design. Please revise Appendix 5.2 accordingly.

Response to Comment No. 10:

Appendix 5.2 has been revised to include references on how the friction angle (degrees) for each component interface was obtained. Additionally, all calculations were reviewed to verify that the values used in the calculations are consistent with the final cover design.

<u>Alternate Final Cover Demonstration – Appendix 5.3</u>

TCEQ Comment No. 11:

Section 1 (Introduction) referenced an August 1, 2006 TCEQ rule interpretation of §330.457(d). The reference of this rule interpretation needs to be deleted from Section 1 (see comment #3 above).

Response to Comment No. 11:

The reference to the TCEQ rule interpretation has been removed.

TCEQ Comment No. 12:

Section 2 (Modeling Approach) stated that the runoff curve was generated by the model using a slope of 5% and a slope length of 200 feet, and these values represents conservative runoff parameters in the final cover system. Please revisit the modeling calculations to ensure that these values are consistent with the final cover design. A discussion should be provided that substantiates these values as conservative when compared to the final cover design.

Response to Comment No. 12:

A slope of 5% with a slope length of 200 feet is consider conservative while using the HELP model as steeper slopes and longer slope lengths both generate faster run-off resulting in less infiltration. Therefore, using 5% and 200 feet to generate the run-off curve for modeling purposes is considered a conservative approach because it maximizes the infiltration capabilities of the model. Additionally, the same slope values were used in all modeled simulations.

TCEQ Comment No. 13:

Section 2 states in part:

> *"The simulations were performed with the HELP model using the program's synthetic weather data generation capabilities for Houston, Texas, with temperature and precipitation data adjusted with monthly normals from 1971-2000, obtained from the National Climactic Data Center (NCDC). ... The latitude of the landfill was estimated as 31.337°, the coordinates for the City of Lufkin, Texas."*

Please explain and/or justify the use of the weather data for Houston as compared to other cities in closer proximity to the landfill such as Beaumont, Tyler, or Lufkin. Also, explain and/or justify why only the monthly normals from 1971-2000 was used and why was the data from 2001-2007 not included. Please know that the actual latitude of the landfill as stated in the permit is 31° 15.15' N (31.254°). Is there any specific reason why the actual latitude cannot be used? Please address these issues and revise accordingly.

Response to Comment No. 13:

The HELP Model is equipped with synthetic weather capabilities for large cities, such as Houston, Dallas, Austin, San Antonio, etc. Houston was chosen due to proximity to the site and the similarity of seasonal weather averages. The synthetic weather capabilities include precipitation, temperature, solar radiation and evapotranspiration. Where local data existed for the City of Lufkin (closest dataset to the facility) the model was adjusted to include this data. LNV Engineering was able to utilize actual temperature and precipitation data obtained for the City of Lufkin. The monthly normal from 1971-2000 was the most readily available historic weather data. The latitude used in the model correlates to the location of the weather station for the City of Lufkin and was obtained from the National Climactic Weather Center. For clarification, Section 2 of the Alternative Final Cover Demonstration has been revised to state "The latitude used for simulation purposes was 31.337°, the coordinates for the City of Lufkin, Texas."

TCEQ Comment No. 14:

Section 3 (Alternative Final Cover Performance Criteria) states in part:

> *"For simulation purposes, geomembrane manufacturer defects (pinholes) were assumed at one per acre and field installation defects were assumed at two per acre with a placement factor of 3 (good)."*

Please provide a reference or explain how the geomembrane manufacturer defect assumptions were derived and provide documentation that justifies the validity of these values.

Response to Comment No. 14:

The HELP Model User's Guide recommendations were used in deriving the defect values. As stated in "The HELP Model User's Guide for Version 3" by Paul R. Schroeder, Cheryl M. Lloyd, Paul A. Zappi, and Nadim M. Aziz, "Typical geomembranes may have about 0.5 to 1 pinholes per acre (1 to 2 pinholes per hectare) from manufacturing defects. ... Representative installation defect densities as a function of the quality of installation are given below for landfills being built today with the state-of-the-art in materials, equipment and QA/QC. ...

Installation Quality	Defect Density (number per acre)
Good	1 to 4

... Good: Assumes good field installation with well-prepared, smooth soil surface and geomembrane wrinkle control to insure good contact between geomembrane and adjacent soil that limits drainage rate."

TCEQ Comment No. 15:

Section 4 (Alternative Final Cover Model) States in part:

> *"The alternative cover system was modeled using four layers, a 24-inch erosion layer, a 200 mil geonet, 40 mil linear low density polyethylene and <u>a 0.24-inch bentonite GCL with a hydraulic conductivity of 5.0x10^{-9} cm/sec</u> which was modeled as a barrier layer. ..." <u>[emphasis added]</u>*

Please provide justification and/or reference for the hydraulic conductivity value of the GCL used in the model.

Response to Comment 15:

In accordance with Geosynthetic Research Institute (GRI) Standard Specification GRI-GCL3 "Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners (GCLs)", GCLs (as manufactured) shall have a minimum hydraulic conductivity of 5.0x10^{-9} cm/sec.

<u>Final Cover System Quality Control Plan – Appendix 5.4</u>

TCEQ Comment No. 16:

Section 3 (Definitions) provides a list of definitions. Please provide references of where these definitions were obtained as applicable. Some of the definitions appear to be a quasi derivative from other sources, and it is unclear whether these definitions as proposed were intended to be redefined. Please clarify.

As an example, the proposed plan includes the following definition:

> *"Constructed Soil Infiltration Layer: Soil infiltration layers constructed from reworked soils from a borrow source or bentonite-amended soils."*

This definition is almost the same as the definition for constructed soils liners in the TCEQ Liner Construction and Testing Handbook dated July 1, 1994, which states:

> *"CONSTRUCTED SOILS LINERS - Soils liners constructed from reworked in situ soils, soils from a borrow source, or bentonite-amended soils."*

This permit modification application does not propose using bentonite-amended soils as an option for the soil infiltration layers. Please revisit all of the definitions as proposed to ensure their validity when compared to the derived sources, and their applicability for this permit modification application. Please revise accordingly.

Response to Comment No. 16:

The definition for constructed soil infiltration layer has been revised to remove the reference to bentonite-amended soils.

TCEQ Comment No. 17:

Section 4 (Soil Infiltration Layer (Pre-Subtitle D Area) lists the requirements for constructed soil infiltration layer and soil infiltration layer materials. The required value for "Permeability" references "As outlined in Final Closure Plan." The required value also needs to be addressed in the final cover system quality control plan. Please revise accordingly (see comment #3 above regarding Section 2.2 in the proposed final closure plan).

Response to Comment No. 17:

The required value for the soil infiltration layer over pre-Subtitle D areas will be calculated at the time of closure as outlined in the Final Closure Plan. Therefore, at this time, a value cannot be included in the Alternative Final Cover Demonstration or the Final Cover Quality Control Plan.

TCEQ Comment No. 18:

The required value for "Thickness of infiltration and erosion layers" in Section 4 references "As outlined in Final Closure Plan." The required value also needs to be addressed in the final cover system quality control plan. Please revise accordingly.

Response to Comment No. 18:

The required value for thickness of infiltration layer has been revised to reflect 18" and the thickness of the erosion layer has been revised to reflect 24".

TCEQ Comment No. 19:

Section 4.1 (Preconstruction Testing – Soil Infiltration Layer) states the following as item #4:

> *"If the permeability is less than the permeability outlined in the Final Closure Plan for a specific area of the landfill, soil infiltration layer construction may begin with that soil material over the specified area."*

The following is stated in part as item #5:

> *"...content does not satisfy the permeability requirements outlined in the Final Closure Plan ..."*

The following is stated in part as item #6:

> *"... will be based on the criteria used in the permeability test which met the permeability requirement outlined in the Final Closure Plan."*

All permeability requirements need to also be outlined in the final cover system quality control plan (see comment #18 above). Please revise accordingly.

Response to Comment No. 19:

See response to TCEQ Comments 3 and 17, above.

TCEQ Comment No. 20:

Section 5.3 (Source Quality Control – Preconstruction Testing) states the following as item #5:

> *"The <u>Geotechnical Quality Control Professional (GQCP)</u> or their representative may request additional testing of individual rolls to more closely identify non-complying rolls and to qualify individual rolls at the discretion and expense of the GCL Manufacturer." <u>[emphasis added]</u>*

Section 3 does not include a definition for GQCP. Is the GQCP as referenced in item #5 and elsewhere in the final cover system quality control plan synonymous with Geotechnical Engineering Professional (GEP) as defined in Section 3? If so, please revise to provide consistent terminology as defined in Section 3. Otherwise, provide a separate definition in Section 3 for GQCP.

Response to Comment No. 20:

A definition has been provided in Section 3 for Geotechnical Quality Control Professional (GQCP).

TCEQ Comment No. 21:

Footnote #1 under Table 3 (Standard Tests on LLDPE Geomembrane Material) states that GRI Test Method GM 17 can be found in Attachment B of this plan. Please revise to state that it can be found in Attachment A of this plan.

Response to Comment No. 21:

Footnote #1 under Table 3 has been revised to state that GRI Test Method GM 17 can be found in Attachment A of this plan.

TCEQ Comment No. 22:

Section 8 (Erosion Layer Requirements [All Areas]) states in part:

> *"An erosion layer, consisting of a minimum of 24 inches of earthen material which is capable of sustaining native plant growth, <u>will be placed over the soil infiltration layer</u>. ..." <u>[emphasis added]</u>*

Please distinguish the erosion layer requirements regarding the final cover over landfill units with and without synthetic bottom liners. For constructability purposes it is recommended that for landfill units with a synthetic bottom liner, the clay-rich soil layer or GCL be overlain by the geomembrane, and the geomembrane be overlain by the erosion layer.

Response to Comment No. 22:

The erosion layer requirements for the final covers systems over landfill units with or without synthetic bottom liners do not differ. For clarification purposes, Section 8 has been revised to state "An erosion layer, consisting of a minimum of 24 inches of earthen material which is capable of sustaining native plant growth, will be placed over the infiltration layer."

TCEQ Comment No. 23:

Section 9 (Documentation) states in part:

> *"In accordance with 30 TAC, §330.253(e)(6), documented certification of closure must be submitted to the TCEQ upon completion of closure activities for a MSW site or MSWLF unit. The certification will in the form of the Final Cover System Evaluation Report (FCSER) which must be signed by the GEP and must include all documentation necessary for certification of closure." [emphasis added]*

The correct rule citation is §330.457(f)(5), which states:

> *"Following completion of all closure activities for the MSW landfill unit, the owner or operator shall comply with the post-closure care requirements specified in §330.463(b) of this title (relating to Pos-Closure Care Requirements). The owner or operator shall submit to the executive director by registered mail for review and approval a certification, signed by and independent licensed professional engineer, verifying that closure has been completed in accordance with the approved closure plan. The submittal to the executive director shall include all applicable documentation necessary for certification of closure. Once approved, this certification shall be placed in the operating record."*

Please understand that the certification required by §330.457(f)(5) is a separate document than the FCSER. The FCSER is a report documenting the construction quality assurance/quality control testing of the final cover system, which is a part of all closure activities. The certification document can include the FCSER as part of the applicable documentation necessary for certification of closure. Please revise Section 9 accordingly.

Response to Comment No. 23:

Section 9 has been revised as follows:

"In accordance with 30 TAC, §330.253(e)(6), documented certification of closure must be submitted to the TCEQ upon completion of closure activities for a MSW site or MSWLF unit. The certification will signed by the GEP and will include a Final Cover System Evaluation Report which will provide all documentation necessary for certification of closure."

The following permit documents have been revised as a result of this response and are included with this submittal:

1. TCEQ Part I Application Form
2. Revised Attachment 12, Final Closure Plan
3. Revised Attachment 12, Appendix 5.2, Slope Stability Analysis
4. Revised Attachment 12, Appendix 5.3, Alternative Final Cover Demonstration
5. Revised Attachment 12, Appendix 5.4, Final Cover Quality Control Plan

An original plus two (2) copies of this response are enclosed. Additionally, redline/strikeout copies have been provided for all proposed text changes. If you have any questions, or require additional information, please feel free to contact me at (361) 883-1984.

Sincerely,

Cathy Skurow

Catherine A. Skurow, P.E.
Vice President of Environmental Services

Enclosures

cc: Mr. Rick Freeman, Everett, Griffith and Associates, Inc.
Mr. Chris Fitzgerald, Landfill Manager, Angelina County Waste Management Center

ANGELINA COUNTY
WASTE MANAGEMENT CENTER
TCEQ Permit No. MSW-2105A

SDP Attachment 12
Final Closure Plan

prepared by:

LNV ENGINEERING
engineers & consultants

November 20, 2007
Revised April 11, 2008

STATE OF TEXAS
CATHERINE A. SKUROW
76166
REGISTERED PROFESSIONAL ENGINEER
4/11/08
Catherine A. Skurow
FOR PERMITTING PURPOSES ONLY

SDP ATTACHMENT 12

Final Closure Plan
Angelina County Waste Management Center
Type 1 MSW Landfill
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76166
REGISTERED PROFESSIONAL ENGINEER
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EXHIBITS

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STATE OF TEXAS
CATHERINE A. SKUROW
76166
REGISTERED PROFESSIONAL ENGINEER
4/11/08
Catherine A. Skurow

FOR PERMITTING PURPOSES ONLY

SDP ATTACHMENT 12

Final Closure Plan
Angelina County Waste Management Center
Type 1 MSW Landfill
TCEQ Permit No. MSW-2015A

1 INTRODUCTION

This plan has been prepared to fulfill the requirements of 30 TAC Subchapter J, §§330.457, 330.459, and 330.461 regarding closure requirements for all Municipal Solid Waste (MSW) landfill units. As stated in the regulations, the required final closure system for each MSW landfill unit is determined by the date which the MSW landfill unit stops receiving waste and by the underlying bottom liner system for the unit. All MSW landfill units at the Angelina County Waste Management Center (ACWMC) received waste after October 9, 1993. This document details the requirement for final closure of all MSW landfill units at the Angelina County Waste Management Center.

2 FINAL COVER SYSTEM REQUIREMENTS

2.1 MSW Landfill Units with Synthetic Bottom Liners

2.1.1 Subtitle D Final Cover System

30 TAC §330.457(a)(1) states that the final cover system for a MSW landfill unit with a synthetic bottom liner must have a synthetic membrane that has permeability less than or equal to the permeability of any bottom liner system overlain by a clay rich cover layer consisting of a minimum of 18 inches of earthen material with a coefficient of permeability no greater than $1x10^{-5}$ cm/sec.

The synthetic membrane currently permitted for the Angelina County Waste Management Center consists of 40 mil linear low density polyethylene. The synthetic membrane will be smooth on the gently sloping top sections of the cap and textured on the 4-horizontal:1-vertical side slopes.

2.1.2 Alternative Final Cover System

In accordance with 30 TAC §330.457(d), the executive director may approve an alternative final cover design that achieves an equivalent reduction in infiltration as the clay-rich soil layer detailed in 30 TAC §330.457(a)(1) and provides equivalent protection from wind and water erosion as detailed in 30 TAC §330.457(a)(3).

As detailed in the Alternative Final Cover Demonstration (Appendix 5.3 of this plan), the currently permitted final cover system is more stringent than the requirements of §330.457(a)(1) and (3), therefore an alternative final cover has been designed that achieves an equivalent or greater reduction in infiltration and provides equivalent protection from wind and water erosion as the currently permitted design.

An alternative final cover system (AFCS) has been designed for the MSW landfill units with synthetic bottom liners and consists of replacing the clay-rich soil layer component in the site's currently permitted final cover system with a geosynthetic clay liner (GCL). The GCL will be overlain with a 40 mil LLDPE geomembrane. The synthetic membrane will be textured on the 4-horizontal:1-vertical side slopes and smooth on lesser top slopes. The alternative final cover system will be used on all areas with a synthetic bottom liner.

2.1.3 Drainage Layer

A geocomposite drainage layer will be placed over the synthetic membrane. The geocomposite drainage layer will consist of a 200 mil geonet heat-fused to 10 oz geotextile filter fabric (single-sided for top slopes, double-sided for the 4-horizontal:1-vertical side slopes).

2.2 MSW Landfill Units With No Synthetic Liner

30 TAC §330.457(a)(2) states that the final cover system for a MSW landfill unit with no synthetic bottom liner must have a clay-rich cover soil layer consisting of a minimum of 18 inches of earthen material with a coefficient of permeability less than or equal to the permeability of any constructed bottom liner or natural subsoil present. The coefficient of permeability of the infiltration layer shall in no case exceed $1x10^{-5}$ cm/sec, even though the coefficient of permeability of the constructed bottom liner or natural subsoil is greater than $1x10^{-5}$ cm/sec or no data exist for the value(s) of the coefficient of permeability of the constructed bottom liner or natural subsoil.

Approximately 6.9 acres are underlain with pre-Subtitle D compacted clay liners with no synthetic bottom liners. Prior to initiating final closure of this area, an average of the permeabilities for the underlying compacted clay liner system will be calculated to determine the pre-construction permeability criteria for the final cover system.

The final cover for the MSW landfill unit with no synthetic bottom liner will be constructed with an infiltration layer consisting of a minimum of 18 inches of compacted clay with an average coefficient of permeability less than or equal to the pre-construction permeability criteria as discussed above or $1x10^{-5}$ cm/sec, whichever is less. Additionally, no measured infiltration layer permeability from individual tests will be greater that $1x10^{-7}$ cm/sec.

2.3 Erosion Layer

In accordance 30 TAC §330.457(a)(3), all final cover systems must include an erosion layer consisting of a minimum of six inches (6") of earthen material that is capable of sustaining native plant and must be seeded or sodded immediately following the application of final cover in order to minimize erosion.

The erosion layer for the Angelina County Waste Management Center will consist of 24 inches of earthen material with the top six inches (6") being capable sustaining native plant growth and will be seeded or sodded immediately following the application of final cover in order to minimize erosion.

3 QUALITY CONTROL TESTING

In accordance with 30 TAC §330.457(c), quality control testing shall be performed and documented on the 18 inches of compacted clay-rich soil cover for its coefficient of permeability at a frequency of no less than one test per surface acre of final cover. Permeability data shall be submitted to the executive director.

Quality control/quality assurance testing and documentation procedures for each final cover system installed will be in accordance with the site's Final Cover Quality Control Plan (FCQCP). A copy of the FCQCP can be found in Appendix 5.4 of this document.

4 LARGEST AREA REQUIRING FINAL COVER

The largest area requiring final cover is based upon the largest active area at any given time during the active life of the landfill. At the present time, approximately 36 acres have been developed. Of the 36 acres, one (1) acre was closed in 1995 and 35 acres are active. Therefore, 35 acres represent the largest area of the landfill requiring final cover.

5 MAXIMUM INVENTORY OF WASTES

The maximum inventory of waste that will ever be on-site during the active life of the landfill is estimated to be approximately 8,000,000 cubic yards. This estimate is based upon the permitted design capacity of the landfill less daily cover and final cover.

6 IMPLEMENTATION OF FINAL CLOSURE PLAN

Implementation of the final closure plan for the Angelina County Waste Management Center will be as follows:

- No later than 45 days prior to the initiation of closure activities for an MSW landfill unit, ACWMC shall provide written notification to the executive director of the intent to close the unit and place this notice of intent in the operating record.
- Upon notification to the executive of its intent to close, ACWMC shall post a minimum of one sign at the main entrance and all other frequently used points of access for the facility notifying all persons who may utilize the facility of the date of closing for the entire facility and the prohibition against further receipt of waste materials after the stated date. Further, suitable barriers shall be installed at all gates or access points to adequately prevent the unauthorized dumping of solid waste at the closed facility.
- ACWMC shall begin closure activities for each unit no later than 30 days after the date on which the unit receives the known final receipt of wastes or, if the unit has remaining capacity and there is a reasonable likelihood that the unit will receive additional wastes, no later than one year after the most recent receipt of wastes. A request for an extension beyond the one-year deadline for the initiation of closure may be submitted to the executive director for review and approval and shall include all applicable documentation necessary to demonstrate that the unit has the capacity to receive additional waste and that the owner or operator has taken and will continue to take all steps necessary to prevent threats to human health and the environment from the MSW landfill unit.

- ACWMC shall complete closure activities for the unit in accordance with the approved closure plan within 180 days following the initiation of closure activities. A request for an extension for the completion of closure activities may be submitted to the executive director for review and approval and shall include all applicable documentation necessary to demonstrate that closure will, of necessity, take longer than 180 days and all steps have been taken and will continue to be taken to prevent threats to human health and the environment from the unclosed MSW landfill unit.

- Following completion of all closure activities for the MSW landfill unit, ACWMC shall comply with the post-closure care requirements. ACMWC shall submit to the executive director by registered mail for review and approval a certification, signed by an independent licensed professional engineer, verifying that closure has been completed in accordance with the approved closure plan. The submittal to the executive director shall include all applicable documentation necessary for certification of closure. Once approved, this certification shall be placed in the operating record.

- Following receipt of the required closure documents, as applicable, and an inspection report from the agency's regional office verifying proper closure of the MSW landfill unit according to the approved closure plan, the executive director may acknowledge the termination of operation and closure of the unit and deem it properly closed.

- Within ten days after closure of all MSW landfill units, ACWMC shall submit to the executive director by registered mail a certified copy of an affidavit to the public in accordance with the requirements of 330.19 (relating to Deed Recordation) and place a copy of the affidavit in the operating record. In addition, the owner or operator shall record a certified notation of the deed to the facility property, or on some other instrument that is normally examined during title search, that will in perpetuity notify any potential purchaser of the property that the land has been used as a landfill facility and use of the land is restricted according to the provisions specified in 330.465 (relating to Certification of Completion of Post-Closure Care). ACWMC shall submit a certified copy of the modified deed to the executive director and place a copy of the modified deed in the operating record within the time frame specified in this subsection.

- No later than 90 days prior to the initiation of a final facility closure, ACWMC, through a public notice in the newspaper(s) of largest circulation in the vicinity of the facility, provide public notice for final facility closure. This notice shall provide the name, address, and physical location of the facility; the permit number; and the last date of intended receipt of waste. ACWMC shall also make available an adequate number of copies of the approved final closure and post-closure plans for public access and review. ACWMC shall also provide written notification to the executive director of the intent to close the facility and place this notice of intent in the operating record.

7 FINAL CONTOUR MAP

The Angelina County Waste Management Center consists of two fill sectors, Tract 1 and Tract 2. Final contours for each tract consist of 4-horizontal:1-vertical side slopes with top slopes ranging from 2 percent to 6 percent. Intermediate plateaus will be built along portions of the side slopes as shown in Exhibit 4.5, Sheets 1 and 2 of 2.

8 SOIL EROSION LOSSES COMPUTATIONS

Soil erosion losses computations can be found in Appendix 5.1.

9 SLOPE STABILITY ANALYSIS

Slope stability analysis for the final cover can be found in Appendix 5.2.

ANGELINA COUNTY
WASTE MANAGEMENT CENTER
TCEQ Permit No. MSW-2105A

SDP Attachment 12, Appendix 5.2
Slope Stability Analysis

prepared by:

LNV ENGINEERING
engineers & consultants

November 20, 2007
Revised April 11, 2008

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SDP ATTACHMENT 12, APPENDIX 5.2

Slope Stability Analysis
Angelina County Waste Management Center
Type 1 MSW Landfill
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Slope Stability Analysis
Angelina County Waste Management Center
Type 1 MSW Landfill
TCEQ Permit No. MSW-2105A

1 INTRODUCTION

This documentation will show that the alternative final cover system that has been designed for the Angelina County Waste Management Center is stable with regards to sliding failure and tensile stresses on the side slopes.

2 STABILITY ANALYSIS

2.1 Sliding Failure Analysis

Failures related to interface friction angles are commonly referred to as sliding failure. The infinite slope stability analysis method was used to verify the stability of the alternate final cover system against sliding failure. The factor of safety (FS) for slope stability is determined using the following equation:

$$FS = A * [(\tan \varphi) / (\tan \beta)] + B * [c / (\gamma * H)]$$

where,
- φ = interface friction angle (degrees)
- c = cohesion between different components (psf)
- β = angle of slope (degrees)
- A = parameter (see Attachment A)
- B = parameter (see Attachment A)
- γ = unit weight of soil (pcf)
- H = soil load along slope (ft)

To determine the critical interface friction angle (φ), the following component interfaces were considered:

- Compacted Clay and GCL Interface;
- GCL and 40 mil textured LLDPE Interface;
- 40 mil textured LLDPE and Geocomposite Interface; and
- Geocomposite and Erosion Layer Interface.

A summary of the friction angles for the component interfaces are as follows:

Component Interface	Friction Angle, φ (degrees)
Compacted Clay and GCL	19
GCL and 40 mil textured LLDPE	28
40 mil textured LLDPE and Geocomposite	26
Geocomposite and Erosion Layer Soil	26

The critical interface friction angle of the alternate final cover system is the friction angle between the GCL and the underlying compacted clay soil (φ = 19 degrees). This critical interface will be used to determine the factor of safety for the slope stability of alternate final cover system against sliding failure.

For the critical interface,

φ = 19
c = 50
β = 14
A = 1
B = 4.3
γ = 120
H = 2

Angle of slope, β, is based upon the steepest side slope of 4-horizontal:1-vertical. Parameters A and B are determined from slope stability charts for infinite slopes based upon slope ratio b (cot β) and pore pressure ratio (r_u). For the worst case scenario for the critical interface, r_u = 0, therefore parameter A = 1. Stability charts are provided in Attachment A of this Appendix.

Substituting the values for the critical interface into the equation above yields a factor of safety (FS) for the stability of the alternate final cover system against sliding failure.

FS = 2.3

2.2 Tensile Stress Analysis

Tensile stresses for the static condition are induced in the liner due to self weight and overyling material weight. For the dynamic condition, the tensile stress are induced by the self weight and overyling material weight plus the weight of equipment operating on the liner system. The tensile stresses are resisted by the friction between the liner components. The tensile stresses are determined by calculating the shear forces in the liner system.

For the static condition, the shear force (P) on liner due to the self weight of liner and overlying erosion layer is:

$P_S = W_S * \sin\beta$

where, β = angle of slope (degrees)
W_S = weight of geocomposite (W_{COMP}) plus weight of geomembrane (W_{GEO}) plus weight of GCL (W_{GCL}) plus weight of soil erosion layer (W_{SOIL}) (lbs)

Given a slope length of 100 ft,

W_{COMP}= [0.94 g/cm^3 * (1 lb/453.59 g) * (16.387 cm^3/in^3) * (1,728 in^3/ft^3) * (0.2 in) * (1 ft/12 in) * 1 ft * 100 ft] + [[10 oz/yd^2 * (1lb/16 oz) * (1 yd^2/9 ft^2) * 1 ft * 100 ft] * 2] = 111.7 lbs

W_{GEO} = 0.94 g/cm^3 * (1 lb / 453.59 g) * (16.387 cm^3/in^3) * (1,728 in^3/ft^3) * (0.04 in) * (1 ft/12 in) * 1 ft * 100 ft = 19.6 lbs

W_{GCL} = 0.89 lb/ft^2 * 1 ft * 100 ft = 89 lbs; and

W_{SOIL} = 120 pcf * 2 ft * 1 ft * 100 ft = 24,000 lbs

Summing the weights of each liner component results in a weight (W_S) of approximately 24,220.3 lbs. Therefore, the shear force (P_S) for the static condition is 5,859.4 lbs.

For the dynamic condition, the shear force (P_D) on liner due to the self weight of liner, weight of overlying erosion layer and weight of equipment is:

$P_D = W_D * \sin \beta + F_b$

where, β = angle of slope (degrees)
W_D = weight of geocomposite (W_{COMP}) plus weight of geomembrane (W_{GEO}) plus weight of GCL (W_{GCL}) plus weight of soil erosion layer (W_{SOIL}) plus weight of equipment (W_E) (lbs)

where, W_{COMP}= 111.7 lbs

W_{GEO} = 19.6 lbs

W_{GCL} = 89 lbs

W_{SOIL} = 24,000 lbs; and

W_E = 70,000 lb / 12 ft * 1 ft = 5,833 lbs

F_b = breaking force of equipment (lbs)

where, F_b = 0.3 * Equipment Weight = 1,750 lbs

Summing the weights of each liner component results in a weight (W_D) of approximately 30,053.3 lb. Therefore, the shear force (P) for the static condition is 9,020.6 lb.

The resisting forces (F) as a result of friction between liner components are calculated by the following equation:

$F = N * \tan \varphi$

where, φ = interface angle (degrees)
N = normal force on liner

where, N = W_S*cos β for the static condition
N = W_D*cos β for the dynamic condition

The factor of safety (FS) is calculated as follows:

FS = F / P

where, F = resisting force of component interface
P = shearing force on liner system

The interface friction angles provided in the table above are used to calculate the resisting force for each component interface. The resisting forces and factors of safety (FS) are summarized in the table below.

Component Interface	Static Condition		Dynamic Condition	
	Resisting Force, F_S (lbs)	Factor of Safety, FS	Resisting Force, F_D (lbs)	Factor of Safety, FS
Compacted Clay and GCL	8,091.9	1.38	10,040.8	1.11
GCL and 40 mil textured LLDPE	12,495.6	2.13	15,504.9	1.72
40 mil textured LLDPE and Geocomposite	11,462.1	1.96	14,222.6	1.57
Geocomposite and Erosion Layer Soil	11,462.1	1.96	14,222.6	1.57

The shear force (P) is less than the resistance (F) of the compacted clay and GCL, therefore the GCL is stable on the compacted clay.

The shear force (P) is less than the resistance (F) of the GCL and 40 mil textured LLDPE interface, therefore the 40 mil LLDPE is stable on the GCL.

The shear force (P) is less than the resistance (F) of the 40 mil textured LLDPE and geocomposite interface, therefore the geocomposite is stable on the 40 mil LLDPE.

The shear force (P) is less than the resistance (F) of the geocomposite and erosion layer soil interface, therefore the erosion layer is stable on the geocomposite.

3 CONCLUSION

The alternate final cover system, as designed, is stable against sliding failure and tensile stresses.

A stability analysis should be performed using test data from actual materials to be used for final cover construction. Test results should verify that actual interface friction values can be achieved that exceed the values used in this analysis.

4 REFERENCES

The following references were used to determine the friction angles for each component interface.

1. Principals of Geotechnical Engineering, Braja M. Das, 1985

2. "An Engineering Manual for Slope Stability Studies" by J.M. Duncan and A.L. Buchignani, Department of Civil Engineering - University of California at Berkley, 1975.

3. "Addressing the Special Concerns of Landfill Closures: VLDPE and Textured Geomembranes" by Mark Cadwallader, Gundle Reference Manual.

ANGELINA COUNTY
WASTE MANAGEMENT CENTER
TCEQ Permit No. MSW-2105A

SDP Attachment 12, Appendix 5.3
Alternative Final Cover Demonstration

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November 20, 2007
Revised April 11, 2008

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SDP ATTACHMENT 12, APPENDIX 5.3

Alternative Final Cover Demonstration
Angelina County Waste Management Center
Type 1 MSW Landfill
TCEQ Permit No. MSW-2105A

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Alternative Final Cover Demonstration
Angelina County Waste Management Center
Type 1 MSW Landfill
TCEQ Permit No. MSW-2105A

1 INTRODUCTION

In accordance with 30 TAC §330.457(d), the executive director may approve an alternative final cover design that achieves an equivalent or greater reduction in infiltration as the clay-rich soil layer detailed in 30 TAC §330.457(a)(1) and provides equivalent protection from wind and water erosion as detailed in 30 TAC §330.457(a)(3).

One alternative final cover system (AFCS) has been designed for the MSW landfill units with synthetic bottom liners and consists of replacing the clay-rich soil layer component in the site's currently permitted final cover system with a geosynthetic clay liner (GCL).

This documentation will show that the alternative final cover system that has been designed for the Angelina County Waste Management Center meets the requirements of 30 TAC §330.457(d).

2 MODELING APPROACH

All modeling for this demonstration was performed utilizing the Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3.07 (1 November 1997).

The simulations were performed with the HELP model using the program's synthetic weather data generation capabilities for Houston, Texas, with temperature and precipitation data adjusted with monthly normals from 1971-2000, obtained from the National Climactic Data Center (NCDC). Data was generated for a thirty year period to correspond with the post-closure care period for the facility. The runoff curve was generated by the model using a slope of 5% and a length of 200 feet. The slope length of 200 feet and a slope of 5% represents conservative runoff parameters in the final cover system. Run-off was allowed from the area modeled. The latitude used for simulation purposes was 31.337°, the coordinates for the City of Lufkin, Texas.

An evaporative zone depth of 22 inches was assumed. This depth was suggested by the model as a fair value for corresponding to the presence of fair vegetative cover. This should be a fair assumption considering that vegetation will be promoted on the final cover system to limit erosion and the low permeability soils in the final cover will hold water and promote evapotranspiration in addition to reducing infiltration.

3 ALTERNATIVE FINAL COVER PERFORMANCE CRITERIA

In order to determine the most stringent final cover design and to establish performance criteria for an alternative final cover system, the currently permitted design was modeled and compared to the final cover design specified in §330.457(a)(1) (Subtitle D final cover system) and §330.457(a)(3) (Erosion Layer).

The currently permitted final cover system was modeled using four layers; a 24-inch erosion layer, a 200 mil geonet drainage layer, a 40 mil linear low density polyethylene, and an 18-

inch barrier layer of compacted clay with a hydraulic conductivity not exceeding $1x10^{-5}$ cm/sec. For simulation purposes, geomembrane manufacturer defects (pinholes) were assumed at one per acre and field installation defects were assumed at two per acre with a placement factor of 3 (good).

As calculated by the HELP model using the currently permitted final cover system design parameters, the peak daily percolation/leakage through layer 4 for years 1 to 30 is 5.85021 cubic feet, as shown on page 6 of 7 of the HELP model output for this analysis (Attachment A of this Appendix).

The Subtitle D final cover system was modeled using three layers; a 6-inch erosion layer, an 18-inch barrier layer of compacted clay with a hydraulic conductivity not exceeding $1x\ 10^{-5}$ cm/sec and a geomembrane layer consisting of 40 mil linear low density polyethylene. For simulation purposes, geomembrane manufacturer defects (pinholes) were assumed at one per acre and field installation defects were assumed at two per acre with a placement factor of 3 (good).

As calculated by the HELP model using the Subtitle D final cover system parameters, the peak daily percolation/leakage through layer 3 for years 1 to 30 is 15.51400 cubic feet, as shown on page 5 of 5 of the HELP model output for this analysis (Attachment B of this Appendix).

The HELP model results indicate that the currently permitted design is more stringent than the final cover design specified in §330.457(a)(1) and (3), therefore the alternative final cover design must achieve an equivalent reduction in infiltration and provide equivalent protection from wind and water as the currently permitted design.

4 ALTERNATIVE FINAL COVER MODEL

The alternative cover system was modeled using four layers, a 24-inch erosion layer, a 200 mil geonet, 40 mil linear low density polyethylene and a 0.24-inch bentonite GCL with a hydraulic conductivity of $5.0x10^{-9}$ cm/sec which was modeled as a barrier layer.

As calculated by the HELP model, the peak daily percolation/leakage through layer 4 of the alternative final cover system, for years 1 to 30, is 0.05090 cubic feet, as shown on page 6 of 6 of the HELP model output for this analysis (Attachment C of this Appendix).

5 CONCLUSION

The HELP model simulations performed for this demonstration show that the alternative final cover design proposed for the Angelina County Waste Management Center will achieve an equivalent or greater reduction in infiltration and provides equivalent protection from wind and water erosion as the currently permitted final cover design which is more stringent than the final cover design specifications detailed in 30 TAC §330.457(a)(1) and in 30 TAC §330.457(a)(3).

ANGELINA COUNTY
WASTE MANAGEMENT CENTER
TCEQ Permit No. MSW-2105A

SDP Attachment 12, Appendix 5.4
Final Cover Quality Control Plan

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November 20, 2007
Revised April 11, 2008

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Final Cover Quality Control Plan
Angelina County Waste Management Center
Type 1 MSW Landfill
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Final Cover Quality Control Plan
Angelina County Waste Management Center
Type 1 MSW Landfill
TCEQ Permit No. MSW-2105A

1 INTRODUCTION

As per 30 TAC §330.457(e)(1), this Final Cover Quality Control Plan (FCQCP) was prepared to detail methods and procedures for the installation of final cover at the Angelina County Waste Management Center.

2 SCOPE

This Final Cover Quality Control Plan (FCQCP) has been prepared to provide materials, construction, and QA/QC (Quality Assurance/Quality Control) criteria for the various elements of the final cover system which includes:

- Soil infiltration layers
- Geosynthetic clay liners
- Infiltration layer geomembrane (as required)
- Drainage layers (as required), and
- Erosion layer

Materials, construction, and QA/QC criteria for the alternate final cover system are also included.

This plan also provides guidance necessary for testing and reporting evaluation procedures to the professional preparing the Final Cover System Evaluation Report (FCSER) describing the necessary procedures for implementation.

3 DEFINITIONS

The following list of definitions pertinent to the FCQCP is provided for reference:

ASTM: American Society for Testing and Materials - One of the largest, professionally recognized voluntary standards development systems in the world.

Atterberg Limits: (ASTM D4318) A series of six "limits of consistency" of fine-graded soils defined by Swedish soil scientist Albert Atterberg, two of which are frequently used today to establish a soil's physical boundaries dealing with its plasticity characteristics. These soil boundaries or limits used most frequently are based upon the numerical difference of the Liquid Limit and the Plastic Limit as defined below:

> Liquid Limit (LL): The percentage of moisture in a soil, subjected to a prescribed test, that defines the upper point which is the soil's consistency changes from the plastic to the liquid state.
>
> Plastic Limit (PL): The percentage of moisture in a soil, subjected to a prescribed test, that defines the lower point at which the soil's consistency changes from the plastic to the semi-solid state.

Plasticity Index (PI): The numerical difference between the LL and the PL of a fine-graded soil that denotes the soils plastic range. The larger the PI the greater a soil's plasticity ranger and the greater the plasticity characteristics.

Classification System: The soil classification system will be in accordance with the standard test method for classification of soils for engineering purposes (ASTM D2487).

Coefficient of Permeability: (aka Hydraulic Conductivity) The amount of flow per unit of time through soil under a unit of hydraulic gradient at standard temperature.

Compaction: The process of increasing the density or unit weight of soil by rolling, tamping, vibrating, or other mechanical means.

Compactive Effort: The amount of compaction energy held constant, and usually transferred into a soil sample with a compaction hammer device, used on soil samples in various laboratory test procedures to establish a soil's density at various moisture contents.

Constructed Soil Infiltration Layer: Soil infiltration layers constructed from reworked soils from a borrow source.

Construction Quality Assurance (CQA): A planned system of activities that provides the owner and permitting agency assurance that the facility was constructed as specified in the design (US EPA, 1993).

Construction Quality Control (CQC): A planned system of inspections that is used to directly monitor and control the quality of a construction project.

Density: Mass density of a soil is its weight per unit volume, usually reported in pounds per cubic foot.

Extrusion Weld: A bond between two linear low density polyethylene (LLDPE) materials which is achieved by extruding a bead of LLDPE over the leading edge of the seam between the upper and lower sheet using a hand-held apparatus. Extrusion welds will be used for patch repairs, destructive repairs, and in some tie-ins.

FCSER: Final Cover System Evaluation Report - A stand alone, quality control test report prepared in accordance with the methods and procedures contained in this FCQCP that details the installation and testing of the final cover system.

Film Tear Bond: A failure in the geomembrane sheet material on either side of the seam and not within the seam itself.

Fusion Weld: A bond between two LLDPE geomembrane materials which is achieved by fusing both surfaces in a homogeneous bond of the two surfaces using a power driven apparatus capable of heating and compressing the overlapped portions of the geomembrane sheets.

Geotechnical Engineering Professional (GEP): A Professional Engineer registered in the State of Texas who possesses professional experience in geotechnical engineering and testing.

Geomembrane Infiltration Layer: An essentially impermeable geosynthetic composed of one or more synthetic sheets.

Geotechnical Quality Control Professional (GQCP): A professional engineer registered in this state who possesses professional experience in geotechnical engineering and testing, or a graduate geologist who has a minimum of four years experience in engineering geology and is experienced in geotechnical testing and its interpretations.

GRI: Geosynthetic Research Institute - Located at Drexel University, the GRI conducts research with geosynthetic materials and develops industry testing standards for these materials. This institute is supported by many geosynthetic manufacturers, installers, and raw materials suppliers to the industry.

Independent Geosynthetics Laboratory (IGL): A qualified geosynthetics testing laboratory not affiliated with either the manufacturer or the owner.

LLDPE: Linear Low Density Polyethylene - An ethylene/α-olefin copolymer having a linear molecular structure. The comonomers used to produce the resin can include hexane, octane, or methyl pentene. LLDPE resins have a natural density in the range of 0.915 to 0.926 g/ml (ref. Pate, T.J. Chapter 29 in Handbook of Plastic Materials and Technology, I.I. Rubin Ed., Wiley, 1990).

Moisture Content: Ratio of quantity of water in the soil (by weight) to the weight of the soil solids (dry soil), expressed in percentage; also referred to as water content.

Moisture/Density Relationship: A test in which soil samples are compacted in a known volumetric container at various moisture contents at a constant level of compactive effort and their corresponding densities are determined. The test procedures and compactive efforts used are those normally prescribed in ASTM D 698 and ASTM D 1157 (See Optimum Moisture Content).

Optimum Moisture Content (OMC): Moisture content corresponding to maximum dry density as determined in standard Proctor test (ASTM D 698) or modified Proctor (ASTM D 1557).

Project Representative: The on-site or designated representative of the Angelina County Waste Management Center.

Qualified Engineering Technician: A representative of the GEP who is represented to be NICET-certified in Geotechnical Engineering Technology at level 2 for soils and geomembrane testing, an engineering technician with a minimum of four years of directly related experience, or a graduate engineer or geologist with one year of directly related experience.

Secondary Structure: The macrostructure of a geologic stratum. Structural features in a soil or rock deposit which can be seen with little or no magnification, to include, but not limited to, pockets, lenses, layers, seams, or partings of varying soil types, slickensided fissures, laminated structure, and/or mineral concretions or staining.

Sieve Analysis: A laboratory soil test consisting of placing a known weight of soil sample through a series of wire mesh sieves stacked upon each other in successively smaller mesh size and used to determine the percentage size gradation of the sample.

Soil Borrow Source: Soils in which the Liquid Limit (LL) and Plasticity Index (PI) do not vary by 10 points or more. A soil that varies by 10 or more from the originally established LL or PI is considered as a separate soil source for the purpose of this document and requires a separate soils test series.

TCEQ: Texas Commission on Environmental Quality and its successors.

4 SOIL INFILTRATION LAYER (PRE-SUBTITLE D AREA)

The soil infiltration layer of the final cover system will have continuous on-site inspection during construction and/or installation by the GEP or his/her Qualified Engineering Technician. The GEP or his/her Qualified Engineering Technician will perform all field sampling and testing, both during construction and/or installation and after completion of the infiltration layer construction or installation.

The requirements for constructed soil infiltration layer and soil infiltration layer materials are as follows:

Property	Method	Required Value
Atterberg limits	ASTM D 4318	Liquid Limit not less than 30 Plasticity Index not less than 15
Sieve Analysis	ASTM D 422	>30% passing #200 mesh sieve
Permeability	ASTM D 5084	As outlined in Final Closure Plan
Soil Classification	ASTM D 2487	N/A
Moisture Content	ASTM D 2216	N/A
Standard Proctor	ASTM D 698	See compaction curve for reference
Modified Proctor	ASTM D 1557	See compaction curve for reference
Thickness of infiltration layers	Survey methods	18"
Thickness of erosion layers	Survey methods	24"

4.1 Preconstruction Testing - Soil Infiltration Layer

After identifying a potential soil infiltration layer material, characteristic tests will be conducted on representative samples of the material as follows:

1. Sieve analysis, Atterberg limits and soil classification will be conducted to determine if the soil meets the criteria outlined above. If the results of these tests indicate acceptable source material, a Proctor compaction test will be conducted to determine the maximum dry density and optimum moisture content. The type of ASTM Proctor compaction test, standard or modified, will be determined by the certifying engineer based on types of heavy equipment to be used in the field. Equipment capable of providing a minimum of 12,400 ft-lbf/ft^3 will be used for compaction. If a modified Proctor is to be used, equipment capable of providing 56,000 ft-lbf/ft^3 or greater compaction must be used.

2. Using the results from the standard Proctor test, a permeability test sample will be prepared at no less than 95% of the maximum dry density and at the optimum moisture content. If modified Proctor test is used as a reference, a permeability test sample will be prepared at no less than 90% of maximum dry density and at a moisture content 1% drier than the optimum moisture content.

3. Permeability tests will be conducted per the specified test method using tap water or 0.05N calcium sulfate solution as the permeant fluid. Distilled or deionized water is not acceptable for use as permeant fluid. The permeant fluid will be deaired.

4. If the permeability is less than the permeability outlined in the Final Closure Plan for a specific area of the landfill, soil infiltration layer construction may begin with that soil material over the specified area.

5. If the permeability test for the sample prepared at 95% of the maximum dry density and at the optimum moisture (see (4.1)(2) above if modified Proctor test method is used) content does not satisfy the permeability requirements outlined in the Final Closure Plan, permeability test(s) with increased dry density and/or increased moisture content will be required if the soil material is to be used for soil infiltration layer construction. Using systematic increases in compaction effort and moisture content, an additional permeability test sample(s) will be prepared and tested.

6. The minimum acceptable compaction criteria for soil infiltration layer construction will be based on the criteria used in the permeability test which met the permeability requirement outlined in the Final Closure Plan.

7. All permeability test data on soil materials which are used for a soil infiltration layer must be submitted regardless of test method used or test results.

8. If materials vary by more than 10 points in either the liquid limit or plasticity index from previous evaluated materials, a separate preconstruction evaluation will be conducted.

9. If multiple borrow sources are to be used, a separate preconstruction evaluation will be made for the different sources. If different soil layers or types are encountered in the same borrow area, a separate preconstruction

evaluation will be performed for the different materials under consideration for use as soil infiltration layer.

10. A moisture-density compaction curve must be established prior to field testing. The moisture-density compaction curve will include a zero air voids line. It is required that the specific gravity used for the zero air voids line be included, but it may be estimated.

11. The maximum clod size of the soil infiltration layer soils will be approximately one inch (1") in diameter but in all cases soil clods will be reduced to the smallest size necessary to achieve the coefficient of permeability reported by the testing laboratory and to destroy any macrostructure evidence after the compaction of the clods under density-controlled conditions.

12. The soil infiltration layer material will contain no rocks or stones larger than one inch in diameter or that total more than 10% by weight. One-hundred percent (100%) of the material used in the soil infiltration layer must pass the one inch (1") screen.

4.2 Soil Infiltration Layer Installation

A. General

1. The surface of the waste/intermediate cover should be compacted to the maximum possible density to prepare a working surface on which to place the first lift of final cover soil.

2. Infiltration layer soil will not be placed or compacted during sustained periods of temperatures below 30°F. Infiltration layer soil may be placed during early morning freezing temperatures with warming trends during the day.

3. Soil infiltration layer construction and testing should be completed in a systematic and timely fashion. Delays should be avoided in soil infiltration layer completion. There should not be more than a 14-day hiatus in construction unless adverse weather prevents construction progress.

B. Hydrating Infiltration Layer Soil

1. In order to ensure proper hydration of the infiltration layer soil, clod size reduction should be completed through discing, pulverizing, possibly screening, or other equivalent methods, prior to adding water.

2. A minimum of five (5) passes of a disk or three (3) passes of a pulverizer should be made at alternating right angles where space permits for soil processing. Additional passes should be performed if necessary to thoroughly break up and blend the infiltration layer soil prior to compacting.

3. After water is added, the soil must be thoroughly mixed and stockpiled, if necessary, to allow adequate time (usually overnight or longer) to hydrate. The higher the plasticity of the soil, the longer this mixing and hydration process will take.

4. Water used in the hydrating infiltration layer soils must be clean and will not have come into contact with waste or any objectionable material.

C. Placement

1. Approved soil infiltration layer material will be placed in uniform layers not exceeding nine inches (loose lift). If the pads of the compactor to be used will not penetrate into the top of the previously compacted lift, the thickness of the loose lift will be reduced to allow for full penetration by the compactor pads.

2. Compaction equipment will be maintained to avoid clogging of infiltration layer soil around the compactor pads. A minimum of one (1) lift for each six-inches (6") of soil infiltration layer will be used.

D. Compactive Effort

1. As each lift (approximately six inches (6") of compacted thickness) of infiltration layer has been completed, field density and moisture content tests will be performed at the frequency outlined.

2. Minimum field compaction criteria for a constructed soil infiltration layer is 95% (or as Section (4.1)(2) above if modified Proctor test method is used) of the maximum dry density at a moisture content at or above the optimum moisture content, or the compaction criteria established during preconstruction testing, whichever is more restrictive.

3. Soil infiltration layers will not be compacted with a bulldozer or any track-mobilized equipment unless it is used to pull a pad-footed roller. Compaction of soil infiltration layer material loose lifts will be performed with an appropriately heavy, properly ballasted, penetrating foot compactor such as a pad foot, prong-foot, or sheepsfoot compactor similar to a CAT 815 or equivalent.

4. A minimum of four passes are required, with a pass being defined as two applications of the compacting roller (i.e., for a one roller compactor, a pass is a trip forward and back, for a two-roller compactor, a pass is a trip forward). Additional passes may be required to achieve compaction requirements.

5. Within a construction area, each lift will be thoroughly compacted and satisfy moisture and density controls through field testing prior to placement of subsequent lifts.

E. Lift Bonding

1. The top of each lift should be roughened to a willow depth prior to placement of the next lift of soil for compaction.

2. No loose lifts will be thicker than the pads of the compactor so that complete bonding with the top of the previous lift is achieved.

3. During construction, finished lifts or sections may be sprinkled with water as needed to prevent drying and desiccation.

4. If desiccation and crusting of a lift surface occur before placement of the next lift, the area will be sprinkled with water, scarified, and tested for acceptable moisture content prior to placement of a subsequent lift.

5. Completed lifts or sections of compacted soil infiltration layer will be sealed by rolling with a rubber tired or smooth drum roller and sprinkled with water as needed.

6. The top surface of the completed soil infiltration layer must be proof rolled with a smooth-wheel roller prior to final infiltration layer-thickness surveying.

7. If possible, the surface of a soil infiltration layer will be proof rolled when construction is shut down for more than 24 hours to mitigate the effects of desiccation.

F. Infiltration Layer Tie-Ins

Soil infiltration layer section must not be constructed by "butting" the entire thickness of a new layer section to the previously constructed infiltration layer section. Either of the following methods must be followed:

1. The edge of the old section of infiltration layer must be cut back on a slope that the entire existing infiltration edge is tied to new construction without superimposed construction joints; or

2. The edge of the old section of infiltration layer will be cut back on one-foot (1') offset layers (stair steps) so that each foot of the existing infiltration layer edge is tied to new construction without superimposed construction joints. The length of the tie-in area should be at least 5 feet per foot of infiltration layer thickness.

G. Field Testing

Each constructed area developed as a separated segment (non-monolithically) must be considered as separately evaluated areas independent of each other for the purposes of calculating dimensions to determine the required number of samples.

1. Minimum requirements for field testing during construction of soil infiltration layer are as follows:

   a. A field density and moisture content test will be conducted per every 8,000 square feet for each six inch (6") compacted lift, (but not less than three (3) tests per six inch (6") compacted lift).

   b. Sieve analysis will be performed at a frequency of one test per every 100,000 square feet or major fraction thereof. A minimum of one test per 6 inch compacted lift is required.

   c. Atterberg limits will be determined at a frequency of one test per every 100,000 square feet or major fraction thereof. A minimum of one test per 6 inch compacted lift is required.

   d. Permeability tests will be performed at a frequency of one test per every surface acre of final cover, or major fraction thereof, evenly distributed over the entire soil infiltration layer thickness with a minimum of one permeability test per each 6-inch compacted lift.

      For an 18-inch infiltration layer constructed in three 6-inch lifts, for example, the regulatory requirement of one permeability test per surface acre of final cover should be met by testing each lift for permeability at a frequency of one (1) test per three (3) surface acres.

   e. Thickness verification will be performed by instrument survey methods only. A minimum of one verification point per 10,000 square feet of surface area is required. If the construction area is less than 10,000 square feet, a minimum of two verification points will be required. Reference locations with elevations will be noted on a drawing of the area evaluated. All elevation calculations necessary for thickness verification determination will be attached as part of the supporting documentation to the FCSER including corrections for true thicknesses measured perpendicularly to sidewalls.

2. When sampling for permeability tests, two Shelby tubes/drive cylinders will be retrieved. One tube/cylinder will serve as the primary test sample. The second tube/cylinder will serve as the backup sample in case of damage or sample disturbance in the first tube, or in case of a non-conforming permeability test.

3. Care will be taken to reference field density tests to the correct Proctor curve for the material being used in construction.

4. An increase in the frequency of field density testing does not require a corresponding increase in sieve analysis, Atterberg limits or permeability testing.

5. If the frequency of field density testing is increased, the frequency of the other tests remains one test per 100,000 square feet per 6 inch compacted lift or major fraction thereof.

6. Throughout construction of soil infiltration layer, test results will be reviewed. If the liquid limit or plasticity index of the soil varies more than 10 points from the limits determined during preconstruction testing, a compaction test will be performed on the varying material. A laboratory permeability test will be performed on the varying material to ensure a permeabilities requirements, as outlined in the Final Closure Plan, will be achieved using the construction compaction criteria.

7. Sand cone tests, rubber balloon tests, or drive cylinder samples may be used to correlate dry density and moisture content measurements with those of the nuclear gauge. The results of these tests will be documented and reviewed to determine if re-calibration of the nuclear density gauge is necessary.

8. All sampling or testing locations will be backfilled with appropriate bentonite grout or a mixture of at least 20% bentonite-enriched infiltration layer soil and compacted by hand tamping. These locations include field density test locations, material sample locations, and tube sample locations, as well as any other infiltration layer penetration.

9. If used, field permeability testing of constructed soil infiltration layer will be in accordance with ASTM D 5093 or the Boutwell STEI two-stage field permeability test. Field permeability testing will be used only with the prior consent of the TCEQ.

10. All test results will be reported. In case of non-conforming test results, the steps taken to correct the nonconformity will be explained in the FCSER following procedures outlined below.

H. Non-Conforming Tests - Field Density and Moisture Tests

1. Sections of compacted soil infiltration layer which do not meet the density and moisture content requirements may be reworked and retested until the section does pass the criteria or the section of compacted soil infiltration layer may be removed and replaced to passing standards.

2. In the event of a failed moisture-density test, it is necessary to isolate the non-conforming area. Additional tests will be performed approximately half-way between the failed test and the nearest adjacent passing test locations. If the additional tests pass, the area

bounded by passing tests will be reworked and retested. If the additional tests fail, a second set of additional tests will be performed between the failing additional tests and surrounding passing tests. This process will be repeated until the non-conforming area is defined. Once the non-conforming area is defined, it will be reworked and retested until compaction and moisture criteria are met.

3. In lieu of additional tests to define the non-conforming area, it is acceptable to rework entire area bounded by the initial surrounding passing tests.

4. If reworking consistently fails and the section does not pass the criteria, the non-conforming area will be removed and replaced.

5. All reworked areas will be tested and confirmed to satisfy the compaction criteria. The reporting of retests will clearly indicate the number and location of the non-conforming test and the subsequent conforming retest. Retests will be taken near the location of the original non-conforming test.

I. Non-Conforming Tests - Permeability Tests

1. In the event of a non-conforming permeability test, the test procedures and test sample will be reviewed for inconsistency in test procedure or flaw in the permeability test sample. A review of the associated soil characteristic tests and field density/moisture content tests will be performed to confirm that the appropriate compaction criteria was used.

2. A permeability sample will be prepared from the backup drive cylinder or Shelby tube sample and an additional permeability test will be performed on the backup sample.

3. If the backup sample provides an acceptable permeability result, the results of the first sample will be disregarded if it is determined that the first sample or test procedure was flawed. If the backup sample does not provide an acceptable permeability, a review of the required compaction criteria will be performed to determine if the compaction criteria require revision.

4. Additional permeability test samples will be retrieved between the non-conforming permeability location and the surrounding passing permeability test locations. The results from these additional permeability tests will be used to bound the area requiring rework or removal and replacement. The area to be reworked or removed and replaced will be bounded by passing permeability tests. In lieu of additional testing to define the nonconforming area, the area between the initial passing permeability tests may be reworked or removed and replaced.

5. If reworking consistently fails and the section does not pass the criteria, the non-conforming area will be removed and replaced.

6. All reworked areas will be tested and confirmed to satisfy the permeability criteria. The reporting of retests will clearly indicate the number and location of the non-conforming test and the subsequent conforming retest. Retests will be taken near the location of the original non-conforming test.

J. Survey Control

1. The as-built thickness of the soil infiltration layer will be determined by survey methods.

2. Prior to the placement of <u>any</u> soil infiltration layer, the prepared surface will be surveyed once per 10,000 square feet on a pre-established grid.

3. Upon completion of the soil infiltration layer, and prior to the installation of subsequent elements, the top of the soil infiltration layer will be surveyed to ensure the specified thickness of soil infiltration layer has been achieved.

4. Upon completion of the erosion layer the top of the layer will be surveyed to ensure the specified thickness has been placed.

5 GEOSYNTHETIC CLAY LINER (SUBTITLE D AREA)

Geosynthetic clay liner placement will have continuous on-site inspection during construction by the GEP or his/her Qualified Engineering Technician. All field sampling and testing, both during construction and after completion of geosynthetic clay liner plaement, will be performed under the observation of the GEP or his/her Qualified Engineering Technician.

5.1 General Material Requirements

1. All proposed GCL will meet the specifications detailed in Table 1, below, and will be capable of retaining its structure during deployment. For each lining event, the manufacturer will provide recommended seaming procedures and supporting test documentation showing the GCL seams are no more permeable than the GCL itself at the confining pressure anticipated in the field.

Table 1 - GCL Properties

Material Property	Standard Test Method	Specified Value
Free Swell	ASTM D 5890 (or as amended)	24 ml. (min.)
Fluid Loss	ASTM D 5891 (or as amended)	18 ml. (max.)
Bentonite Mass/Area (@ 0% Moisture)	ASTM D 5993 (or as amended)	0.75 lb/ft^2 (min.)
Grab Tensile	ASTM D 4632 (or as amended)	90 lbs. *75 lbs (min.)
Permeability/Index Flux	ASTM D 5887 (or as amended)	5 x 10^{-9} cm/sec (max)/ 1 x 10^{-9} m^3/m^2 sec (max.)
Hydrated Internal Shear Strength	ASTM D 5321 (or as amended)	500 psf. *50 psf (min.)

2. The GCL will be supplied in rolls with structurally sound cores and wrapped to protect from ultraviolet light exposure, moisture, excess humidity, puncture, cutting, and/or any other deleterious conditions.

3. GCL rolls will be marked or tagged with manufacturer's name, product id, roll number and roll dimension.

5.2 On-Site Storage and Handling

1. On-site handling will be performed with a front end-loader, backhoe, dozer, or other equipment with the spreader bar and core pipe or slings. Alternatively, a forklift with a "stinger" attachment may be used for on-site handling and, in certain cases, installation. A forklift without a stinger attachment should not be used to lift or handle the GCL rolls.

2. Rolls will be stored at the job site away from high traffic areas but sufficiently close to the active work area to minimize handling. The designated storage area should be flat, dry and stable. Moisture protection of the GCL is provided by its packaging; however, an additional tarpaulin or plastic sheet is recommended.

3. Rolls should be stacked in an manner that prevents them from sliding or rolling. (This can be accomplished by frequent choking of the bottom layer of rolls). The rolls should be stacked no higher than the height at which they can be safely handled by laborers (typically no higher than four layers or rolls). Rolls should never be stacked on end.

4. GCL rolls will be stored above ground (i.e., wooden pallets).

5.3 Source Quality Control - Preconstruction Testing

1. GCL testing will be performed by the supplier, manufacturer and the third-party independent laboratory to evaluate characteristics for quality control.

2. At a minimum, laboratory tests will be performed at the specified frequencies as detailed in Table 2 as follows:

Table 2 - GCL Testing Frequencies

Tester	Material	Material Property	Standard Test Method	Frequency of Testing
Supplier or GCL Manufacturer	Bentonite[A]	Free Swell	ASTM D 5890 (or as amended)	1 per 50 tons and every truck or trailer
		Fluid Loss	ASTM D 5891 (or as amended)	
GCL Manufacturer	GCL Product	Mass/Unit Area	ASTM D 5993 (or as amended)	1 per 40,000 ft^2
		Moisture Content	ASTM D 2216 (or as amended)	1 per 40,000 ft^2
		Grab Tensile Strength[B]	ASTM D 4632 (or as amended)	1 per 200,000ft^2
		Permeability/Index Flux[B, D]	ASTM D 5887 (or as amended)	1 per week for each production line[C]
Independent Laboratory (Conformance Testing)	GCL Product	Mass/Unit Area	ASTM D 5993 (or as amended)	1 per 40,000 ft^2
		Permeability/Index Flux[B, D]	ASTM D 5887 (or as amended)	1 per week for each production line[C]
		Hydrated Internal Shear Strength[D, E]	ASTM D 5321 (or as amended)	1 per GCL/adjoining material type

Notes:

A Tests to be performed on bentonite before incorporation into GCL

B Not applicable for geomembrane-backed GCL. Manufacturer of geomembrane-backed GCL must, however, certify that product will meet required permeability standards based on prior testing

C Report last 20 permeability values, ending on production date of supplied GCL

D Test at confining/consolidating pressures simulating field conditions

E Not applicable for slopes of 7H:1V of flatter. Testing must be in hydrated state unless GCL is to include geomembrane on both sides of GCL

3. Samples not satisfying these specifications and manufacturer's specification will result in the rejection of applicable rolls.

4. Testing of needle-punched GCL will be performed by passing GCL directly over magnets to try to remove broken needles, and continuous testing with metal detectors to verify there are no broken needles.

5. The Geotechnical Quality Control Professional (GQCP) or their representative may request additional testing of individual rolls to more closely identify non-complying rolls and to qualify individual rolls at the discretion and expense of the GCL Manufacturer.

6. Samples of the GCL will be taken across the entire width of the roll but will not include the first 1 ft. Unless otherwise specified, size of the samples will be 1 ft long by the roll width. The samples will be identified by type, lot and roll numbers. The sampler will mark the machine direction on the samples with an arrow.

7. A lot will be defined as a group of consecutively numbered rolls from the same manufacturing line.

8. Samples will be taken at the rates specified in Table 2, above. These samples will then be forwarded to the Geosynthetic Quality Assurance Laboratory (QAL) for testing to ensure conformance to the project specifications.

5.4 Geosynthetic Clay Liner (GCL) Construction

All GCLs will have continuous on-site inspection during construction by the GQCP or their qualified representative. All field sampling and testing, both during construction and after completion of the GCL construction, will be performed under the observation of the GQCP or their qualified representative

A. Subgrade Preparation Procedures

1. Verify the subgrade surface is free of rocks which may damage the membrane, desiccation cracks which may affect the integrity of the clay liners, ruts, voids, etc.

2. Remove debris and rock particles greater than $^3/_8$-inch in diameter from soil surface

3. Scarify, moisture condition, and compact the upper six (6) inches soil. Compaction will first be performed with a tamping-foot compactor and then the surface finished with a smooth drum roller.

4. Do not place GCL on an area that has become softened by precipitation or otherwise damaged.

5. Prior to GCL installation, the condition of the subgrade must be deemed suitable for GCL installation by the GQCP and the installer.

6. Provide required anchor trench at the liner perimeter to secure the GCL. Ensure loose soil underlying the GCL in the anchor trench is minimized.

B. Placement

1. Remove protective cover soil and prepare tie-in to existing liner(s).

2. On slopes, anchor GCL securely and deploy it down slope in a controlled manner to continually keep the GCL in tension. Unroll GCL panels onto the subgrade; do not drag panels across it.

3. Install GCL with the appropriate side of the material facing upward.

4. Ensure GCL panels lie flat on the underlying subgrade with no wrinkles or folds.

5. Cut GCL with a cutter (hook blade). Protect adjacent materials from potential damage due to cutting.

6. Provide temporary loading, such as sandbags, or equivalent, in presence of high wind that may dislocate panels. Do not remove loading until replaced with appropriately loaded cover material.

7. Prevent damage to underlying subgrade during placement of GCL. Do not use equipment to deploy the GCL that may cause excessive rutting (> 1") of the subgrade.

8. During deployment, do not entrap stones, excessive dust or moisture, in or beneath the GCL.

9. Prevent excess loss of bentonite on edges during installation.

10. Visually examine entire GCL surface and ensure no potentially harmful foreign objects are present. Remove foreign objects encountered or replace GCL.

11. Deploy GCL in such a manner so as to protect the GCL from moisture and precipitation during and after installation. Do not install GCL in standing water or during inclement weather such as rain or high winds.

12. Do not deploy more GCL material during any one working day than can be covered by the end of that day.

13. Maintain a correlation between panel numbers and roll numbers.

14. Position the edges of the upslope panels above the edges of the downslope panels in a shingle-like fashion.

C. Anchorage

1. If placed on a side slope, the end of the GCL roll should be placed in an anchor trench at the top of a slope. The front edge of the anchor trench should be rounded to eliminate any sharp corners that could cause excessive stress on the GCL. Loose soil should be removed or compacted into the floor of the anchor trench.

2. If a trench is used for anchoring the end of the GCL, soil backfill should be placed in the anchor trench to provide resistance against pullout.

3. Place GCL in the anchor trench such that it covers the entire anchor trench floor but does not extend up the rear anchor trench wall.

D. Seaming

1. Overlap GCL edges a minimum of 6 inches (150 mm). Apply a continuous bead of granular bentonite approximately 3 inches (75 mm) from the underlying edge of the GCL.

2. Overlap roll end-of-panel seams a minimum of 12 inches (300 mm).

3. Shingle overlapped seams so that the edge of the upslope panel is positioned above the downslope panel.

4. Do not use horizontal seams on side-slopes unless slope length exceeds roll length. In that case, place seams only in the lower half of slopes and stagger with end overlaps accomplished in accordance with manufacturer's recommendation.

5. With the exception of corners, when required, do not "Piece-in" an area with small panels. Plan for and provide sufficient material to avoid the use of repetitive small panels.

6. For reinforced GCL, add granular bentonite as supplied by the GCL manufacturer to seams at a rate equal to 1/4 pound per linear foot (0.4 kg/m) using a method or device approved by the GCL manufacturer.

7. Visually inspect seam continually to ensure:

   a. GCL material entirely covers the subgrade;

   b. Panel edges cover the 6 inch lap line printed on the upper surface of each panel;

   c. Overlap zone is not contaminated with loose soil or other debris; and

   d. Bentonite added to seams is continuous.

E. Defects & Repairs

1. Sections which have been prematurely hydrated will be removed and replaced.

2. Repair holes and tears in GCL as follows:

   a. Place a piece of new material extending over the entire area of damage with a minimum 12 inch overlap in all directions.

   b. Add powder or granular bentonite to patches as required by manufacturer's recommendations. Secure patches so that placement overlying layer does not dislodge the patch. Placing the patch beneath the damaged sheet generally eliminates this potential.

5.5 Geosynthetic Clay Liner (GCL) Protection

Operation of construction equipment on the GCL will be minimized to reduce the potential for damage or puncture. Vehicles, other than low contact pressure vehicles, are not allowed on deployed GCL. Deployed GCL panels should contain no folds or excessive slack. The GQCP or their representative will verify that generators, tools, or supplies are not be stored directly on GCL. Deployed GCL must not be used as a work area unless a protective tarpaulin is placed over the GCL. Installation personnel must not smoke or wear damaging shoes when working on the GCL.

5.6 Interface with Geomembrane

Upon completion of GCL installation, the geomembrane should be installed as soon as possible. When deploying the geomembrane on top of the GCL, extra care must be taken to ensure that the GCL and underlying lining materials are not damaged, minimal slippage of GCL on underlying layers occurs, and no excess tensile stress occurs on the GCL.

Special precaution should be taken if textured geomembrane will be installed directly over the GCL. Because considerable friction may develop between the geomembrane and the GCL, it may be difficult to pull the geomembrane into position for welding to adjacent panels. A smooth "slip sheet" should be used to provide a low-friction sliding surface for the geomembrane until it is in position for welding.

6 GEOMEMBRANE INFILTRATION LAYER REQUIREMENTS (SUBTITLE D AREA)

Any geomembrane infiltration layers that are constructed as part of a composite final cover system will have continuous on-site inspection during construction by the GEP or his/her Qualified Engineering Technician. All field sampling and testing, both during construction and after completion of the infiltration layer construction, will be performed under the observation of the GEP or his/her Qualified Engineering Technician.

Geomembrane material will be LLDPE (linear low-density polyethylene), or other equivalent geomembrane material approved by TCEQ in the event LLDPE is no longer manufactured.

The geomembrane must have a minimum thickness of 40 mils. Approved geomembrane material used must overlay and be in direct contact with an approved subgrade soil or geosynthetic material.

6.1 LLDPE Material Requirements

1. Geomembrane infiltration layer material must be produced from virgin raw materials. Reground, reworked or trim materials from the same lot may be acceptable but recycled or reclaimed materials must not be used in the manufacturing process.

2. LLDPE material and required welding rods will contain between 2% and 3% carbon black and may contain no more than 1% other additives.

3. Geomembrane sheet must be free from pinholes, surface blemishes, scratches, or other defects (e.g., non-uniform color, streaking, roughness, agglomerates of carbon black or other additives or fillers, visibly discernible regrind or rework, etc.).

4. The geomembrane used will meet, at a minimum, the standards included in the Geosynthetic Research Institute (GRI) Test Method GM-13, Revision 4 dated December 13, 2000.

5. Resin documentation, including density and melt flow index, will be submitted for resins used.

6. All LLDPE geomembrane material will be shipped in rolls. Folded or creased sections of panels are not acceptable and will not be used unless they are a normal part of the manufacturing process.

7. The GEP or his/her Qualified Engineering Technician will inspect the delivered materials for damage and defects. Pushing, sliding or dragging of rolls or pallets can cause damage and should be avoided.

8. Geomembrane material must be protected from soft or wet ground and rocky or rough ground. LLDPE geomembrane must not be stacked more than five (5) rolls high (or as recommended by the manufacturer) to avoid crushing the cores of the rolls. A sacrificial cover must be used to protect the geomembrane if store on-site for more than six (6) months. The rolls and pallets must be stored in such a manner to avoid shifting, abrasion, or other adverse movements that can damage the geomembrane infiltration layer material.

6.2 LLDPE Preconstruction Testing

The geomembrane manufacturer conducts many tests throughout the manufacturing process and after the geomembrane is produced. The manufacturer's test may include thickness, specific gravity, carbon black content, carbon black dispersion, tensile properties, tear and puncture resistance, oxidation induction time, oven aging, UV resistance, volatile loss, resistance to soil burial, stress cracking resistance, and dimensional stability.

1. All geomembrane sheets and seams will be tested and evaluated prior to acceptance. In general, testing of the geomembrane will be conducted by the manufacturer prior to shipping. Manufacturer testing will be performed in accordance with Table 3, on the following page.

2. The GEP or his/her Qualified Engineering Technician or IGL may perform additional testing as required by these detailed Specifications or as required in the judgement of the GEP or his/her Qualified Engineering Technician or to verify that the geomembrane sheet and seams meet the specifications. At a minimum, the GEP or his/her Qualified Engineering Technician or IGL, will perform conformance testing at the frequencies indicated in Table 3 and these specifications.

3. The Installer or supplier (manufacturer) will be required to submit his Quality Control results for each roll of geomembrane and each separate resin used in manufacturing to the GEP or his/her Qualified Engineering Technician.

4. As a minimum, the Installer will perform the tests at the frequencies given in Table 3.

5. Test results will be submitted to the GEP or his/her Qualified Engineering Technician, who will review and confirm the geomembrane material meets specifications prior to installation of a geomembrane sheet.

TABLE 3
Standard Tests on LLDPE Geomembrane Material

TEST	TYPE OF TEST	STANDARD TEST METHOD	FREQUENCY OF TESTING
Resin (LLPDE)	Density	ASTM D1505	1 test per 100,000 sq. ft. and every resin lot
	Melt Flow Index	ASTM D 1238 (90/2.16 and 190/21.6)	
Manufacturer's Quality Control	Testing per GRI Test Method GM 17 for LLDPE[1]		
Conformance Testing by Third Party Independent Laboratory	Thickness[2]	ASTM D5199 (Smooth LLDPE), D5994 (Textured LLDPE)	1 test per 100,000 sq. ft. and every resin lot
	Specific Gravity/Density	ASTM D1505/D792 (LLDPE)	
	Carbon Black Content	ASTM D1603	
	Carbon Black Dispersion	ASTM D5596	
	Tensile Properties	ASTM D63832 Type IV	
Destructive Seam Field Testing	Shear and Peel	ASTM D4437	Varies for field, lab, and archive
Non-destructive Seam Field Testing	Air Pressure	GRI GM6	all dual-track fusion
	Vacuum (LLDPE)	ASTM D4337	all non-air pressure tested seam when possible

[1] GRI Test Method GM 17 can be found in Attachment A of this plan.

[2] Field thickness measurements for each panel must be conducted. Use ASTM D374/D5994 and perform 1 series of measurements along the leading edge of each panel, with individual measurements no greater than 5 feet apart. No single measurement shall be less than 10% (for LLDPE) below the required normal thickness in order for the panel to be acceptable.

[3] Break Elongation calculated using 2-inch initial gauge length.

6.3 Geomembrane Installation

A. General

1. The geomembrane infiltration layer will be installed as soon as practical after completion of the soil infiltration layer and associated testing. Each sequential section of geomembrane will be secured

in an anchor trench and continuously welded to the adjacent sections.

2. The geomembrane should not be placed during inclement weather such as rain, high winds or freezing temperatures.

3. No vehicular traffic will be allowed on the geomembrane prior to placement of the erosion or drainage layers. Only low-ground pressure equipment (e.g. golf carts, ATVs or other small rubber tired equipment with a ground pressure less than 5 psi and a total weight of less than 750 pounds) may be allowed to traverse the geomembrane.

4. If supporting equipment is operating on the geomembrane, it must be placed on a sacrificial surface or rub sheet in order to help protect the geomembrane. Personnel working on the geomembrane will not smoke, wear damaging shoes, or engage in any other activity likely to damage the geomembrane.

B. Preparation

1. Areas to receive geomembrane infiltration layer installation will be relatively smooth and even and free of rocks which may damage the membrane and/or desiccation cracks which may affect the integrity of the soil infiltration layer.

2. The surface of the subgrade must be finished by rolling with a flat wheel roller until a smooth uniform surface is achieved. Prior to geomembrane installation, the condition of the subgrade must be deemed suitable for geomembrane installation by the GEP or his/her Qualified Engineering Technician and the installer.

3. The soil subgrade must be protected from desiccation and cracking, rutting, erosion, and ponding prior to and during placement of the geomembrane. The condition of the subgrade must be preserved by regular watering and proof-rolling or by placing a minimum of twelve inches (12") of temporary soil cover which must be removed prior to geomembrane placement and the soil subgrade surface reassessed by the GEP or his/her Qualified Engineering Technician.

C. Placement

1. Installation of the geomembrane will be as follows:

   a. Unroll only those sections, which are to be seamed together or anchored in one day. Panels will not be placed in inclement weather such as rain or high winds. Panels will be positioned with the overlap recommended by the manufacturer, but not less than 3 inches. The edge of the upslope sheet will be positioned above the edge of the downslope sheet. The geomembrane sections will be placed in an anchor trench which is then backfilled with soil compacted to 90 percent of the maximum dry density as determined by the Standard Proctor Compaction Tests (ASTM D 698).

b. After panels are initially in place, remove as many wrinkles as possible. Unroll several panels and allow the infiltration layer to "relax" before beginning field seaming. The purpose of this is to make the edges, which are to be bonded as smooth and free of wrinkles as possible. The number of rolls deployed ahead of seaming operations will be at the discretion of the Installer.

2. Thickness confirmation will be performed by the GEP or his/her Qualified Engineering Technician in the field on every roll of geomembrane to be installed. Field micrometer measurements will be performed in five feet increments along the leading edges of each geomembrane.

D. Trial Seams

1. Testing of trial seams will be conducted by the Installer under observation by the GEP or his/her Qualified Engineering Technician.

2. The Installer will maintain and use equipment and personnel at the site to perform testing of test seams.

3. A test seam will be made for each seaming apparatus to be used in field seaming. If more than one seaming technician uses the same apparatus, a separate test seam will be made for each apparatus/technician combination that will perform field welding. Test seams will be made each day prior to commencing field seaming. These seams will be made on fragment pieces of geomembrane infiltration layer to verify that seaming conditions are adequate. Time, tip temperature, and seamer name will be recorded for each trial seam.

4. Such test seams will be made at the beginning of each seaming period, such as morning start-up and after mid-day or lunch break. Tests seams will also be made for each occurrence of significantly different environmental condition such as temperature change, humidity, dust, etc., any time the machine is turned off for more than 30 minutes; and when seaming different geomembranes (tie-ins and smooth to textured) At the GEP's or his/her Qualified Engineering Technician's discretion, additional trial seams may be required. Each seamer will make at least one test seam each day.

5. The test seam sample will be at least 3-feet (0.91 meter) long by 1-foot wide (0.30 meter) with the seam centered lengthwise. Four (six when possible if using dual track fusion welding) adjoining 1-inch wide specimens will be die cut from the test seam sample. Two (2) specimens will be tested in the field for shear and two (2) for peel (4

when possible if testing both inner and outer welds for dual track fusion welding).

6. The extentiometer testing apparatus used for peel and shear tests must have an updated calibration certificate traceable to National Bureau of Standards (NBS).

7. Test seams will be tested by the Installer under observation of the GEP or his/her Qualified Engineering Technician. The specimens will not fail in the weld.

8. Failure criteria is the same as that for destructive seam testing outlined in Section 6.F.2.

9. If a test seam fails, the entire operation will be repeated. If the additional test seam fails, the seaming apparatus or seamer will not be accepted and will not be used for seaming until the deficiencies are corrected and two consecutive successful test seams are achieved.

E. Field Seaming

Field seaming (and repairs) will be performed in strict accordance with methods approved by the manufacturer. Strict attention to the details of seam preparation procedures recommended by the manufacturer is crucial in order to produce consistent seams that will not allow fluid leakage and will pass QA testing.

1. All foreign matter (dirt, water, oil, etc.) will be removed from the edges to be bonded. No solvents will be used to clean the geomembrane infiltration layer.

2. For extrusion-type welds, the bonding surfaces must be thoroughly cleaned by mechanical abrasion or alternate methods approved by the GEP or his/her Qualified Engineering Technician to remove surface cure and prepare the surfaces for bonding. The grinding will be performed so that grind marks are generally perpendicular to the edge of sheet.

3. Tack welds (if used) will use heat only; no double sided tape, glue, or other method will be permitted. The geomembrane will be seamed completely to the ends of all panels to minimize the potential of tear propagation along the seam. Excessive overgrind, as determined by the GEP or his/her Qualified Engineering Technician, will be repaired.

4. Field seaming may be performed by extrusion or fusion welding or a combination of these methods. Extrusion welding applies a molten bead of material to the leading edge of the seam between sheets of geomembrane. The fusion welding process heats the area to be joined to the melting point and then applies pressure to join the melted surfaces. Solvent welding is not acceptable.

5. The sheets should be positioned with the overlap recommended by the manufacturer, but not less than 3 inches for LLDPE.

6. The seams will be oriented generally parallel to the line of maximum slope, i.e., oriented up and down, not across, the slope. In corners and odd shaped geometric locations, the number of field seams will be minimized.

7. Seams on side slopes (steeper than 6H:1V) should be oriented parallel to the sideslip direction. Seams that join the side slopes and top or bottom sections should be located at least five feet (5') from the sideslip. In corners and odd-shaped geometric locations, the number of field seams should be minimized.

8. No seaming will be attempted above 40°C (104°F) ambient air temperature. Below 5°C (41°F) ambient air temperature, preheating of the geomembrane will be required, unless it is demonstrated that this is not necessary (i.e., acceptable trial test (start-up) seams which duplicate, as closely as possible, actual field conditions). Preheating may be achieved by natural and/or artificial means (shelters and heating devices). Ambient temperature is measured 18 inches above the infiltration layer surface.

9. A moveable protective layer of plastic may be required, as recommended by the GEP or his/her Qualified Engineering Technician, to be placed directly below each overlap of geomembrane that is to be seamed. This is to prevent any moisture build-up between the sheets to be welded.

10. Seaming will extend to the outside edge of panels to be placed in anchor trenches.

11. If required, a firm working surface will be provided by using a flat board, a conveyor belt, or similar hard surface directly under the seam overlap to achieve proper support.

12. Seams at panel corners of 3 or 4 sheets will be completed with a patch having a minimum dimension of 24 inches, extrusion welded to the parent sheet.

13. No folds, large wrinkles, or fish mouths will be allowed in the seam. Only normal factory-induced creasing from the blown film process may be acceptable. Where wrinkles or folds occur, the material will be cut, overlapped, and welded. This process should be accomplished in such a manner that constructed seams are not required to carry significant tensile loads. During wrinkle or fold repairs, adjacent geomembrane may not necessarily be required to meet the 3 to 4-inch minimum overlap if approved by the GEP or his/her Qualified Engineering Technician.

14. All complete seams will be tightly bonded and sealed.

F. Field Testing - Geomembrane Infiltration Layer

All geomembrane seams will be tested and evaluated prior to acceptance. The GEP or his/her Qualified Engineering Technician will observe all production seam field test procedures. Testing of the seams will be conducted by the Installer under observation by the GEP or his/her Qualified Engineering Technician. At his discretion, the GEP or his/her Qualified Engineering Technician may have additional testing performed to verify that the geomembrane seams meet the specifications.

1. Non-Destructive Testing

Continuous, non-destructive testing will be performed on all seams by the installer. Air-pressure testing on dual-track fusion welds and vacuum-box testing on extrusion welds are the only acceptable methods for LLDPE geomembrane seams. All factory seams, in addition to field seams, should be non-destructively tested. All indicated leaks must be isolated and should be repaired by following the procedures described in Section 6.G, below.

a. Air-Pressure Testing

The ends of the air channel of the dual-track fusion weld must be sealed and pressured to approximately 30 psi. The air pump must then be shut off and the air pressure observed after 5 minutes. A loss of less than 4 psi is acceptable if it is determined that the air channel is not blocked between the sealed ends. A loss equal to or greater than these pressure indicates the presence of a seam leak which must then be isolated and repaired by following the procedures described in Section 6.G, below. The GEP or his/her Qualified Engineering Technician should observe and record all pressure gauge readings.

b. Vacuum-Box Testing

A suction value of approximately 3 to 5 inches of gauge volume must be applied to all extrusion welded seams that can be tested in this manner. Examples of extrusion welded seams that do not easily lend themselves to vacuum testing would be around boots, appurtenances, etc. The seam must be observed for leaks for at least 10 seconds while subjected to this vacuum. The GEP or his/her Qualified Engineering Technician must observe 100% of this testing.

c. Other Testing

Other non-destructive testing must have prior written approval from the TCEQ.

2. Destructive Testing

Destructive testing will be performed at least once within each 500 linear feet of production seam. The locations will be selected by the GEP or his/her Qualified Engineering Technician in such a manner as to representatively sample the geomembrane seam quality for the entire installation. Repairs greater than 10 feet in length must be counted in determining the total seam length for testing. At a minimum, a destructive test will be performed for each welding machine used for seaming or repairs.

A sufficient amount of the seam must be removed in order to conduct field testing, independent laboratory testing, and archiving of enough material in order to retest the seam when necessary. Field testing will include at least two (2) peel test specimens (four (4) when possible fo testing both tracks on dual-track fusion welded seams). Independent laboratory testing will consist of five (5) shear test specimens and five (5) peel test specimens (10 when possible for both tracks of dual-track fusion seams). Destructive seam-testing locations will be cap-stripped and the cap completely seamed by extrusion welding LLDPE to the parent geomembrane. Capped sections will not be non-destructively tested. Additional destructive test samples may be taken if deemed necessary by the GEP or his representative.

a. Passing Criteria

Field-tested specimens from destructive-test location must pass in both shear and peel for the seam to be considered passing. Field-tested specimens are determined as passing if the specimen tested in peel fail in film tear bond (FTB) and all test specimens meet the criteria listed in this subsection. Independent laboratory testing must confirm these field results.

The minimum passing criteria for independent laboratory testing are as follows:

- At least 4 of 5 specimens tested in the peel mode must fail in FTB
- At least 4 of 5 specimens from each peel and sheer determination must meet the minimum specified values given in parts 1 and 2 of this subsection, below.
- The average value of the 5 specimens from each peel and sheer determination must meet the minimum specified value given in parts 1 and 2 of this subsection, below.

1. Sheer Requirements - For LLDPE, the shear strength must meet the manufacturer's specifications and GRI or PGI Standards as applicable.

2. Peel Requirements - For LLDPE, the peel strength must meet the manufacturer's specifications and GRI or PGI Standards as applicable.

The above criteria must be met by both tracks from each dual-track fusion welded seam before it is considered passing.

Test methods and frequency of testing for geomembrane are found in Table 1. It should be noted that geomembrane manufacturers may have differing values for their geomembrane sheets and, therefore, the specific values are not stated in this plan, only percentages. Consequently, the manufacturer's sheet-strength values must be provided to determine if the test results are passing.

b. Failing Criteria

If less than 4 of the 5 specimens from each destructive test pass, or if the average calculated from all 5 specimens is less than the specified values given in Table 2, or if more that one (1) specimen of LLDPE from the group of 5 specimens exhibits a non-FTB failure, the seam has failed.

If unresolved discrepancies exist between the GEP's or his/her Qualified Engineering Technician's and Installers's test results, the archived sample may be tested by the GEP or his/her Qualified Engineering Technician.

G. Non-Conforming Test Results

1. Samples, which do not pass the shear and peel tests will be re-sampled from locations at least 10 feet on each side of the original location. These two re-test samples must pass both shear and peel testing. If these two samples do not pass, then additional samples will continue to be obtained until the questionable seam area is defined.

2. If desired, it is acceptable to cap strip the non-conforming seam length with the cap strip extending the entire length between two passing seam tests.

3. Damaged and sample coupon areas of geomembrane will be repaired by the Installer by construction of a cap strip. The cap strip will extend a minimum of 6 inches in all direction from the area of concern.

4. No repairs will be made to seams by application of an extrusion bead to a seam edge previously welded by fusion or extrusion methods. Spot welding and extrusion beads may be used to repair surface flaws or irregularity.

5. Repaired areas will be non-destructive tested for seam integrity. At the discretion of the GEP or his/her Qualified Engineering Technician, destructive tests may be conducted on the repaired areas.

H. Anchor Trench and Backfilling

The anchor trench will be completed around all portions of the geomembrane where the leading edge(s) of the geomembrane will not be needed for a tie-in for the next area to receive final cover. The excavated anchor trench will have rounded corners in order to help protect the geomembrane. No loose soil will be allowed to underlie the geomembrane in the anchor trench. Excavation of the anchor trench will not be done too far in advance of geomembrane deployment.

The anchor trench will be backfilled and compacted to at least 90 percent of the density determined by the moisture/density compaction values detailed in Section 4 of this plan. Care should be used when backfilling and compacting the trench to prevent damage to the geomembrane. The anchor trench will be backfilled at the earliest practicable time following synthetics deployment. Results of the compaction testing need not be reported.

I. Survey Control

The edge locations of the geomembrane (interior upper edge of the anchor trench) will be documented by survey methods.

7 DRAINAGE LAYER REQUIREMENTS (SUBTITLE D AREA)

A geocomposite drainage layer will placed between the erosion layer and the geomembrane infiltration layer to reduce storm water infiltration into the waste and to enhance the overall stability of the final cover by removing water which percolates through the erosion layer. The geocomposite will consist of 200-mil HDPE drainage netting heat bonded to 10 oz geotextile filter fabric. Double-sided geocomposite will be placed on side slopes and single-sided geocomposite on top slopes.

All materials placed over the geomembrane should be placed during the coolest part of the day and deployed in "fingers" along the surface to control the amount of slack and minimize wrinkles and folds in the geocomposite. These materials must be deployed only up-slope on the side slopes so that stress imparted to the geomembrane is minimized. Full-time observation by the GEP or his/her Qualified Engineering Technician is required during deployment of the geocomposite drainage material.

Materials, placement procedures, and construction quality assurance for geocomposite will be in accordance manufacturer's recommendations.

8 EROSION LAYER REQUIREMENTS (ALL AREAS)

An erosion layer, consisting of a minimum of 24 inches of earthen material which is capable of sustaining native plant growth, will be placed over the infiltration layer. The erosion layer will be seed or sodded immediately after completion of the final cover. Temporary or permanent erosion control measures may be used to minimize erosion and aid establishment of vegetation.

The erosion layer will be placed using any appropriate equipment capable of accomplishing the work and should receive only the minimal compaction required for stability. The thickness of the erosion layer will be verified by survey methods at a frequency of one (1) verification point every 10,000 ft^2. Other quality assurance for the erosion layer should consist of continuous observation by the GEP or his/her Qualified Engineering Technician during construction, and performing additional tests felt necessary by the GEP to verify that the erosion layer has been constructed in accordance with the Final Closure Plan.

9 DOCUMENTATION

In accordance with 30 TAC, §330.253(e)(6), documented certification of closure must be submitted to the TCEQ upon completion of closure activities for a MSW site or MSWLF unit. The certification will be signed by the GEP and include a Final Cover System Evaluation Report with all documentation necessary for certification of closure.

All final cover quality assurance/quality control testing must be performed in conformance with this plan. Data from all testing will be submitted in the FCSER.

Each FCSER submittal will include:

1. A discussion of construction of each of the final cover elements;
2. A clearly legible final cover placement map that depicts the site grid system, graphic scale, north arrow, area(s) covered by current submittal, and areas covered by all previous FCSER submittals with the dates of acceptance by the TCEQ;
3. All field and laboratory test documentation for soil infiltration layers including a sample location plot plan;
4. Manufacturer's certification, documentation of all manufacturer's and independent testing, seaming and repair records, and seam tests for any geomembrane used;
5. A geomembrane panel layout drawing showing locations of panels, repairs and tests for any geomembrane used;
6. Manufacturer's certification and testing documentation for any geosynthetic used; and
7. A GCL panel layout drawing locations of panels and repairs for any GCL used;
8. Manufacturer quality control test results and conformance test results for any GCL used;

9. All subgrade acceptance documentation;

10. Survey documentation detailing as-built subgrade elevations, thickness of soil infiltration layers and erosion layers.

All field and laboratory sampling and testing of components of the infiltration layer and its construction should be under the direct supervision of the GEP of his/her Qualified Engineering Technician. Any completed final cover area that fails to meet the minimum specified conditions of the required tests should be replaced (seam or liner flaw, etc. patched) or reworked, as appropriate, to achieve the required results. Inability to achieve the required results through reworking may be cause for rejection of the area in question. All reworked areas should be retested to prove adequacy to meet all applicable requirements.