RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services

Permit No.	Date	Document ID No.
94-04	**January 22, 2010**	**9360**

January 15, 2010

Mr. Ming-Tai Chao, P.E.
Environmental Engineer II
NC DENR - Division of Waste Management
401 Oberlin Road, Suite 150
Raleigh, NC 27605

RECEIVED
January 19, 2010 via Hand delivery
Solid Waste Section
Raleigh Central Office

Re: Washington County C&D Landfill (Permit No. 94-04)
Permit Application for Continued Operations
Response to Comments

Dear Mr. Chao:

On behalf of Washington County, Richardson Smith Gardner & Associates, Inc. (RSG) would like to respond to the comments in your letter dated December 19, 2008 (see **attached**), as follows. The comments stated in your letter are repeated below in *italics* and our response follows in **bold**.

Permit Amendment (5-year Review) Application (March 2005) (The Wooten Company)

1. *Please describe the history and current status of the tire mono-fill which is on the immediately east side of the C&DLF unit. According to the Closure and Post Closure Plan (RSG, 2008), the tire mono-fill will be converted to a C&DLF unit, please provide data to verify if there is sufficient quantity of earthen material from the existing on-site the borrow source to meet the need for cover (weekly and final covers) material.*

   RSG has completely revised the permit amendment application for the next phase of development (Phase 2). Please see the attached Permit Amendment application.

   According to County records, the County ceased disposal of tires in the tire monofill in January 2001.

2. *The Item f. of Section 5.0 Solid Waste Management Compliance Data in the approved Construction Plan Report (Diehl & Phillips, P.A., dated August 3, 1995) reported that "a sediment and erosion control plan (the Plan) will be submitted to the North Carolina Division of Land Resources (NCDLR) with the Construction Plans." Has this Plan been approved by the NCDLR? Please provide the NCDLR approved letter and approved Plan as a portion of the permit application document.*

   A copy of the requested approval letter dated July 10, 1995 is attached. Based on available information, this approval was for the plan submitted by Diehl & Phillips, P.A. Once comments are completed for this application, the County plans to submit the updated erosion and sedimentation control plan (see Attachment F of the attached revised Permit Amendment application) to the Division of Land Resources for approval.

3. *Please provide the following information, but not limited to:*

- *The types of wastes allowed and permitted to accept at the C&DLF facility.*
- *Average yearly disposal rates in ton and a representative daily rate that is consistent with the Washington County Board of Commissioners.*
- *The area served by the C&DLF facility.*
- *Remaining landfill capacity, projected active life of the C&DLF, and 5-year phased development.*

Please refer to the Facility and Engineering Plan (Attachment A of the attached revised Permit Amendment application).

4. *Please provide the updated operations plan of the C&DLF in accordance with the requirements stated in Rule .0542. A landfill gas control plan or landfill gas management plan (See Comment 22) appended to the Operations Plan must be prepared in accordance with Rule .0544(d).*

Please refer to the Operations Manual (Attachment D - Section 3.4 of the attached revised Permit Amendment application).

5. *According to the Division's Facility Compliance Audit Report dated May 11, 2007, a pad to store white goods was proposing to construct at the landfill property. Please show the proposed or as-built pad location on the facility drawings.*

Please refer to the Permit Drawings (Attachment G of the attached revised Permit Amendment application) for location of the now existing pad.

6. *Please describe the operation plan for managing the white goods. The plan may include, but not limited to, prevention from surface water to contact wastes, removal of Freon from white goods, the maximum tonnage will be allowed to store at any time at the facility, the estimated tonnage per month, the contact information of a contractor or recycler to handle, off-site transportation, and/or recycle the white goods, and the frequency or schedule to remove the white goods off-site.*

Please refer to the Operations Manual (Attachment D - Section 2.6 of the attached revised Permit Amendment application).

7. *According to the Closure and Post Closure Plan (RSG, 2008), the tire mono-fill will be converted to a C&DLF unit; please provide information if the C&DLF facility will accept used tires in the present and future. If does, please provide the operation plan for managing the scrap tires. The staging area needs to be shown on the facility drawing. The plan may include, but not limited to, prevention from surface water to contact wastes, the maximum tonnage will be allowed to store at any time at the facility, the estimated tonnage per month, the contact information of a contractor or recycler to handle, off-site transportation, and/or recycle the white goods, and the frequency or schedule to remove the waste tires off-site.*

Used tires are accepted at the facility and loaded into one or more trailers for removal by a tire recycler (please refer to the Operations Manual - Attachment D - Section 2.7 of the revised Permit Amendment application.).

8. *Please describe the operation plan for managing the wood waste processing area (or formally called Washington County Land Cleaning and Inert Debris Area).*

Please refer to the Operations Manual (Attachment D - Section 2.8 of the attached revised Permit Amendment application).

9. *Comments related to sampling, analysis, and monitoring of groundwater, surface water. The closure and post-closure requirements for C&DLF facilities [Rule .0543 (e)(B)] require the facility to monitor the ground water and surface water in accordance with the requirements of Rules .0544 through .0545 of the Section and maintaining the groundwater monitoring system. Additionally, Monitoring Plans and Requirements for C&DLF facilities [Rule .0544] require that a groundwater monitoring plan and surface water monitoring plan must be submitted, including information on the groundwater monitoring system, sampling and analysis requirements, and detection monitoring requirements that fulfills the requirements of Part (1) (A) through (1) (E) of this section must be submitted.*

The facility therefore, must submit a groundwater and surface water monitoring plan in the revised permit renewal application, including an updated Sampling & Analysis Plan. The NC Solid Waste Section guidelines for groundwater, soil, and surface water sampling may be found at http://www.wastenotnc.org/swhome/enviro_monitoring.asp.

The guidelines are located under the subcategory Environmental Monitoring and include the following pertinent documents:

"Groundwater, Surface Water, and Soil Sampling for Landfills"
"Leachate Sampling and Analysis"
"Solid Waste Environmental Monitoring Data Form"
"Electronic Data Deliverable (EDD) Template"
"October 2007 Memo"
"October 2006 Memo"
"Addendum to October 2006 Memo"

Please note that the above documents provide guidance primarily for sampling and analysis of groundwater and surface water samples.

Please refer to the Water Quality Monitoring Plan (Attachment H of the attached revised Permit Amendment application).

10. *The Spring 2008 Groundwater Monitoring Report for the Washington County C&D Landfill reported that survey data for the groundwater monitoring wells was unavailable. In order to accurately determine groundwater elevations for each monitoring well, the wells must be surveyed by a NC Registered Land Surveyor. Please provide the well survey data in accordance with Rule .544(b)(1)(F). Additionally, the survey data must be incorporated into the next semiannual groundwater monitoring report with an evaluation of potentiometric surface and groundwater flow direction.*

A survey of on-site wells has been completed. Please refer to Table 1 of the Water Quality

Monitoring Plan (Attachment H of the attached revised Permit Amendment application).

Attachment B - Closure Plan (RSG, June 2008)

11. *(Section 1.3 & CQA in Attachment A) The Rule .0543(c)(1) requires the cap having" a permeability less than or equal soils underlying the landfill, or the permeability specified for the final cover in the effective permit, or a permeability no greater than 1.0 x 10^{-5} cm/sec,* ***whichever is less****." The permeability of a foundation soil underneath the C&DLF was tested and reported in the "Site Application Report for Proposed Construction and Demolition Waste Landfill and Tire Monofill for County of Washington" dated October 31, 1994 and approved by the Division on February 17, 1995. The foundation soil - upper clay, (UD #1) in Table 7 and Section 5.8.2 of the above-referenced Application was reported having a permeability of 5.0 x 10^{-6} cm/sec; therefore, the permeability of any liner material of the proposed final cover for the C&DLF shall be less than or equal to 5.0 x 10^{-6} cm/sec. Please revise the liner criterion in the Closure Plan (including Close Estimate) and CQA Plan in Attachment A.*

Based on our review of the Site Application and an evaluation of near-surface conditions around the landfill unit, the near-surface soils are predominantly clean sands, which have permeability values well in excess of 1 x 10^{-5} cm/sec. Also, due to the apparent lack of fine grained soils on-site, an alternative final cover system is proposed in the revised application.

12. *(Section 1.3) Please provide the slope stability analysis data (including the veneer slope stability and global stability) to support the final cap design. And the soil engineering properties including shear strength, density, internal friction angle used for designing the final soil cover system must be considered as the minimum criteria to select the earthen or synthetic material and be field tested in according to the requirements specified in the Construction Quality Control and Quality Assurance (CQA) Plan.*

A global slope stability analysis is provided in the Facility and Engineering Plan (Attachment A of the attached revised Permit Amendment application). The addition of the cover system to the global stability analysis will have no bearing on the results.

Interface shear strength is expressed in terms of Mohr-Coulomb shear strength parameters based on the following equation:

$$\tau = \sigma \tan \phi + c$$

where:
- τ = **shear strength (psf)**
- σ = **applied normal load (or stress) (psf)**
- ϕ = **friction angle (degrees)**
- c = **cohesion/adhesion (psf).**

Normally, the required shear strength values are specified by the design engineer which correspond to the values required to achieve the minimum allowable factor(s) of safety in the slope stability evaluation. For low normal loads (< 1,000 psf), the required shear strength values are typically determined using a veneer stability analysis. The simplest way

to evaluate veneer stability is to use the infinite slope equation:

$$FS = \frac{\tan\phi}{\tan\delta}$$

where: FS = **factor of safety**
ϕ = **friction angle (typ. secant angle to peak resistance) (degrees)**
δ = **maximum slope angle (degrees).**

A veneer stability analysis as described above is not required for either the geosynthetic portion of the final cover or the soil portion of the final cover for the following reasons:

A. **The geosynthetic portion of the final cover is proposed at a 10% slope (5.7 degrees). Considering an infinite slope analysis and a minimum factor of safety of 1.5, the geosynthetics would have a factor of safety of 1.5 for a minimum interface shear strength as defined by a phi angle of 8.6 degrees (1.5 x 5.7 degrees). For the geosynthetics specified, typical interface shear strength values would be well in excess of 15 degrees (= interface shear strength of approx. 55 psf under 200 psf normal load) (FS = 2.7). To address any concerns, minimum shear strength criteria has been included in the geosynthetics specifications (Reference Table 1 of specification Sections 02712, 02776, and 02778 in Attachment B of the application).**

B. **A veneer stability analysis is not appropriate for the soil cover proposed as the main mode of failure would be erosion - not sliding. Thus, there is no need to specify shear strength parameters for soil layers.**

13. *(Section 1.3, Table 3.1, & CQA in Attachment A) Will there be an intermediate soil cover to be placed, compacted, and graded for surface flow over the C&D wastes prior to install the final cap system? Is the costs of $7,000 for "surface preparation" (See Table 3.1 – Closure Cost Estimate) used for the construction of intermediate soil cover? If so please provide the specification for the construction of the intermediate soil cover and make necessary correction to the details of "Final Cover System" on Figure 3. Please clarify.*

Intermediate cover will be placed as part of operations. The surface preparation line item in the closure cost estimate is for stripping of existing vegetation and general grading of the intermediate cover prior to placement of the final cover system.

14. *(Section 1.5.2, the last sentence on Page 1.0-3) The Closure Plan proposes to use sediment removed from surface water system as daily or intermediate cover. The question is how the removed sediment can be disposed of at the closed landfill. Please clarify.*

This statement covers the case where there is an active landfill unit on-site. It is understood that sediment cannot be disposed of in a closed landfill.

15. *(Section 1.6) Please add the closure notification requirements in accordance with Rule .0543(c)(4) to the proposed Closure Plan.*

Section 1.6 has been revised accordingly.

16. *(Section 1.7) Please describe (i) where to record a notation on the deed and (ii) the requirement of informing the Division upon completion of placing notation on of deed of landfill facility property.*

Section 1.7 has been revised to indicate that deed notations will be recorded with the County Register of Deeds and that the DWM will be notified.

17. *(Table 3-1) Is there a "shrinkage factor" used to calculate the quantity of soil cap system components? What is the assumption of the soil sources - from the on-site or off-site borrow sources? Please clarify.*

The quantities shown are in-place quantities. It is expected that all soil will come from current or future borrow areas located on site.

18. *(Table 3-1) What are the temporary and permanent erosion controls to be constructed during the period of site closure? Please provide an Erosion and Sediment Control Plan and detailed drawings related to the closure activities.*

Please refer to the Erosion and Sedimentation Control Plan (Attachment F of the attached revised Permit Amendment application).

Attachment C - Post-Closure Plan (RSG, June 2008)

19. *(Section 2.4) Please add maintenance requirements for the access road to all monitoring points. The costs for road maintenance need to include in the cost estimate Table 3.2.*

Section 2.3 has been revised to reference the maintenance of access to site monitoring locations through the post-closure period. Table 3.2 has been also revised to add cost for the maintenance of access roads.

20. *(Section 2.4.2) Please describe the requirements for mowing, re-vegetation, and fertilization (See cost items in Table 3.2) to encourage the growth and establish healthy vegetation on the final cover during the post-closure period.*

Specification Section 02930 (Revegetation) covers the establishment of vegetation at the time of closure. Section 2.4.2 has been revised to reflect vegetative requirements also.

21. *(Section 2.4.5) Please provide the "current" Landfill Gas Management Plan, which is not available in 2005 permit application document.*

Section 2.4.5 has been changed to Section 2.4.6 as the result of the addition of Section 2.4.4 to discuss leachate seeps. Reference to a "landfill gas management plan" has been deleted

as there is not a separate plan for this at the present time.

22. *(Table 3.2 – Post-Closure Cost Estimate) Please verify the quantity for groundwater/ surface water monitoring & reporting. Four wells will be sampled semi-annually; therefore, the "quantity" shall be eight (8).*

Table 3.2 has been revised to reflect 2 monitoring events each year.

Attachment A - CQA Plan and Specification (RSG, June 2008)

23. *Please add specifications for construction of intermediate soil cover [or Subgrade preparation for soil liner – (Section 02250, item D.4.)], erosion and sediment control, re-vegetation, and passive gas vent.*

Please refer to the Technical Specifications (Attachment B of the attached revised Permit Amendment application). Note that the specifications have been modified to reflect the use of an alternative cover as described in the Facility and Engineering Plan (Attachment A of the attached revised Permit Amendment application).

24. *(Section 02250) Item C.2. describes the specifications for the off-site borrow sources only; what about the on-site borrow sources? The Division believes the proposed soil liner specification needs to be applicable to both on-site and off-site borrow sources. Please clarify.*

Section 02250 (Soil Liner) has been deleted from the specifications as it is not a part of the proposed alternative cover.

25. *(Section 02250, Tables 1 & 2) (See Comment 11) Please revise the criterion of hydraulic conductivity of soil liner to 5.0×10^{-6} cm/sec.*

See response to Comment 24.

26. *(Section 02250, Table 2) Based on the experiences from waste industry, the maximum lift thickness in a loose condition is 9 inches, and the maximum lift thickness in final compacted condition is 6-inches. The proposed maximum lift thickness (compacted) is not acceptable. Please revise the criterion accordingly.*

See response to Comment 24.

27. *(Section 02250, Table 2) Please add the minimum values of soil density and friction angle and shear strength of soil liner to the specification (See Comment 13). Please also add test frequency (Number of test per lift per acre) to Table 2. This comment is also applicable to the specification for Subgrade for soil liner.*

See response to Comment 24.

28. *(Section 02258) Please add the minimum values of soil density and friction angle and shear strength of vegetative soil layer to the specification the item D. (See Comment 13). The testing*

methods and frequencies needs to be specified in Section 02258 as well.

Per the response to Comment 12, a veneer stability analysis is not appropriate for the soil cover proposed as the main mode of failure would be erosion - not sliding. Thus, there is no need to specify shear strength parameters for soil layers.

29. *The CQA Plan for constructing final cover must be prepared in accordance with Rule .0541. Please provide the revised CQA Manual/Plan.*

Please refer to the CQA Manual (Attachment C of the attached revised Permit Amendment application).

30. *(Soil Liner CQA, Section 5.0 - Item G) The last sentence (on page 3) indicated that geo-synthetics will be laid over the finished soil liner which is different from the proposed final soil cover system. Please clarify.*

Reference to Soil Liner has been removed as it is not a part of the proposed alternative cover. Please refer to the CQA Manual (Attachment C of the attached revised Permit Amendment application).

31. *(Table 3) The proposed CQA testing frequency for hydraulic conductivity (ASTM D 5084) of soil liner is 80,000 square feet per lift. This proposed testing frequency is less than the waste industry standard of 1 test per lift per acre. Please explain why the proposed testing frequency is sufficient and adequate enough to ensure the quality of the final soil cap system exceeding or equivalent to the requirements specified in the CQA plan.*

See response to Comment 30.

Note that Washington County is currently working on the local government approval process for the landfill to both revise and clarify information (service area, disposal rate, volumes, etc.) related to the landfill. Upon completion, Attachment I of the attached Permit Amendment application will be revised and submitted.

Please contact me at your earliest convenience with any questions or comments which you may have on this submittal or any further questions or comments you may have on this application.

Sincerely,
Richardson Smith Gardner & Associates, Inc.

Pieter K. Scheer, P.E.
Principal, Project Manager
pieter@rsgengineers.com

NORTH CAROLINA PROFESSIONAL SEAL 021666 ENGINEER PIETER K. SCHEER
1/15/10

Attachments: NC DWM Letter - December 19, 2008
Land Quality Approval Letter (July 10, 1995)
Permit Amendment Application

cc: Lou Manring, Washington County
Carl Critcher, Washington County

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REC'D DEC 24 2008

NCDENR

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

Dexter R. Matthews, Director
Division of Waste Management
Michael F. Easley, Governor
William G. Ross Jr., Secretary

December 19, 2008

Mr. Carl Critcher
Washington County Sanitation
P.O. Box 1007
Plymouth, North Carolina 27962

Re: Comments on Permit Application (5-year Permit Review) of Washington County Construction and Demolition Debris Landfill (C&DLF), Washington County, North Carolina
Permit No. 94-04, Document ID No. 6496

Dear Mr. Critcher:

The Division of Waste Management (the Division) has received the above-referenced permit application including:

- *CDLF Permit Renewal, County of Washington, NC.* (A cover letter and a set of three figures) Prepared by: The Wooten Company, Greenville, NC. March 10, 2005. DIN 6500

- *Permit Application, Washington County C&D Landfill (Permit 94-04) Continued Operations*. Prepared by: Richardson Smith Gardner & Associates (RSG), Raleigh, NC. Prepared for: Washington County Public Utilities. June 20, 2008. DIN 4983.

Reviews of compliance with the Solid Waste Management Rule (Rules), 15A NCAC 13B were conducted by the Solid waste Section (SWS), and the following additional information is required:

Permit Amendment (5-year Review) Application (March 2005)

1. Please describe the history and current status of the tire mono-fill which is on the immediately east side of the C&DLF unit. According to the Closure and Post Closure Plan (RSG, 2008), the tire mono-fill will be converted to a C&DLF unit, please provide data to verify if there is sufficient quantity of earthen material from the existing on-site the borrow source to meet the need for cover (weekly and final covers) material.

2. The Item f. of Section 5.0 Solid Waste Management Compliance Data in the approved Construction Plan Report (Diehl & Phillips, P.A., dated August 3, 1995) reported that "a sediment and erosion control plan (the Plan) will be submitted to the North Carolina Division of Land Resources (NCDLR) with the Construction Plans." Has this Plan been approved by the NCDLR? Please provide the NCDLR approved letter and approved Plan as a portion of the permit application document.

3. Please provide the following information, but not limited to:
    - The types of wastes allowed and permitted to accept at the C&DLF facility.

- Average yearly disposal rates in ton and a representative daily rate that is consistent with the Washington County Board of Commissioners.
- The area served by the C&DLF facility.
- Remaining landfill capacity, projected active life of the C&DLF, and 5-year phased development.

4. Please provide the updated operations plan of the C&DLF in accordance with the requirements stated in Rule .0542. A landfill gas control plan or landfill gas management plan (See Comment 22) appended to the Operations Plan must be prepared in accordance with Rule .0544(d).

5. According to the Division's Facility Compliance Audit Report dated May 11, 2007, a pad to store white goods was proposing to construct at the landfill property. Please show the proposed or as-built pad location on the facility drawings.

6. Please describe the operation plan for managing the white goods. The plan may include, but not limited to, prevention from surface water to contact wastes, removal of Freon from white goods, the maximum tonnage will be allowed to store at any time at the facility, the estimated tonnage per month, the contact information of a contractor or recycler to handle, off-site transportation, and/or recycle the white goods, and the frequency or schedule to remove the white goods off-site.

7. According to the Closure and Post Closure Plan (RSG, 2008), the tire mono-fill will be converted to a C&DLF unit; please provide information if the C&DLF facility will accept used tires in the present and future. If does, please provide the operation plan for managing the scrap tires. The staging area needs to be shown on the facility drawing. The plan may include, but not limited to, prevention from surface water to contact wastes, the maximum tonnage will be allowed to store at any time at the facility, the estimated tonnage per month, the contact information of a contractor or recycler to handle, off-site transportation, and/or recycle the white goods, and the frequency or schedule to remove the waste tires off-site.

8. Please describe the operation plan for managing the wood waste processing area (or formally called Washington County Land Cleaning and Inert Debris Area).

9. Comments related to sampling, analysis, and monitoring of groundwater, surface water. The closure and post-closure requirements for C&DLF facilities [Rule .0543 (e)(B)] require the facility to monitor the ground water and surface water in accordance with the requirements of Rules .0544 through .0545 of the Section and maintaining the groundwater monitoring system. Additionally, Monitoring Plans and Requirements for C&DLF facilities [Rule .0544] require that a groundwater monitoring plan and surface water monitoring plan must be submitted, including information on the groundwater monitoring system, sampling and analysis requirements, and detection monitoring requirements that fulfills the requirements of Part (1) (A) through (1) (E) of this section must be submitted.

   The facility therefore, must submit a groundwater and surface water monitoring plan in the revised permit renewal application, including an updated Sampling & Analysis Plan. The NC Solid Waste Section guidelines for groundwater, soil, and surface water sampling may be found at http://www.wastenotnc.org/swhome/enviro_monitoring.asp.

The guidelines are located under the subcategory Environmental Monitoring and include the following pertinent documents:

"Groundwater, Surface Water, and Soil Sampling for Landfills"
"Leachate Sampling and Analysis"
"Solid Waste Environmental Monitoring Data Form"
"Electronic Data Deliverable (EDD) Template"
"October 2007 Memo"
"October 2006 Memo"
"Addendum to October 2006 Memo"

Please note that the above documents provide guidance primarily for sampling and analysis of groundwater and surface water samples.

10. The *Spring 2008 Groundwater Monitoring Report for the Washington County C&D Landfill* reported that survey data for the groundwater monitoring wells was unavailable. In order to accurately determine groundwater elevations for each monitoring well, the wells must be surveyed by a NC Registered Land Surveyor. Please provide the well survey data in accordance with Rule .544(b)(1)(F). Additionally, the survey data must be incorporated into the next semiannual groundwater monitoring report with an evaluation of potentiometric surface and groundwater flow direction.

Attachment B - Closure Plan (RSG, June 2008)

11. (Section 1.3 & CQA in Attachment A) The Rule .0543(c)(1) requires the cap having" a permeability less than or equal soils underlying the landfill, or the permeability specified for the final cover in the effective permit, or a permeability no greater than 1.0×10^{-5} cm/sec, **whichever is less**." The permeability of a foundation soil underneath the C&DLF was tested and reported in the "*Site Application Report for Proposed Construction and Demolition Waste Landfill and Tire Monofill for County of Washington*" dated October 31, 1994 and approved by the Division on February 17, 1995. The foundation soil - upper clay, (UD #1) in Table 7 and Section 5.8.2 of the above-referenced Application was reported having a permeability of 5.0×10^{-6} cm/sec; therefore, the permeability of any liner material of the proposed final cover for the C&DLF shall be less than or equal to 5.0×10^{-6} cm/sec. Please revise the liner criterion in the Closure Plan (including Close Estimate) and CQA Plan in Attachment A.

12. (Section 1.3) Please provide the slope stability analysis data (including the veneer slope stability and global stability) to support the final cap design. And the soil engineering properties including shear strength, density, internal friction angle used for designing the final soil cover system must be considered as the minimum criteria to select the earthen or synthetic material and be field tested in according to the requirements specified in the Construction Quality Control and Quality Assurance (CQA) Plan.

13. (Section 1.3, Table 3.1, & CQA in Attachment A) Will there be an intermediate soil cover to be placed, compacted, and graded for surface flow over the C&D wastes prior to install the final cap system? Is the costs of $7,000 for "surface preparation" (See Table 3.1 – Closure Cost Estimate) used for the construction of intermediate soil cover? If so please provide the specification for the construction of the intermediate soil cover and make necessary correction to the details of "Final Cover System" on Figure 3. Please clarify.

14. (Section 1.5.2, the last sentence on Page 1.0-3) The Closure Plan proposes to use sediment removed from surface water system as daily or intermediate cover. The question is how the removed sediment can be disposed of at the closed landfill. Please clarify.

15. (Section 1.6) Please add the closure notification requirements in accordance with Rule .0543(c)(4) to the proposed Closure Plan.

16. (Section 1.7) Please describe (i) where to record a notation on the deed and (ii) the requirement of informing the Division upon completion of placing notation on of deed of landfill facility property.

17. (Table 3-1) Is there a "shrinkage factor" used to calculate the quantity of soil cap system components? What is the assumption of the soil sources - from the on-site or off-site borrow sources? Please clarify.

18. (Table 3-1) What are the temporary and permanent erosion controls to be constructed during the period of site closure? Please provide an Erosion and Sediment Control Plan and detailed drawings related to the closure activities.

Attachment C - Post-Closure Plan (RSG, June 2008)

19. (Section 2.4) Please add maintenance requirements for the access road to all monitoring points. The costs for road maintenance need to include in the cost estimate Table 3.2.

20. (Section 2.4.2) Please describe the requirements for mowing, re-vegetation, and fertilization (See cost items in Table 3.2) to encourage the growth and establish healthy vegetation on the final cover during the post-closure period.

21. (Section 2.4.5) Please provide the "current" Landfill Gas Management Plan, which is not available in 2005 permit application document.

22. (Table 3.2 – Post-Closure Cost Estimate) Please verify the quantity for groundwater/ surface water monitoring & reporting. Four wells will be sampled semi-annually; therefore, the "quantity" shall be eight (8).

Attachment A - CQA Plan and Specification (RSG, June 2008)

23. Please add specifications for construction of intermediated soil cover [or Subgrade preparation for soil liner – (Section 02250, item D.4.)], erosion and sediment control, re-vegetation, and passive gas vent.

24. (Section 02250) Item C.2. describes the specifications for the off-site borrow sources only; what about the on-site borrow sources? The Division believes the proposed soil liner specification needs to be applicable to both on-site and off-site borrow sources. Please clarify.

25. (Section 02250, Tables 1 & 2) (See Comment 11) Please revise the criterion of hydraulic conductivity of soil liner to 5.0×10^{-6} cm/sec.

26. (Section 02250, Table 2) Based on the experiences from waste industry, the maximum lift thickness in a loose condition is 9 inches, and the maximum lift thickness in final compacted condition is 6-inches. The proposed maximum lift thickness (compacted) is not acceptable. Please revise the criterion accordingly.

27. (Section 02250, Table 2) Please add the minimum values of soil density and friction angle and shear strength of soil liner to the specification (See Comment 13). Please also add test frequency (Number of test per lift per acre) to Table 2. This comment is also applicable to the specification for Subgrade for soil liner.

28. (Section 02258) Please add the minimum values of soil density and friction angle and shear strength of vegetative soil layer to the specification the item D. (See Comment 13). The testing methods and frequencies needs to be specified in Section 02258 as well.

29. The CQA Plan for constructing final cover must be prepared in accordance with Rule .0541. Please provide the revised CQA Manual/Plan.

30. (Soil Liner CQA, Section 5.0 - Item G) The last sentence (on page 3) indicated that geo-synthetics will be laid over the finished soil liner which is different from the proposed final soil cover system. Please clarify.

31. (Table 3) The proposed CQA testing frequency for hydraulic conductivity (ASTM D 5084) of soil liner is 80,000 square feet per lift. This proposed testing frequency is less than the waste industry standard of 1 test per lift per acre. Please explain why the proposed testing frequency is sufficient and adequate enough to ensure the quality of the final soil cap system exceeding or equivalent to the requirements specified in the CQA plan.

The Division appreciates your efforts and cooperation in this matter. If you have any questions or would like to schedule a meeting to discuss this matter further, please contact Ming-Tai Chao at (919) 508- 8507 or Christine Ritter at (919) 508-8506.

Sincerely,

Ming-Tai Chao, P.E.
Environmental Engineer II
Solid Waste Section

Christine Ritter
Hydrogeologist II
Solid Waste Section

cc: Pieter K. Scheer, P.E., RSG
Todd A. Tripp, P.E., The Wooten Company
Ed Mussler, SWS
Donna Wilson, SWS
Dennis Shackelford, SWS
Chuck Boyette, SWS
Central Files

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CLD 94-04

State of North Carolina
Department of Environment,
Health and Natural Resources
Washington Regional Office

James B. Hunt, Jr., Governor
Jonathan B. Howes, Secretary
Nancy W. Smith, Regional Manager

DEHNR

DIVISION OF LAND RESOURCES
LAND QUALITY SECTION
July 10, 1995

LETTER OF APPROVAL OF REVISED PLAN

County of Washington
ATTN: Mr. Lee Smith, Manager
P.O. Box 1007
Plymouth, North Carolina 27962

RE: Erosion and Sedimentation Control Plan
County Landfill
Lee Mills Township - Washington County
Date Received: June 16, 1995
Responsible Party: County of Washington

Dear Mr. Smith:

This office has completed its review of the revised erosion and sedimentation control plan for the referenced project. The revision is a decrease in disturbed area and a change from a borrow source to a "C & D" and a tire monofill disposal area. Based upon the information provided, we find the plan to be acceptable and hereby issue this LETTER OF APPROVAL.

The Sedimentation Pollution Control Act requires the owner/developer to use appropriate methods for the protection of adjoining natural resources and properties, both during and after construction, from the effects of accelerated erosion. This program is performance oriented. It is your responsibility to understand and comply with the requirements of the Act.

The following minimal mandatory standards of the Act are hereby made a part of the approved plan:

-- a copy of the latest approved soil erosion and control plan must be on file at the job site;

-- a buffer zone, sufficient to restrain sedimentation, must be maintained between the land-disturbing activity and any adjacent property or watercourse;

1424 Carolina Avenue, Washington, North Carolina 27889 Telephone 919-946-6481 FAX 919-975-3716
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-- new or affected slopes must be at an angle that can be retained by vegetative cover and exposed slopes must be provided with a ground cover sufficient to restrain erosion within 30 working days of completion of any phase (rough or final) of grading (RYE GRASS IS NOT in the approved seeding specifications nor is it an ACCEPTABLE substitute for the providing of a ground cover); and

-- a permanent ground cover, sufficient to restrain erosion, must be provided within the shorter of 30 working or 120 calendar days after completion of construction or development.

Be advised that unannounced periodic inspections of the project will be made to ensure compliance with the approved plan and the program requirements. If the plan and/or its implementation is determined to be inadequate, this office may require that it be revised to comply with state law. Failure to comply with the approved plan or with any requirements of this program or to affect areas in other than to those designated to be affected in the approved plan, could result in a civil penalty assessment of up to $500 per day for each day the site is out of compliance against the financially responsible party (County of Washington).

In recognizing the desirability of early coordination of sedimentation control, we believe it would be beneficial for you and your contractor to arrange a pre-construction conference to discuss the requirements of the approved erosion and sedimentation control plan. It would be appreciated if you would contact this office to let me know the date of construction start-up and the date of the pre-construction conference.

The land-disturbing activity described in this plan may require approval or permitting from other Federal, State or local agencies. These could include the U.S. Army Corps of Engineers under Article 404 jurisdiction, the Division of Environmental Management under water quality regulations (contact Bill Moore, 919-946-6481), county, city or town agencies under other local ordinances, or other approvals that may be required. This approval cannot supersede any other approval or permit.

Please be advised that all land-disturbing activities affecting 5 acres or more are required to have a NPDES permit. Contact Mr. Bill Mills, Division of Environmental Management - Stormwater Group, at (919) 733-5083 for more information. We have enclosed information regarding NPDES permit requirements.

Sincerely,

Patrick H. McClain, P.E.
Assistant Regional Engineer

PHM:pm

Enclosure

cc: Alan R. Keith, P.E., Diehl and Phillips
Terry Dover, Division of Solid Waste Management

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Permit Amendment Application

Washington County C&D Landfill (Permit 94-04)
Phase 2
Roper, North Carolina

Prepared For:

Washington County Public Utilities
396 Millpond Road
Roper, North Carolina 27970

Prepared By:

RICHARDSON SMITH GARDNER
& ASSOCIATES
ENGINEERING & GEOLOGICAL
SERVICES
14 N. BOYLAN AVENUE
RALEIGH, NORTH CAROLINA 27603
NC LIC. NO. C-0828 (ENGINEERING)

January 2010

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PERMIT AMENDMENT APPLICATION

Washington County C&D Landfill
Phase 2
Roper, North Carolina

Prepared for:
Washington County Public Utilities
Roper, North Carolina

RSG Project No. WASH-09-1

Statement of Compliance with Engineering Plan Requirements:

The engineering elements of this Permit Application have been prepared by the undersigned Professional Engineer licensed to practice engineering in accordance with NCGS 89C and the Administrative Rules developed thereunder. It is my opinion that the design described in the application meets the intent of the 15A NCAC 13B.0531 et seq. of the Solid Waste Management Rules.

NORTH CAROLINA PROFESSIONAL SEAL 021666 ENGINEER PIETER K. SCHEER

1/15/10

Pieter K. Scheer, P.E.
Principal, Project Manager

January 2010

RICHARDSON SMITH GARDNER & ASSOCIATES
ENGINEERING & GEOLOGICAL SERVICES
14 N. BOYLAN AVENUE
RALEIGH, NORTH CAROLINA 27603
NC LIC. NO. C-0828 (ENGINEERING)

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WASHINGTON COUNTY C&D LANDFILL
PHASE 2

PERMIT AMENDMENT APPLICATION

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A guide to specific North Carolina Solid Waste Management (15A NCAC 13B.0500), Sedimentation Control (15A NCAC 4) rules addressed in each section of this document is shown in italics after each section.

EXECUTIVE SUMMARY

ATTACHMENT A	FACILITY AND ENGINEERING PLAN *(15A NCAC 13B.0537, .0539)*
ATTACHMENT B	TECHNICAL SPECIFICATIONS *(15A NCAC 13B.0539)*
ATTACHMENT C	CONSTRUCTION QUALITY ASSURANCE MANUAL *(15A NCAC 13B.0541)*
ATTACHMENT D	OPERATIONS MANUAL *(15A NCAC 13B.0542)*
ATTACHMENT E	CLOSURE AND POST-CLOSURE PLAN *(15A NCAC 13B.0543)*
ATTACHMENT F	EROSION AND SEDIMENTATION CONTROL PLAN *(15A NCAC 13B.0540 and 15A NCAC 4)*
ATTACHMENT G	PERMIT AMENDMENT DRAWINGS *(15A NCAC 13B.0537, .0539, .0540, .0542, and .0543, and 15A NCAC 4)*
ATTACHMENT H	WATER QUALITY MONITORING PLAN *(15A NCAC 13B.0538)*
ATTACHMENT I	LOCAL GOVERNMENT APPROVAL DOCUMENTATION *(15A NCAC 13B.0536)*

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EXECUTIVE SUMMARY

GENERAL

The following is a Permit Amendment Application submitted on behalf of Washington County for construction of Phase 2 of the County's construction and demolition debris (C&D) Landfill. Phase 2 is a lateral expansion of the landfill and it is the intent of Washington County to proceed with construction of this unit as soon as possible.

This submittal focuses on the engineering design of Phase 2 and follows the Site Application and Construction Plan Reports prepared by Diehl & Phillips, P.A.[1] [2] and a permit amendment application prepared by The Wooten Company[3]. Note that this submittal supercedes the application submitted by The Wooten Company, which was never approved by the NC Division of Waste Management (DWM).

Note that the County was previously permitted to operate a tire monofill as a part of the C&D landfill (reference Drawing S1 (Existing Site Conditions), which shows the approximate extent of the monofill). The County ceased placement of tires in the monofill in January 2001. The quantity of tires placed in the monofill is unknown. Used tires are currently placed in a trailer near the site entrance, which is periodically picked up by a tire recycler. The County has no plans to place tires in the landfill in the future.

The proposed Phase 2 will occupy approximately 0.93 acres to the southeast of the existing Phase 1 (2.34 acres). At the projected gate rate of 1,500 tons/year, Phase 2 has been designed for approximately 5.0 years of disposal volume. This submittal also presents the proposed phasing of future Phases 3-6 (0.74 acres). In that additional vertical expansion volume is proposed for the landfill from that shown in the originally approved documents [1, 2], this application represents a substantial amendment to the permit.

The design of the final cover system for the C&D landfill will use either a regulatory specified final cover system or an alternative final cover system, as allowed under North Carolina regulations. The equivalency of the proposed alternative final cover system to the regulatory specified final cover system is demonstrated in the Facility and Engineering Plan (**Attachment A**). The components of the final cover system will consist of the following components (top-down):

---

[1] Diehl & Phillips, P.A. (1994), "Site Application Report for Proposed Construction and Demolition Waste Landfill and Tire Monofill for County of Washington", dated 10/31/1994, approved by NC DWM on 2/17/95.

[2] Diehl & Phillips, P.A. (1995), "Construction Plan Report for Washington County Construction and Demolition Waste Landfill and Tire Monofill", dated 6/12/1995, approved by NC DWM on 8/9/95.

[3] The Wooten Company (2005), "Washington County Landfill, Landfill C&D Plan - Proposed CDLF Expansion", dated 3/10/05, currently under review by the DWM.

Regulatory Final Cover System (.0543 (c) (1)):

- an 18-inch thick vegetative soil layer; and
- an 18-inch thick soil liner with a permeability of no more than 1×10^{-5} cm/sec ("compacted soil barrier").

OR

Alternative Final Cover System (.0543 (c) (3)):

Top Slopes (Typically 5 to 10%):

- an 18-inch thick vegetative soil layer;
- a drainage geocomposite (with drainage breaks);
- a 30-mil textured LLDPE geomembrane or geosynthetic clay liner (GCL); and
- a 12-inch thick intermediate cover layer.

Side Slopes (Typically 4H:1V):

- a 24-inch thick vegetative soil layer.

REGULATORY REFERENCES

This submittal has been prepared in accordance with the requirements of the North Carolina Solid Waste Management Rules (15A NCAC 13B.500 et. seq.) and the North Carolina Sedimentation Control Rules (15A NCAC 4) which are enforced by the Division of Waste Management (DWM) and the Division of Land Quality, respectively, of the North Carolina Department of Environment and Natural Resources. Included in this document are the following attachments:

Facility and Engineering Plan;
Technical Specifications;
Construction Quality Assurance (CQA) Manual;
Operations Manual;
Closure and Post-Closure Plan;
Erosion and Sedimentation Control Plan;
Permit Amendment Drawings;
Water Quality Monitoring Plan; and
Local Government Approval Documentation.

Facility and Engineering Plan

Washington County C&D Landfill
Phase 2
Roper, North Carolina

Prepared for:

Washington County Public Utilities
Roper, North Carolina

January 2010

RICHARDSON SMITH GARDNER
ENGINEERING & GEOLOGICAL
14 N. BOYLAN AVENUE
RALEIGH, NORTH CAROLINA 27603
NC LIC. NO. C-0828 (ENGINEERING)

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WASHINGTON COUNTY C&D LANDFILL
PHASE 2

FACILITY AND ENGINEERING PLAN

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WASHINGTON COUNTY C&D LANDFILL
PHASE 2

FACILITY AND ENGINEERING PLAN

1.0 OVERVIEW

Washington County, North Carolina currently owns and operates a landfill facility off of NC Highway 308 (Mackeys Road) near Roper. Access for the facility is and will continue to be off of Landfill Road. The landfill is permitted under NC Permit 94-04 for the disposal of construction and demolition debris (C&D) waste. The County also conducts several other solid waste management activities at the facility. Refer to the attached **Drawing S1** (Existing Conditions) (**Attachment I**), which shows the existing conditions and **Section 2.1**, which describes facility services.

The County has operated the landfill facility under the current permit since 1996. From the 1980s through 1993 (ceased receipt of waste before Oct. 9, 1993), the facility was permitted to receive municipal solid waste (MSW) under NC Permit 94-02. The MSW was disposed of in an unlined disposal unit (see **Drawing S1**) located on County owned property to the west of the C&D site. The MSW landfill unit was closed in accordance with applicable State Solid Waste Management Rules.

This plan presents information describing the development of Phase 2 and future phases of the C&D landfill.

2.0 FACILITY SERVICES AND WASTE STREAM

2.1 Facility Services

Currently, the following activities or services are provided at the Washington County Landfill facility:

- Scales and office/scale house building
- Maintenance building
- C&D landfill
- Used tire storage area
- White goods and scrap metal handling area
- Yard waste processing area
- Mobile home deconstruction area.

The County may also add roll-off or other suitable containers for recyclables and/or municipal solid waste (MSW). Areas in the vicinity of the white goods/scrap metal handling area would be used for this purpose.

Another proposed use of the site is the installation of a firing range for the County

Sheriff's Department. As shown on **Drawing S1**, the firing range is to be located at the south end of the closed MSW landfill unit. The direction of fire will be toward the west where a soil berm is currently being placed.

2.2 Types of Waste

C&D waste, used tires, white goods and scrap metal, and yard waste are accepted at the Washington County landfill facility. Wastes are routed to the landfill or other area as appropriate.

2.3 Disposal Rate and Anticipated Variances

An average of approximately 1,500 tons per year of C&D waste (average of approximately 5 tons per day based on 280 days of operation per year) is currently accepted for disposal at the Washington County facility. The County proposes to dispose of a maximum of 10,000 tons per year of C&D waste (average of approximately 36 tons per day based on 280 days of operation per year). Actual annual and daily amounts of C&D waste are expected to vary but will not exceed the proposed annual maximum.

2.4 Service Area

The landfill facility currently serves Washington County.

2.5 Procedures for Waste Segregation

A brief description of procedures for waste segregation is as follows.

Wastes are segregated at the scales. Operators at the scalehouse are trained to classify and segregate the waste stream. C&D wastes are directed to the landfill. Yard wastes are directed toward the yard waste storage and processing area.

Employees at the landfill are trained in the safety procedures for the handling and detection of illegal waste. The screening of unacceptable waste is done through the random checking of incoming loads by a County employee at the scale house and at the tipping area. When unacceptable waste is detected at the scale house, the load is rejected and not permitted into the facility. If hazardous waste is found at the tipping area, identification of the truck or persons is made (if possible) and documented, then the hazardous waste is identified and placed in a hazardous waste container and taken to a designated hazardous waste staging area for proper disposal. If this occurs, the event is reported to the appropriate authorities.

2.6 Equipment Requirements

The County will maintain on-site equipment required to perform the necessary landfill activities. The County currently uses a CAT 953 bulldozer in their day to day operation

of the C&D landfill unit. Periodic maintenance of all landfilling equipment, and minor and major repair work will be performed in the landfill's maintenance building.

3.0 LANDFILL CAPACITY

3.1 Total Operating Capacity and Life Expectancy

Drawing S3 (Site Development Plan - Final Cover Grading and Drainage), identifies the final configurations for the C&D landfill. The exterior side slopes will be at a 4H to 1V slope and the top elevation will be at approximately 46 feet.

The estimated total gross operating capacity, net capacity (accounts for periodic and final cover), disposal area, and life expectancy for the landfill are shown in **Table 1**.

3.2 In-Place Ratio of Waste to Soil and Compaction Factor

The capacities obtained above were based on a 10 percent periodic cover ratio and an assumed compaction factor of 900 pounds per cubic yard (0.45 tons/cy). The assumed periodic cover ratio is typical for C&D landfills.

4.0 AVAILABLE SOIL RESOURCES AND REQUIRED SOIL QUANTITIES

The soils required to construct the proposed landfill will be removed from on-site borrow sources.

4.1 Earthwork Quantities

The anticipated quantity of soil to be required as structural fill for foundation soils and berms is shown in **Table 2**.

4.2 Periodic Cover

Assuming the previously mentioned periodic cover ratio of 10 percent, the estimated quantity of soil that will be required for use as periodic cover during C&D landfill operations is shown in **Table 2**.

4.3 Vegetative Soil Layer

On the basis of an average 2 foot thickness, the estimated in-place volume of the vegetative soil layer component of the final cover system required is shown in **Table 2**.

4.4 Soil Summary

The above soil quantities are summarized in **Table 2**. Available on-site borrow sources are anticipated to have an adequate supply of soil to meet the expected needs.

5.0 FACILITY DESIGN CRITERIA

The Washington County C&D landfill is designed and operates in accordance with Section .0542 of the North Carolina Administrative Code, Title 15A, Chapter 13, Subchapter 13B including the following requirements.

5.1 Horizontal Separation Requirements

The horizontal separation requirement between the disposal boundary (edge of waste) and the property lines is a more than 50 feet (as required for existing facilities) (for all phases, the minimum buffer exceeds 200 feet), the minimum buffer between private residences and wells and the disposal boundary is 500 feet, and the minimum buffer between any surface water (stream, river, creek) and the disposal boundary is 50 feet.

5.2 Vertical Separation Requirements

The landfill subgrade elevations have been designed to meet the minimum requirement of four feet above the seasonal high groundwater table and bedrock. Additionally, the in-situ or modified soils making up the upper two feet of separation will consist of SC, SM, ML, CL, MH, or CH soils per the Unified Soil Classification System (USCS).

6.0 CONTAINMENT AND ENVIRONMENTAL CONTROL SYSTEMS

Technical specifications and a project construction quality assurance (CQA) manual for the following materials can be found in **Attachments B and C**, respectively.

6.1 Landfill Subgrade

The subgrade elevations will be achieved by excavation or placement of compacted structural fill (embankment). During excavation, a determination of unsuitable soils (i.e. soils which are too soft, wet, or organic) will be made. Where unsuitable soils are found, the soils will be undercut and backfilled with structural fill. Structural fill will consist of on-site soils, except that no CH, OL, or OH soils will be allowed.

6.2 Final Cover System

The components of the final cover system will consist of the following components (top-down):

Regulatory Final Cover System (.0543 (c) (1)):

- a 6-inch thick vegetative soil layer; and
- an 18-inch thick soil liner with a permeability of no more than 1×10^{-5} cm/sec ("compacted soil barrier").

OR

Alternative Final Cover System (.0543 (c) (3)):

Top Slopes (Typically 5 to 10%):

- an 18-inch thick vegetative soil layer;
- a drainage geocomposite;
- a 30-mil textured LLDPE geomembrane or geosynthetic clay liner (GCL); and
- a 12-inch thick intermediate cover layer.

Side Slopes (Typically 4H:1V):

- a 24-inch thick vegetative soil layer.

The final cover system will be placed on prepared intermediate cover at a maximum slope of 4H:1V. Top slopes will be approximately 8%. A landfill gas (LFG) control system and surface water control devices will also be incorporated into the final cover. The final cover surface will be vegetated upon completion of the final cover installation according to the project seeding specifications.

A final cover infiltration analysis was performed to demonstrate that the proposed final cover system allows less infiltration than the regulatory final cover system (see **Appendix A**). Note that this permit application assumes the installation of the proposed alternative final cover system.

6.3 Erosion and Sedimentation Control

The Erosion and Sedimentation Control structures provided will be designed and maintained to manage the run-off generated by the 24-hour, 25-year storm event, and conform to the requirements of the Sedimentation Pollution Control Law (15A, NCAC, 4).

A detailed discussion of site erosion and sedimentation control for the landfill can be found in the Project Erosion and Sedimentation Control Plan (**Attachment F**).

6.4 Landfill Gas Control

Landfill gas control will consist of 4 passive wells/vents as shown on **Drawing S3**. Due to a number of factors (the limited depth to groundwater, the sandy soils around the perimeter of the landfill, the distance to site structures, and the existence of wetlands around much of the property), no perimeter monitoring of gas from the C&D landfill is proposed.

6.5 Access and Roadways

Site operations will provide for all-weather access to active areas and site monitoring locations.

7.0 SLOPE STABILITY

The slope stability of the waste mass is addressed in **Appendix A**. The results of the slope stability analysis indicates that the proposed C&D landfill configuration is stable.

TABLE 1
SUMMARY OF LANDFILL CAPACITY AND LIFE EXPECTANCY

Unit	Area (Ac.)	Capacity (See Note 1)		Life Expectancy (Years) (See Note 2)
		Gross (CY)	Net (CY/Tons)	
Phase 1 (Filled Through March 28, 2009)	2.34	45,000	40,500 CY 19,777 Tons	-----
Phase 2	0.93	20,159	16,691 CY 8,346 Tons	5.6
Phase 3	0.74	18,045	15,079 CY 7,539 Tons	5.0
Phases 4-6	----- (See Note 3)	63,018	47,714 CY 23,857 Tons	15.9
Totals:	4.01	146,222	119,984 CY 59,519 Tons	26.5

Notes:
1. The net capacity is based on an assumed 10% periodic cover soil ratio and waste density of 0.5 tons/CY.
2. Phase 2 life expectancy is based on an assumed average disposal rate of 1,500 tons/year and is projected from March 28, 2009 (date of most recent survey).
3. Phases 4-6 are a vertical expansion of Phases 1-3.

TABLE 2
SOIL SUMMARY

Material				
	Phase 2	**Phase 3**	**Phases 4-6 (Final)**	**Total**
Excavation	213	37	-----	250
Embankment	(1,742)	(1,837)	-----	(3,579)
Periodic Cover	(1,855)	(1,675)	(5,302)	(8,832)
Final Cover Soil	(1,613)	(1,291)	(10,003)	(12,907)
Total =	(4,997)	(4,766)	(15,305)	(25,068)

Notes:
1. Phase 2 volumes estimated from March 28, 2009.

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Appendix A

Landfill Design Calculations

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WASHINGTON COUNTY C&D LANDFILL
PHASE 2

FACILITY AND ENGINEERING PLAN
APPENDIX A: LANDFILL DESIGN CALCULATIONS

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1.0 Capacity Evaluation (Density & Life Calcs.)
2.0 Earthwork Quantities
3.0 Final Cover Infiltration Analysis
4.0 Slope Stability Evaluation

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PROJECT Washington County C&D Landfill - Phase 2

SUBJECT Capacity Evaluation (Density & Life Calcs.)

JOB NO. WASH-09-1
DATE 11/13/2009
COMPUTED BY PKS
CHECKED BY

Objective To determine the capacity of landfill units. Also, to estimate the expected life of the landfill unit(s) given the proposed contours and the anticipated waste loading rate(s). As part of the evaluation, an evaluation or estimate of waste density will be required based on the known or assumed percentage of periodic cover soil.

Analysis The volume(s) will be calculated by using AutoCAD. Alternatively, the volume(s) will be calculated by taking cross sections of the landfill, using a planimeter to measure the area of the cross sections, and using the average end area method.

CAPACITY LF DENSITY & LIFE.WPD

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue Tel: 919-828-0577
Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 2/7
JOB #: WASH-09-1
DATE: 11/13/09
BY: PKS
CHKD BY:

Washington County C&D Landfill - Phase 1
Capacity Evaluation - Filling Rate & Density Calculations

Density and Filling Rate Calculations:

Start Date	Period of Interest End Date	Total Time (years)	Volume Filled (cy)	Quantity of Waste Disposed (tons)	Waste Filling Rate* (lbs/cy)	Periodic Cover Assumed %	Periodic Cover Volume (cy)	Waste Volume (cy)	Waste Density** (lbs/cy)
6/1/1996	3/28/2009	12.83	45,000 *	19,777	**879**	10	4,500	40,500	**977** **
		Total Volume =	45,000	19,777			4,500	40,500	

* 45,000 CY Estimated Based on Orig. Design of Soil Berm and Existing Topography.
** Density of Waste is Lower than Actual Based on Unknown Weight of Tires in Monofill. Assume 1,000 pcf is conservative figure.

Notes:
*Waste Filling Rate = (Tons of Waste Disposed)/(Volume Filled).
**Waste Density = (Tons of Waste Disposed)/(Volume Filled - Volume of Periodic Cover).

EXISTING VOLUME USED:

Through 3/28/09

Composite Volumes

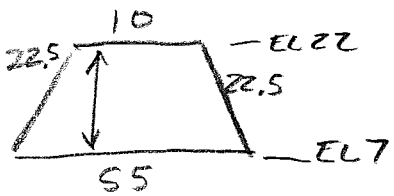
Index	Surface Pair Base Surface	Comparison Surface	Volume Cut	Fill	Net	Net Graph
1	TOPO 050709-ELEV_8	TOPO 050709	0.27 Cu. Yd.	50221.36 Cu. Yd.	50221.09 Cu. Yd...	

+ 1' to EL 7' ≈ 5100 CY

− Berm (660' x 18 CY/LF) ≈ 11,880 CY

Σ = 43,441 ⇒ SAY 45K CY

Panorama



RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue Tel: 919-828-0577
Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 4/7
JOB #: WASH-09-1
DATE: 11/16/09
BY: PKS
CHKD BY:

Washington County Landfill
Capacity Evaluation - C&D - Phase 2

Waste & Periodic Cover Parameters:

Waste Density (pcy) =	1,000	(From Filling Rate and Density Calcs.)
Waste Density (tcy) =	0.50	
Percentage of Periodic Cover =	10	

Volume Calculations:

Volume From AutoCAD (cy) = **(= Gross Volume Remaining)**	20,159	(Compared to March 28, 2009 Topo.)

Net (Waste) Capacity:

Adjustment For Other Layers:

	Area of Final Cover (Ac.) =	0.5
2 feet	Vegetative Soil Layer =	(1,613) cy
	Sum =	(1,613) cy
	Volume of Waste and Periodic Cover (cy) =	18,546
	Volume of Periodic Cover (cy) =	(1,855)
	Net (Waste) Capacity (cy) =	16,691
	Net (Waste) Capacity (tons) =	8,346

Life Expectancy Calculations:

Start Time	End Time	Tons Disposed	Total Tons	Remainder	
2009.24	2010	1,140	1,140	7,206	
2010	2014	6,000	7,140	1,206	Based on 1,500 Tons/Year
2014	2014.8	1,206	8,346	(0)	

Landfill Life Expectancy (years) = 5.6 October 2014

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue Tel: 919-828-0577
Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 5 / 7
JOB #: WASH-09-1
DATE: 11/16/09
BY: PKS
CHKD BY:

Washington County Landfill
Capacity Evaluation - C&D - Phase 3

Waste & Periodic Cover Parameters:

Waste Density (pcy) =	1,000	(From Filling Rate and Density Calcs.)
Waste Density (tcy) =	0.50	
Percentage of Periodic Cover =	10	

Volume Calculations:

Volume From AutoCAD (cy) = **(= Gross Volume Remaining)**	18,045	(Compared to Phase 2 Fill Contours)

Net (Waste) Capacity:

Adjustment For Other Layers:

	Area of Final Cover (Ac.) =	0.4
2 feet	Vegetative Soil Layer =	(1,291) cy
	Sum =	(1,291) cy
	Volume of Waste and Periodic Cover (cy) =	16,754
	Volume of Periodic Cover (cy) =	(1,675)
	Net (Waste) Capacity (cy) =	15,079
	Net (Waste) Capacity (tons) =	7,539

Life Expectancy Calculations:

Start Time	End Time	Tons Disposed	Total Tons	Remainder	
2014.8	2015	300	300	7,239	
2015	2019	6,000	6,300	1,239	Based on 1,500 Tons/Year
2019	2019.83	1,239	7,539	0	

Landfill Life Expectancy (years) = 5.0 October 2019

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue Tel: 919-828-0577
Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 6 / 7
JOB #: WASH-09-1
DATE: 11/16/09
BY: PKS
CHKD BY:

Washington County Landfill
Capacity Evaluation - C&D - Phases 4-6

Waste & Periodic Cover Parameters:

Waste Density (pcy) =	1,000	(From Filling Rate and Density Calcs.)
Waste Density (tcy) =	0.50	
Percentage of Periodic Cover =	10	

Volume Calculations:

Volume From AutoCAD (cy) = **(= Gross Volume Remaining)**	63,018	(Compared to Phase 3 Fill Contours)

Net (Waste) Capacity:

Adjustment For Other Layers:

	Area of Final Cover (Ac.) =	3.1
2 feet	Vegetative Soil Layer =	(10,003) cy
	Sum =	(10,003) cy
	Volume of Waste and Periodic Cover (cy) =	53,015
	Volume of Periodic Cover (cy) =	(5,302)
	Net (Waste) Capacity (cy) =	47,714
	Net (Waste) Capacity (tons) =	23,857

Life Expectancy Calculations:

Start Time	End Time	Tons Disposed	Total Tons	Remainder	
2019.83	2020	261	261	23,596	
2020	2035	22,500	22,761	1,096	Based on 1,500 Tons/Year
2035	2035.73	1,096	23,857	(0)	

Landfill Life Expectancy (years) = 15.9 September 2035

Client
Project
Date

version	date	time	surfBase	surfCompare	volCut	volFill	volNet
1	11/2/2009	13-16-34	TOPO 050709	PHASE 2 ONLY - SUBGRADE	213.39	1,741.93	1,528.53
1	11/2/2009	13-28-05	TOPO-PH2 SGRD	PHASE 3 SUBGRADE	37.37	1,836.70	1,799.33
1	11/2/2009	13-32-02	TOPO-PH2 SGRD	PHASE 2 INTCVR-TOP EL 20	0.19	20,159.31	20,159.12
1	11/2/2009	13-40-41	TOPO-PH3SGRD-PH2 INTCVF	PHASE 3 INTCVR-TOP EL 20	1.91	18,046.69	18,044.78
1	11/2/2009	13-51-14	TOPO-PH 3 INTCVR	FCVR - PH 4-6	2.83	63,021.11	63,018.28

7/7

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PROJECT Washington County C&D Landfill - Phase 2

SUBJECT Earthwork Quantities

JOB NO. WASH-09-1
DATE 11/13/2009
COMPUTED BY PKS
CHECKED BY

Objective To determine the earthwork and related material quantities associated with the construction and operation of the landfill.

Analysis The volumes of each material will be calculated by taking design thicknesses and/or cross sections and multiplying by design areas and/or lengths. Areas and lengths are determined using AutoCAD, a planimeter, and/or direct measurement.

EARTHWORK.WPD

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue Tel: 919-828-0577
Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 2, 3
JOB #: WASH-09-1
DATE: 11/16/09
BY: PKS
CHKD BY:

Washington County C&D Landfill
Earthwork Quantities

Phase 2:

Subgrade Cut and Fill Volumes:

Volume of Cut (cy) = 213 **(From AutoCAD - See Attached)**
Volume of Fill (cy) = 1,742 **(From AutoCAD - See Attached)**

Periodic Cover Soil Volumes:

Volume of Periodic Cover (cy) = 1,855 **(User Input - From Capacity Evaluation)**

Vegetative Soil Layer (VSL) Volume:

Volume of VSL (cy) = 1,613 **(User Input - From Capacity Evaluation)**

Phase 3:

Subgrade Cut and Fill Volumes:

Volume of Cut (cy) = 37 **(From AutoCAD - See Attached)**
Volume of Fill (cy) = 1,837 **(From AutoCAD - See Attached)**

Periodic Cover Soil Volumes:

Volume of Periodic Cover (cy) = 1,675 **(User Input - From Capacity Evaluation)**

Vegetative Soil Layer (VSL) Volume:

Volume of VSL (cy) = 1,291 **(User Input - From Capacity Evaluation)**

Phases 4-6:

Periodic Cover Soil Volumes:

Volume of Periodic Cover (cy) = 5,302 **(User Input - From Capacity Evaluation)**

Vegetative Soil Layer (VSL) Volume:

Volume of VSL (cy) = 10,003 **(User Input - From Capacity Evaluation)**

Client
Project
Date

version	date	time	surfBase	surfCompare	volCut	volFill	volNet
1	11/2/2009	13-16-34	TOPO 050709	PHASE 2 ONLY - SUBGRADE	213.39	1,741.93	1,528.53
1	11/2/2009	13-28-05	TOPO-PH2 SGRD	PHASE 3 SUBGRADE	37.37	1,836.70	1,799.33
1	11/2/2009	13-32-02	TOPO-PH2 SGRD	PHASE 2 INTCVR-TOP EL 20	0.19	20,159.31	20,159.12
1	11/2/2009	13-40-41	TOPO-PH3SGRD-PH2 INTCVF	PHASE 3 INTCVR-TOP EL 20	1.91	18,046.69	18,044.78
1	11/2/2009	13-51-14	TOPO-PH 3 INTCVR	FCVR - PH 4-6	2.83	63,021.11	63,018.28

3/3

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PROJECT Washington County C&D Landfill - Phase 2

SUBJECT Final Cover Infiltration Analysis

JOB NO. WASH-09-1
DATE 11/16/09
COMPUTED BY PKS
CHECKED BY

Objective

To determine the expected average annual infiltration into the landfill through the proposed final cover system. In that the proposed final cover system is an alternate system to the regulatory final cover, the infiltration through the proposed system is compared to the infiltration through the regulatory system. Use the EPA HELP Model (v. 3.07) in the analysis.

References

Schroeder, P.R., Lloyd, C.M., et. al, (1994), "The Hydrologic Evaluation of Landfill Performance (HELP) Model - User's Guide for Version 3," EPA/600/9-94/168a, USEPA Risk Reduction Laboratory, Cincinnati, Ohio.

Schroeder, P.R., Lloyd, C.M., et. al, (1994), "The Hydrologic Evaluation of Landfill Performance (HELP) Model - Engineering Documentation for Version 3," EPA/600/9-94/168b, USEPA Risk Reduction Laboratory, Cincinnati, Ohio.

Analysis

Final Cover Systems Analyzed:

1A. Proposed Final Cover System (Top Slopes - 5 to 8%): (Top Down)

A. 18 inches Vegetative Soil Layer
B. Drainage Geocomposite
C. 30 mil Textured LLDPE Geomembrane or Geosynthetic Clay Liner (GCL)
D. 12 inches Intermediate Cover

1B. Proposed Final Cover System (Side Slopes - 4H:1V):

A. 24 inches Vegetative Soil Layer

2. Regulatory Final Cover System: (Top Down)

A. 6 inches Vegetative Soil Layer
B. 18 inches Compacted Soil Barrier ($k = 1 \times 10^{-5}$ cm/sec)
C. 12 inches Intermediate Cover

Results

The results as summarized below show that the proposed final cover system allows less infiltration than the regulatory final cover system. HELP Model runs are attached.

Case	Avg. Annual Infiltration (in)
1A (GM)	0.03
1A (GCL)	0.03
1B (Soil)	12.2
2 (RMC)	17.9

FCS HELP.WPD

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\PROGRA~1\HELP3\RALNCP.D4
TEMPERATURE DATA FILE:       C:\PROGRA~1\HELP3\RALNCT.D7
SOLAR RADIATION DATA FILE:   C:\PROGRA~1\HELP3\RALNCS.D13
EVAPOTRANSPIRATION DATA:     C:\PROGRA~1\HELP3\RALNCE.D11
SOIL AND DESIGN DATA FILE:   C:\PROGRA~1\HELP3\WCGM08.D10
OUTPUT DATA FILE:            C:\PROGRA~1\HELP3\WCGM08.OUT


TIME:   9:15     DATE:  11/16/2009


******************************************************************************

     TITLE:  Washington County C&DLF - Case 1A (GM) (8% Slope)
******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   4
          THICKNESS                    =     18.00   INCHES
          POROSITY                     =      0.4370 VOL/VOL
          FIELD CAPACITY               =      0.1050 VOL/VOL
          WILTING POINT                =      0.0470 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.0671 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.170000002000E-02 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

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                                  LAYER  2
                                  --------

                     TYPE 2 - LATERAL DRAINAGE LAYER
                         MATERIAL TEXTURE NUMBER  20
          THICKNESS                    =      0.25   INCHES
          POROSITY                     =      0.8500 VOL/VOL
          FIELD CAPACITY               =      0.0100 VOL/VOL
          WILTING POINT                =      0.0050 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.0749 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =   10.0000000000     CM/SEC
          SLOPE                        =      8.00   PERCENT
          DRAINAGE LENGTH              =     70.0    FEET


                                  LAYER  3
                                  --------

                     TYPE 4 - FLEXIBLE MEMBRANE LINER
                         MATERIAL TEXTURE NUMBER  36
          THICKNESS                    =      0.03   INCHES
          POROSITY                     =      0.0000 VOL/VOL
          FIELD CAPACITY               =      0.0000 VOL/VOL
          WILTING POINT                =      0.0000 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.399999993000E-12 CM/SEC
          FML PINHOLE DENSITY          =      1.00   HOLES/ACRE
          FML INSTALLATION DEFECTS     =      8.00   HOLES/ACRE
          FML PLACEMENT QUALITY        =  3 - GOOD


                                  LAYER  4
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   4
          THICKNESS                    =     12.00   INCHES
          POROSITY                     =      0.4370 VOL/VOL
          FIELD CAPACITY               =      0.1050 VOL/VOL
          WILTING POINT                =      0.0470 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.1060 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.170000002000E-02 CM/SEC


                  GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                  ----------------------------------------

     NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
              SOIL DATA BASE USING SOIL TEXTURE # 4 WITH A
              FAIR STAND OF GRASS, A SURFACE SLOPE OF  8.%
              AND A SLOPE LENGTH OF   70. FEET.

     SCS RUNOFF CURVE NUMBER              =     64.60
     FRACTION OF AREA ALLOWING RUNOFF     =    100.0    PERCENT
     AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
     EVAPORATIVE ZONE DEPTH               =     18.2    INCHES
```

2/2

INITIAL WATER IN EVAPORATIVE ZONE	=	1.226	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.078	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.847	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	2.499	INCHES
TOTAL INITIAL WATER	=	2.499	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
RALEIGH NORTH CAROLINA

STATION LATITUDE	=	35.87	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	86	
END OF GROWING SEASON (JULIAN DATE)	=	310	
EVAPORATIVE ZONE DEPTH	=	18.2	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.70	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	78.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00	%

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

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

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

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

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

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

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.44	2.92	3.81	2.20	4.34	3.74
	4.24	5.43	2.40	2.87	3.05	2.80
STD. DEVIATIONS	2.07	1.23	1.51	1.52	2.22	1.98
	1.91	3.72	1.67	2.00	1.79	1.04
RUNOFF						
TOTALS	0.000	0.000	0.005	0.000	0.000	0.000
	0.000	0.026	0.001	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.023	0.000	0.002	0.000
	0.000	0.101	0.006	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	1.422	1.621	2.390	1.916	2.776	2.760
	3.097	3.150	1.653	1.185	1.262	1.143
STD. DEVIATIONS	0.279	0.344	0.586	0.941	1.187	1.390
	1.146	1.259	0.904	0.478	0.432	0.210
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	1.8204	1.4153	1.5422	0.7660	1.6326	1.0592
	1.1420	2.1174	1.0483	1.2971	1.3930	1.5288
STD. DEVIATIONS	1.5094	0.8850	0.9858	0.6279	1.2008	0.7387
	0.9350	2.2062	1.0631	1.2040	1.0598	0.7784
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0035	0.0030	0.0031	0.0017	0.0029	0.0019
	0.0020	0.0034	0.0018	0.0022	0.0027	0.0030
STD. DEVIATIONS	0.0023	0.0016	0.0017	0.0011	0.0020	0.0013
	0.0015	0.0031	0.0016	0.0018	0.0018	0.0013
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0017	0.0015	0.0018	0.0024	0.0022	0.0025
	0.0027	0.0024	0.0027	0.0026	0.0020	0.0020
STD. DEVIATIONS	0.0007	0.0007	0.0007	0.0007	0.0009	0.0007
	0.0006	0.0008	0.0006	0.0009	0.0007	0.0006

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0111	0.0094	0.0094	0.0048	0.0099	0.0067
	0.0070	0.0129	0.0066	0.0079	0.0088	0.0093
STD. DEVIATIONS	0.0092	0.0059	0.0060	0.0039	0.0073	0.0046
	0.0057	0.0134	0.0067	0.0073	0.0067	0.0047

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.25	(8.104)	149735.7	100.00
RUNOFF	0.033	(0.1113)	120.23	0.080
EVAPOTRANSPIRATION	24.375	(3.7723)	88480.87	59.091
LATERAL DRAINAGE COLLECTED FROM LAYER 2	16.76228	(5.00257)	60847.090	40.63633
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.03109	(0.00813)	112.853	0.07537
AVERAGE HEAD ON TOP OF LAYER 3	0.009	(0.003)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.02659	(0.00459)	96.514	0.06446
CHANGE IN WATER STORAGE	0.053	(0.8534)	190.98	0.128

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	0.450	1632.0024
DRAINAGE COLLECTED FROM LAYER 2	1.79238	6506.35205
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.001762	6.39447
AVERAGE HEAD ON TOP OF LAYER 3	0.338	
MAXIMUM HEAD ON TOP OF LAYER 3	0.651	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	2.1 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000159	0.57787
SNOW WATER	1.80	6547.7266

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.2873

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0464

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

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

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	2.1643	0.1202
2	0.0243	0.0974
3	0.0000	0.0000
4	1.3621	0.1135
SNOW WATER	0.000	

```
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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\PROGRA~1\HELP3\RALNCP.D4
TEMPERATURE DATA FILE:       C:\PROGRA~1\HELP3\RALNCT.D7
SOLAR RADIATION DATA FILE:   C:\PROGRA~1\HELP3\RALNCS.D13
EVAPOTRANSPIRATION DATA:     C:\PROGRA~1\HELP3\RALNCE.D11
SOIL AND DESIGN DATA FILE:   C:\PROGRA~1\HELP3\WCGCL08.D10
OUTPUT DATA FILE:            C:\PROGRA~1\HELP3\WCGCL08.OUT


TIME:   9:24     DATE:  11/16/2009


******************************************************************************

     TITLE:  Washington County C&DLF - Case 1A (GCL) (8% Slope)

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   4
          THICKNESS                    =     18.00   INCHES
          POROSITY                     =      0.4370 VOL/VOL
          FIELD CAPACITY               =      0.1050 VOL/VOL
          WILTING POINT                =      0.0470 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.0563 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.170000002000E-02 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                                  LAYER  2
                                  --------

                     TYPE 2 - LATERAL DRAINAGE LAYER
                         MATERIAL TEXTURE NUMBER  20
          THICKNESS                    =      0.25   INCHES
          POROSITY                     =      0.8500 VOL/VOL
          FIELD CAPACITY               =      0.0100 VOL/VOL
          WILTING POINT                =      0.0050 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.0763 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =   10.0000000000     CM/SEC
          SLOPE                        =      8.00   PERCENT
          DRAINAGE LENGTH              =     70.0    FEET

                                  LAYER  3
                                  --------

                     TYPE 3 - BARRIER SOIL LINER
                         MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =      0.20   INCHES
          POROSITY                     =      0.7500 VOL/VOL
          FIELD CAPACITY               =      0.7470 VOL/VOL
          WILTING POINT                =      0.4000 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

                                  LAYER  4
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   4
          THICKNESS                    =     12.00   INCHES
          POROSITY                     =      0.4370 VOL/VOL
          FIELD CAPACITY               =      0.1050 VOL/VOL
          WILTING POINT                =      0.0470 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.1054 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.170000002000E-02 CM/SEC


                  GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                  ----------------------------------------

        NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
                 SOIL DATA BASE USING SOIL TEXTURE # 4 WITH A
                 FAIR STAND OF GRASS, A SURFACE SLOPE OF  8.%
                 AND A SLOPE LENGTH OF   70. FEET.

SCS RUNOFF CURVE NUMBER              =     64.60
FRACTION OF AREA ALLOWING RUNOFF     =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
EVAPORATIVE ZONE DEPTH               =     18.2    INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =      1.033  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =      8.078  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =      0.847  INCHES
INITIAL SNOW WATER                   =      0.000  INCHES
```

5/12

INITIAL WATER IN LAYER MATERIALS	=	2.447	INCHES
TOTAL INITIAL WATER	=	2.447	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
RALEIGH NORTH CAROLINA

STATION LATITUDE	=	35.87	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	86	
END OF GROWING SEASON (JULIAN DATE)	=	310	
EVAPORATIVE ZONE DEPTH	=	18.2	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.70	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	78.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00	%

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

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

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

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

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

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

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.44	2.92	3.81	2.20	4.34	3.74
	4.24	5.43	2.40	2.87	3.05	2.80
STD. DEVIATIONS	2.07	1.23	1.51	1.52	2.22	1.98
	1.91	3.72	1.67	2.00	1.79	1.04
RUNOFF						
TOTALS	0.000	0.000	0.005	0.000	0.001	0.000
	0.000	0.025	0.001	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.022	0.000	0.003	0.000
	0.000	0.106	0.006	0.000	0.001	0.000
EVAPOTRANSPIRATION						
TOTALS	1.467	1.654	2.345	1.909	2.807	2.734
	2.923	3.184	1.684	1.243	1.261	1.159
STD. DEVIATIONS	0.269	0.317	0.614	0.997	1.123	1.440
	1.321	1.131	0.889	0.502	0.465	0.198
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	1.8128	1.5632	1.6989	0.6449	1.5006	1.2998
	1.3085	1.9957	1.0964	1.0334	1.3887	1.4132
STD. DEVIATIONS	1.5435	0.9714	1.1582	0.5873	1.2192	0.9499
	0.9314	2.1968	1.1342	1.0592	1.0185	0.6486
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0043	0.0041	0.0037	0.0024	0.0023	0.0014
	0.0012	0.0018	0.0010	0.0016	0.0032	0.0042
STD. DEVIATIONS	0.0014	0.0011	0.0016	0.0019	0.0016	0.0010
	0.0009	0.0013	0.0009	0.0012	0.0019	0.0014
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0008	0.0006	0.0013	0.0022	0.0025	0.0030
	0.0032	0.0028	0.0032	0.0028	0.0015	0.0009
STD. DEVIATIONS	0.0008	0.0008	0.0012	0.0016	0.0012	0.0010
	0.0011	0.0010	0.0010	0.0012	0.0014	0.0010

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0110	0.0104	0.0103	0.0041	0.0091	0.0082
	0.0080	0.0121	0.0069	0.0063	0.0087	0.0086
STD. DEVIATIONS	0.0094	0.0065	0.0070	0.0037	0.0074	0.0060
	0.0057	0.0134	0.0071	0.0064	0.0064	0.0039

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.25	(8.104)	149735.7	100.00
RUNOFF	0.032	(0.1131)	116.34	0.078
EVAPOTRANSPIRATION	24.371	(3.6606)	88465.12	59.081
LATERAL DRAINAGE COLLECTED FROM LAYER 2	16.75596	(5.15566)	60824.145	40.62100
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.03101	(0.00742)	112.576	0.07518
AVERAGE HEAD ON TOP OF LAYER 3	0.009	(0.003)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.02494	(0.00693)	90.527	0.06046
CHANGE IN WATER STORAGE	0.066	(1.0441)	239.56	0.160

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	0.472	1715.1364
DRAINAGE COLLECTED FROM LAYER 2	1.78592	6482.88867
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000457	1.65831
AVERAGE HEAD ON TOP OF LAYER 3	0.337	
MAXIMUM HEAD ON TOP OF LAYER 3	0.649	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	2.1 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000198	0.71986
SNOW WATER	1.80	6547.7266

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.2871

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0464

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

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

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	2.2069	0.1226
2	0.0243	0.0973
3	0.1500	0.7500
4	1.3859	0.1155
SNOW WATER	0.000	

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\PROGRA~1\HELP3\RALNCP.D4
TEMPERATURE DATA FILE:       C:\PROGRA~1\HELP3\RALNCT.D7
SOLAR RADIATION DATA FILE:   C:\PROGRA~1\HELP3\RALNCS.D13
EVAPOTRANSPIRATION DATA:     C:\PROGRA~1\HELP3\RALNCE.D11
SOIL AND DESIGN DATA FILE:   C:\PROGRA~1\HELP3\WCSOIL25.D10
OUTPUT DATA FILE:            C:\PROGRA~1\HELP3\WCSOIL25.OUT


TIME:   9:25     DATE:  11/16/2009


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     TITLE:  Washington County C&DLF - Cases 1B (Soil) (25%)

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   4
          THICKNESS                  =     24.00   INCHES
          POROSITY                   =      0.4370 VOL/VOL
          FIELD CAPACITY             =      0.1050 VOL/VOL
          WILTING POINT              =      0.0470 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.1780 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.170000002000E-02 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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                    GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                    ----------------------------------------

     NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
              SOIL DATA BASE USING SOIL TEXTURE # 4 WITH A
              FAIR STAND OF GRASS, A SURFACE SLOPE OF 25.%
              AND A SLOPE LENGTH OF  130. FEET.

     SCS RUNOFF CURVE NUMBER              =     64.40
     FRACTION OF AREA ALLOWING RUNOFF     =    100.0    PERCENT
     AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
     EVAPORATIVE ZONE DEPTH               =     22.0    INCHES
     INITIAL WATER IN EVAPORATIVE ZONE    =      3.852  INCHES
     UPPER LIMIT OF EVAPORATIVE STORAGE   =      9.614  INCHES
     LOWER LIMIT OF EVAPORATIVE STORAGE   =      1.034  INCHES
     INITIAL SNOW WATER                   =      0.000  INCHES
     INITIAL WATER IN LAYER MATERIALS     =      4.271  INCHES
     TOTAL INITIAL WATER                  =      4.271  INCHES
     TOTAL SUBSURFACE INFLOW              =      0.00   INCHES/YEAR


                  EVAPOTRANSPIRATION AND WEATHER DATA
                  -----------------------------------

     NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
              RALEIGH                NORTH CAROLINA

         STATION LATITUDE                        =  35.87 DEGREES
         MAXIMUM LEAF AREA INDEX                 =   2.00
         START OF GROWING SEASON (JULIAN DATE)   =     86
         END OF GROWING SEASON (JULIAN DATE)     =    310
         EVAPORATIVE ZONE DEPTH                  =  22.0  INCHES
         AVERAGE ANNUAL WIND SPEED               =   7.70 MPH
         AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  66.00 %
         AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  70.00 %
         AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  78.00 %
         AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  72.00 %


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

              NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

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


     NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    RALEIGH              NORTH CAROLINA
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NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

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

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.44	2.92	3.81	2.20	4.34	3.74
	4.24	5.43	2.40	2.87	3.05	2.80
STD. DEVIATIONS	2.07	1.23	1.51	1.52	2.22	1.98
	1.91	3.72	1.67	2.00	1.79	1.04
RUNOFF						
TOTALS	0.000	0.000	0.006	0.000	0.003	0.000
	0.000	0.031	0.001	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.026	0.000	0.015	0.000
	0.000	0.130	0.004	0.000	0.001	0.000
EVAPOTRANSPIRATION						
TOTALS	1.418	1.672	2.522	2.100	3.766	3.850
	3.851	4.039	2.343	1.222	1.173	1.061
STD. DEVIATIONS	0.163	0.298	0.458	0.960	0.748	1.510
	1.465	1.230	1.061	0.415	0.192	0.144
PERCOLATION/LEAKAGE THROUGH LAYER 1						
TOTALS	2.1528	1.3866	1.4046	0.6721	1.0688	0.5441
	0.2472	1.0644	0.4552	0.5287	1.2643	1.4163
STD. DEVIATIONS	1.6844	1.0386	1.0830	0.6927	1.3560	0.5599
	0.3675	2.2762	0.9140	0.8363	1.1706	0.8777

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.25	(8.104)	149735.7	100.00
RUNOFF	0.042	(0.1365)	152.09	0.102
EVAPOTRANSPIRATION	29.015	(3.3638)	105324.96	70.341
PERCOLATION/LEAKAGE THROUGH LAYER 1	12.20509	(5.86268)	44304.473	29.58845
CHANGE IN WATER STORAGE	-0.013	(0.8544)	-45.85	-0.031

****

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	0.581	2108.7217
PERCOLATION/LEAKAGE THROUGH LAYER 1	2.838470	10303.64550
SNOW WATER	1.80	6547.7266

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3321

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0470

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	4.0187	0.1674
SNOW WATER	0.000	

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9/12

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\PROGRA~1\HELP3\RALNCP.D4
TEMPERATURE DATA FILE:       C:\PROGRA~1\HELP3\RALNCT.D7
SOLAR RADIATION DATA FILE:   C:\PROGRA~1\HELP3\RALNCS.D13
EVAPOTRANSPIRATION DATA:     C:\PROGRA~1\HELP3\RALNCE.D11
SOIL AND DESIGN DATA FILE:   C:\PROGRA~1\HELP3\WCRMC.D10
OUTPUT DATA FILE:            C:\PROGRA~1\HELP3\WCRMC.OUT


TIME:   9:26     DATE:  11/16/2009


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     TITLE:  Washington County C&DLF - Case 2 (RMC)

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   4
          THICKNESS                    =      6.00   INCHES
          POROSITY                     =      0.4370 VOL/VOL
          FIELD CAPACITY               =      0.1050 VOL/VOL
          WILTING POINT                =      0.0470 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.1246 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.170000002000E-02 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                   LAYER  2
                                   --------

                     TYPE 3 - BARRIER SOIL LINER
                         MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =     18.00   INCHES
          POROSITY                     =      0.4750 VOL/VOL
          FIELD CAPACITY               =      0.3780 VOL/VOL
          WILTING POINT                =      0.2650 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.4750 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-05 CM/SEC


                                   LAYER  3
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   4
          THICKNESS                    =     12.00   INCHES
          POROSITY                     =      0.4370 VOL/VOL
          FIELD CAPACITY               =      0.1050 VOL/VOL
          WILTING POINT                =      0.0470 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.1964 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.170000002000E-02 CM/SEC


                 GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                 ----------------------------------------

     NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
              SOIL DATA BASE USING SOIL TEXTURE # 4 WITH A
              FAIR STAND OF GRASS, A SURFACE SLOPE OF 25.%
              AND A SLOPE LENGTH OF  130. FEET.

SCS RUNOFF CURVE NUMBER              =     64.40
FRACTION OF AREA ALLOWING RUNOFF     =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
EVAPORATIVE ZONE DEPTH               =      6.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =      0.748  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =      2.622  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =      0.282  INCHES
INITIAL SNOW WATER                   =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =     11.655  INCHES
TOTAL INITIAL WATER                  =     11.655  INCHES
TOTAL SUBSURFACE INFLOW              =      0.00   INCHES/YEAR


                 EVAPOTRANSPIRATION AND WEATHER DATA
                 -----------------------------------

     NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
              RALEIGH                NORTH CAROLINA

        STATION LATITUDE                          =  35.87 DEGREES
        MAXIMUM LEAF AREA INDEX                   =   2.00
        START OF GROWING SEASON (JULIAN DATE)     =     86
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END OF GROWING SEASON (JULIAN DATE) = 310
EVAPORATIVE ZONE DEPTH = 6.0 INCHES
AVERAGE ANNUAL WIND SPEED = 7.70 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 66.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 78.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 72.00 %

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

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

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

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

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

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

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.44	2.92	3.81	2.20	4.34	3.74
	4.24	5.43	2.40	2.87	3.05	2.80
STD. DEVIATIONS	2.07	1.23	1.51	1.52	2.22	1.98
	1.91	3.72	1.67	2.00	1.79	1.04
RUNOFF						
TOTALS	0.087	0.000	0.037	0.000	0.129	0.012
	0.049	0.327	0.047	0.035	0.041	0.006
STD. DEVIATIONS	0.216	0.000	0.101	0.000	0.380	0.054
	0.218	0.945	0.212	0.109	0.170	0.029
EVAPOTRANSPIRATION						
TOTALS	1.355	1.559	2.188	1.610	2.461	2.576
	3.000	2.953	1.422	1.200	1.227	1.056
STD. DEVIATIONS	0.255	0.371	0.557	0.947	0.875	1.120
	1.029	1.041	0.759	0.496	0.437	0.223
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	2.0194	1.5858	1.5898	0.6479	1.6071	1.2121
	1.3054	2.0999	1.0229	1.3609	1.7422	1.6851
STD. DEVIATIONS	1.6795	1.1497	1.1360	0.8210	1.4135	1.1102
	1.0609	1.9061	0.9160	1.3940	1.4685	0.9376
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	2.0700	1.5523	1.6056	0.8595	1.4706	1.2703
	1.1967	2.0668	1.2331	1.1558	1.7196	1.6903
STD. DEVIATIONS	1.4970	1.0671	1.0509	0.7450	1.3320	1.0369
	1.0795	1.6660	0.8623	1.1723	1.3050	1.0604

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2						
AVERAGES	0.3346	0.1658	0.1823	0.0599	0.2408	0.1527
	0.1475	0.3243	0.1276	0.1651	0.2563	0.1693
STD. DEVIATIONS	0.4122	0.1799	0.2450	0.1313	0.3236	0.1722
	0.1699	0.4872	0.1679	0.2572	0.2941	0.1623

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.25	(8.104)	149735.7	100.00
RUNOFF	0.772	(1.2906)	2800.57	1.870
EVAPOTRANSPIRATION	22.607	(2.8828)	82061.99	54.805
PERCOLATION/LEAKAGE THROUGH LAYER 2	17.87865	(5.10849)	64899.500	43.34270
AVERAGE HEAD ON TOP OF LAYER 2	0.194	(0.101)		
PERCOLATION/LEAKAGE THROUGH LAYER 3	17.89057	(5.24721)	64942.762	43.37159
CHANGE IN WATER STORAGE	-0.019	(0.9040)	-69.62	-0.046

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	2.914	10578.0020
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.453537	1646.34021
AVERAGE HEAD ON TOP OF LAYER 2	6.000	
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.445178	1615.99609
SNOW WATER	1.80	6547.7266

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4370

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0470

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	0.6025	0.1004
2	8.5500	0.4750
3	2.1190	0.1766
SNOW WATER	0.000	

PROJECT Washington County C&D Landfill - Phase 2

SUBJECT Slope Stability Evaluation

JOB NO. WASH-09-1
DATE 11/16/09
COMPUTED BY PKS
CHECKED BY

Objective

To perform a slope stability evaluation for the C&D landfill. Note that only static conditions were evaluated in that the landfill is not in a seismic impact zone ($a_{peak} = \pm 0.06$ according to 2008 USGS mapping). Based on EPA guidance for MSW landfills (EPA/600/R-95/051), landfills are required to have a minimum long-term static factor of safety of 1.5.

Analysis

The slope stability evaluations for the overall C&D landfill area were performed using the computer program STABL5M, a computer program developed by Purdue University.

The slope stability evaluation was performed on the worst case cross section shown on the attached figure (final grades shown). The shear strength envelope assumed for the waste in this evaluation was cohesion = 200 psf and phi = 25 degrees; which is believed to be conservative for C&D wastes. The shear strength envelope assumed for the Alum sludge, which comprises the existing Phase 1 berm, in this evaluation was cohesion = 100 psf and phi = 28.5 degrees; which is based on prior analysis by Law Engineering (1991). Also, the shear strength envelope assumed for the subgrade in this evaluation was cohesion = 0 psf and phi = 30 degrees; which is conservative for sands. The result is as follows:

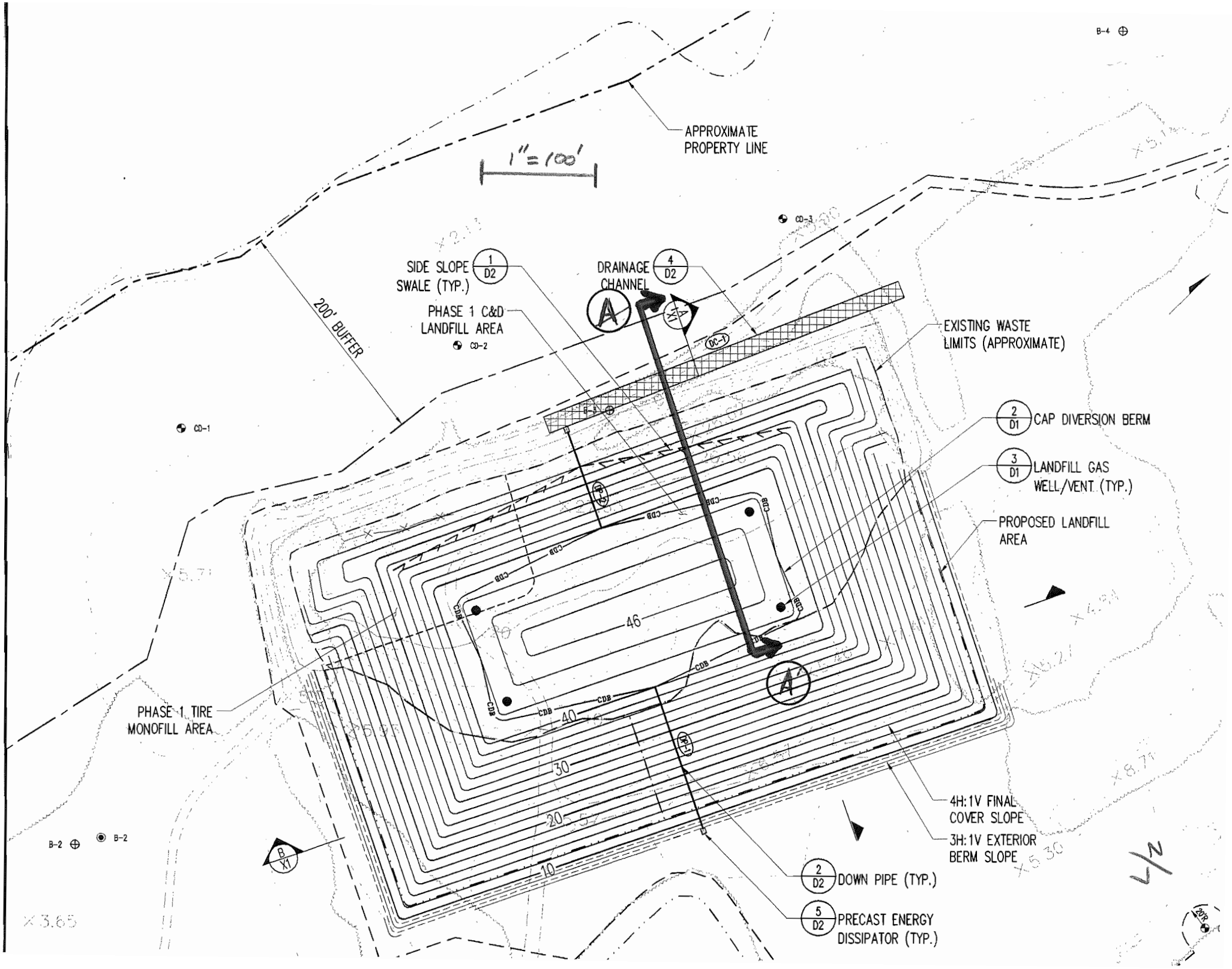
Circular Failure (Static): FS = 2.23

Results

The minimum factor of safety satisfies EPA guidelines.

STABILITY.WPD

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577



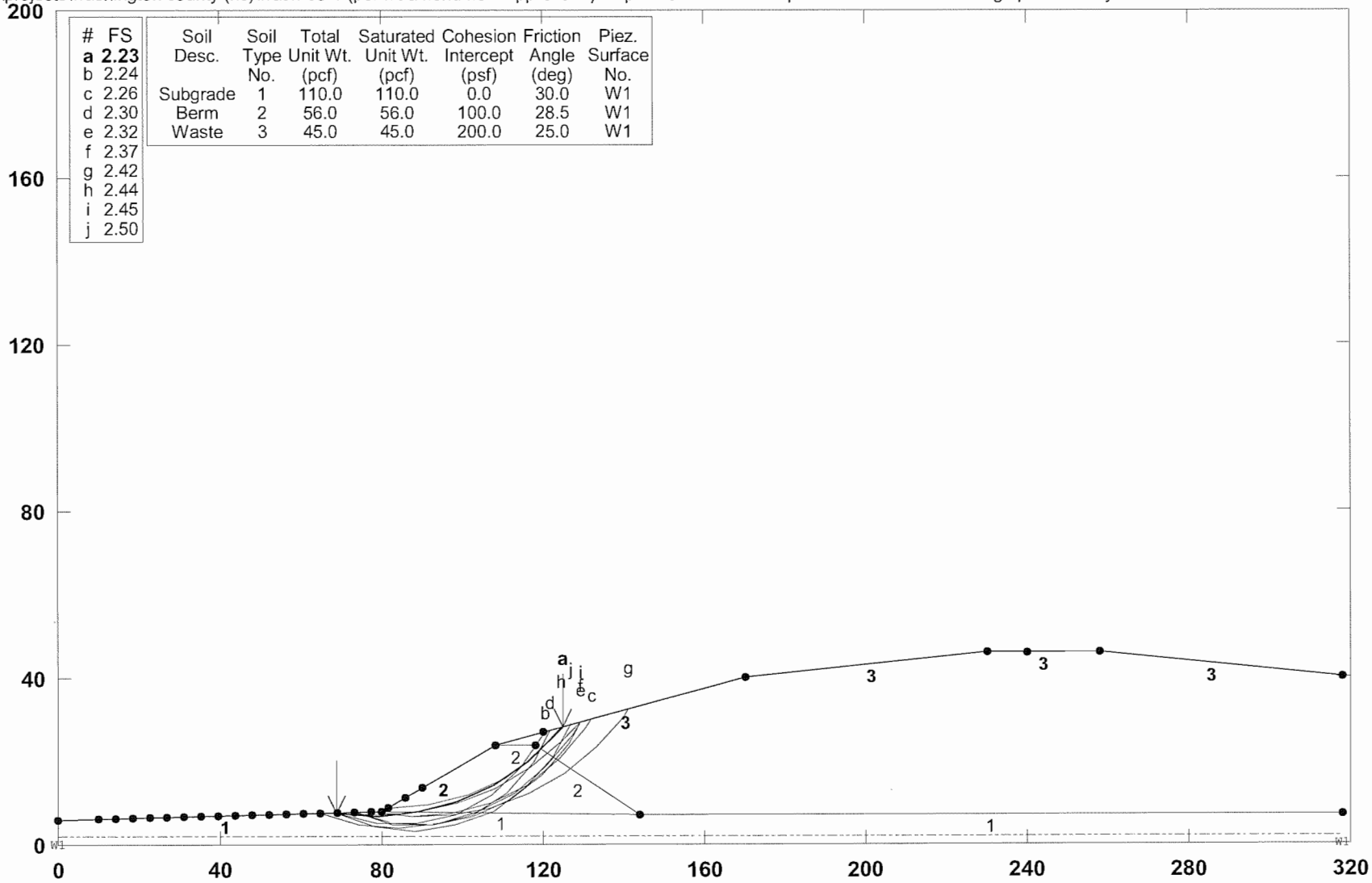
APPROXIMATE PROPERTY LINE
1" = 100'
200' BUFFER
SIDE SLOPE SWALE (TYP.) 1 D2
DRAINAGE CHANNEL 4 D2
PHASE 1 C&D LANDFILL AREA
EXISTING WASTE LIMITS (APPROXIMATE)
2 D1 CAP DIVERSION BERM
3 D1 LANDFILL GAS WELL/VENT (TYP.)
PROPOSED LANDFILL AREA
PHASE 1 TIRE MONOFILL AREA
4H:1V FINAL COVER SLOPE
3H:1V EXTERIOR BERM SLOPE
2 D2 DOWN PIPE (TYP.)
5 D2 PRECAST ENERGY DISSIPATOR (TYP.)
CD-1
CD-2
CD-3
B-2
B-3
B-4
46
40
30
20
10
CDB

Washington County C&DLF - Section A Circular - Global - Static

h:\projects\washington county (nc)\wash-09-1 (permit amendment application)\nc permit amendment - phase 2\calculations\wcacgs.pl2 Run By: Pieter Scheer 11/16/2009 10:56AM

#	FS
a	**2.23**
b	2.24
c	2.26
d	2.30
e	2.32
f	2.37
g	2.42
h	2.44
i	2.45
j	2.50

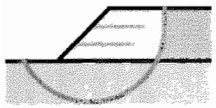
Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
Subgrade	1	110.0	110.0	0.0	30.0	W1
Berm	2	56.0	56.0	100.0	28.5	W1
Waste	3	45.0	45.0	200.0	25.0	W1



PCSTABL5M/si FSmin=2.23

Safety Factors Are Calculated By The Modified Bishop Method

STED



3/7

```
                    ** PCSTABL5M **
                          by
                   Purdue University
             --Slope Stability Analysis--
          Simplified Janbu, Simplified Bishop
             or Spencer`s Method of Slices
Run Date:                  11/16/2009
Time of Run:               10:56AM
Run By:                    Pieter Scheer
Input Data Filename:       H:WCACGS.in
Output Filename:           H:WCACGS.OUT
Unit:                      ENGLISH
Plotted Output Filename:   H:WCACGS.PLT
PROBLEM DESCRIPTION   Washington County C&DLF - Section A
                      Circular - Global - Static
BOUNDARY COORDINATES
    6 Top   Boundaries
   10 Total Boundaries
Boundary     X-Left     Y-Left    X-Right    Y-Right    Soil Type
   No.        (ft)       (ft)       (ft)       (ft)     Below Bnd
    1          .00       6.00      80.00       8.00        1
    2        80.00       8.00     108.00      24.00        2
    3       108.00      24.00     170.00      40.00        3
    4       170.00      40.00     230.00      46.00        3
    5       230.00      46.00     258.00      46.00        3
    6       258.00      46.00     318.00      40.00        3
    7       108.00      24.00     118.00      24.00        2
    8       118.00      24.00     144.00       7.00        2
    9        80.00       8.00     144.00       7.00        1
   10       144.00       7.00     318.00       7.00        1
ISOTROPIC SOIL PARAMETERS
 3 Type(s) of Soil
Soil  Total  Saturated  Cohesion Friction   Pore   Pressure   Piez.
Type Unit Wt. Unit Wt. Intercept   Angle  Pressure Constant Surface
 No.  (pcf)    (pcf)     (psf)     (deg)   Param.    (psf)    No.
  1   110.0    110.0       .0      30.0     .00        .0      1
  2    56.0     56.0     100.0     28.5     .00        .0      1
  3    45.0     45.0     200.0     25.0     .00        .0      1
1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED
Unit Weight of Water =  62.40
Piezometric Surface No.  1 Specified by  2 Coordinate Points
  Point      X-Water     Y-Water
   No.         (ft)        (ft)
    1          .00        2.00
    2       318.00        2.00
A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.
400 Trial Surfaces Have Been Generated.
 20 Surfaces Initiate From Each Of 20 Points Equally Spaced
Along The Ground Surface Between  X =  10.00 ft.
                                and  X =  90.00 ft.
Each Surface Terminates Between   X = 120.00 ft.
                                and  X = 240.00 ft.
Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is  Y =   .00 ft.
10.00 ft. Line Segments Define Each Trial Failure Surface.
Following Are Displayed The Ten Most Critical Of The Trial
      Failure Surfaces Examined.  They Are Ordered - Most Critical
      First.
      * * Safety Factors Are Calculated By The Modified Bishop Method * *
      Failure Surface Specified By  8 Coordinate Points
        Point      X-Surf      Y-Surf
         No.        (ft)        (ft)
          1        68.95        7.72
          2        78.92        6.94
          3        88.88        7.81
          4        98.57       10.30
          5       107.71       14.34
```

6	116.07	19.83
7	123.41	26.62
8	124.73	28.32

Circle Center At X = 78.7 ; Y = 67.1 and Radius, 60.2
*** 2.225 ***

Individual data on the 12 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	10.0	564.8	.0	.0	.0	.0	.0	.0	.0
2	1.1	118.7	.0	.0	.0	.0	.0	.0	.0
3	8.9	1792.1	.0	.0	.0	.0	.0	.0	.0
4	.2	57.4	.0	.0	.0	.0	.0	.0	.0
5	9.5	3624.6	.0	.0	.0	.0	.0	.0	.0
6	9.1	4558.9	.0	.0	.0	.0	.0	.0	.0
7	.3	153.6	.0	.0	.0	.0	.0	.0	.0
8	8.1	3458.1	.0	.0	.0	.0	.0	.0	.0
9	1.9	556.8	.0	.0	.0	.0	.0	.0	.0
10	1.5	322.5	.0	.0	.0	.0	.0	.0	.0
11	3.9	466.5	.0	.0	.0	.0	.0	.0	.0
12	1.3	40.1	.0	.0	.0	.0	.0	.0	.0

Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	68.95	7.72
2	78.61	5.16
3	88.61	5.03
4	98.34	7.35
5	107.21	11.98
6	114.68	18.63
7	120.30	26.90
8	120.41	27.20

Circle Center At X = 84.1 ; Y = 45.4 and Radius, 40.6
*** 2.237 ***

Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	77.37	7.93
2	87.30	6.73
3	97.27	7.45
4	106.92	10.06
5	115.90	14.46
6	123.87	20.51
7	130.53	27.97
8	131.83	30.15

Circle Center At X = 88.6 ; Y = 58.2 and Radius, 51.5
*** 2.257 ***

Failure Surface Specified By 7 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	73.16	7.83
2	82.70	4.84
3	92.70	4.62
4	102.36	7.19
5	110.93	12.35
6	117.73	19.68
7	121.68	27.53

Circle Center At X = 88.5 ; Y = 40.0 and Radius, 35.6
*** 2.299 ***

Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	68.95	7.72
2	78.93	7.08
3	88.90	7.88
4	98.65	10.10

```
    5        107.98        13.70
    6        116.69        18.60
    7        124.61        24.71
    8        129.25        29.48
Circle Center At X =   78.4 ; Y =   75.9  and Radius,   68.8
      ***     2.315   ***
Failure Surface Specified By  8 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         73.16        7.83
    2         82.80        5.18
    3         92.79        4.76
    4        102.62        6.60
    5        111.79       10.59
    6        119.83       16.53
    7        126.34       24.13
    8        129.12       29.45
Circle Center At X =   89.6 ; Y =   48.5  and Radius,   43.8
      ***     2.365   ***
Failure Surface Specified By  9 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         77.37        7.93
    2         87.29        6.68
    3         97.28        7.01
    4        107.10        8.91
    5        116.50       12.34
    6        125.23       17.21
    7        133.08       23.40
    8        139.86       30.75
    9        141.04       32.53
Circle Center At X =   90.2 ; Y =   69.7  and Radius,   63.1
      ***     2.420   ***
Failure Surface Specified By  6 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         81.58        8.90
    2         91.57        9.36
    3        101.28       11.74
    4        110.34       15.96
    5        118.42       21.87
    6        124.24       28.19
Circle Center At X =   84.3 ; Y =   59.6  and Radius,   50.8
      ***     2.437   ***
Failure Surface Specified By  9 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         64.74        7.62
    2         74.36        4.89
    3         84.32        4.02
    4         94.27        5.02
    5        103.86        7.86
    6        112.74       12.45
    7        120.61       18.62
    8        127.19       26.15
    9        129.12       29.45
Circle Center At X =   84.0 ; Y =   57.2  and Radius,   53.2
      ***     2.447   ***
Failure Surface Specified By  8 Coordinate Points
  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)
    1         68.95        7.72
    2         78.37        4.37
    3         88.31        3.30
    4         98.23        4.57
    5        107.58        8.12
    6        115.84       13.75
```

```
    7        122.57       21.15
    8        126.81       28.85
Circle Center At X =   87.8 ; Y =   45.8  and Radius,   42.5
      ***     2.500   ***
```

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Technical Specifications

Washington County C&D Landfill
Roper, North Carolina

Prepared for:

Washington County Public Utilities
Roper, North Carolina

January 2010

RICHARDSON SMITH GARDNER
ENGINEERING & GEOLOGICAL
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RALEIGH, NORTH CAROLINA 27603
NC LIC. NO. C-0828 (ENGINEERING)

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WASHINGTON COUNTY C&D LANDFILL

TECHNICAL SPECIFICATIONS

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Section No.	Specification
02222	Excavation
02223	Embankment
02240	Geotextiles
02258	Vegetative Soil Layer
02270	Erosion and Sedimentation Control
02271	Rip Rap
02275	Rolled Erosion Control Products
02712	Drainage Geocomposite
02720	Storm Water Systems
02776	Geosynthetic Clay Liner
02778	LLDPE Geomembrane
02930	Revegetation

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SECTION 02222

EXCAVATION

Excavation: Excavation includes excavating, sealing, hauling, scraping, undercutting, removal of accumulated surface water or ground water, stockpiling, and all necessary and incidental items as required for bringing the landfill and related structures to the specified lines and grades.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment required to complete Excavation of the project area in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Site Preparation	02110
Embankment	02223
Erosion and Sedimentation Control	02270
CQA Manual	Attached

3. Quality Assurance:

Quality Assurance during Excavation will be provided by the Owner as described in the accompanying Project CQA Manual.

4. Definitions:

a. Excavation: shall consist of the removal and satisfactory disposal and/or stockpiling of materials located with the limits of construction including widening cuts and shaping of slopes necessary for the preparation of roadbeds, landfill slope areas, cutting of any ditches, channels, waterways, entrances, and other work incidental thereto.

b. Borrow: shall consist of approved on-site material required for the construction of embankments/fills or for other portions of the work.

c. Select Borrow: shall consist of approved off-site material required for the construction of embankments/fills, roadway subgrade, backfilling, or for other portions of the work as shown on Contract Drawings or in these Specifications. The Contractor shall make his own arrangements for obtaining select borrow and pay all costs involved.

d. Unsuitable Material: is any in-place or excavated material which contains undesirable materials, or is in a state which is not appropriate; in the opinion of the CQA Engineer, for the intended use or support of planned structures, embankment, or excavation. This may include but not be limited to organic material, waste/refuse, soft, or wet material not meeting required specifications, etc.

e. Unsuitable Materials Excavation (Overexcavation): shall consist of the removal and satisfactory disposal of all unsuitable material located within the limits of construction. Where excavation to the finished grade section shown results in a subgrade or slopes of unsuitable material, the Contractor shall overexcavate such material to below the grade shown on the Contract Drawings or as directed by the Engineer and CQA Engineer.

B. MATERIALS

Excavation shall include the removal of all soil, weathered rock, boulders, conduits, pipe, and all other obstacles encountered and shown on the Contract Drawings or specified herein.

C. SUBMITTALS

The Contractor shall submit the following to the CQA Engineer before approval is given to proceed:

1. Plans of open cut excavations showing side slopes and limits of the excavation at grade.

2. List of disposal site(s) for waste and unsuitable materials.

3. Descriptive information on Excavation equipment to be used.

D. CONSTRUCTION

1. The Contractor shall conduct Excavation activities in such a manner that erosion of disturbed areas and off site sedimentation is absolutely minimized as outlined in Section 02270, Erosion and Sedimentation Control, of these Specifications.

2. The Contractor shall excavate to the lines and grades shown on the Contract Drawings and stockpile all suitable excavated materials. As the excavation is made, the materials will be examined and identified to the CQA Engineer.

   The Contractor will perform all surveys necessary to establish and verify lines and grades for all Excavation, including pipe excavations, soil overexcavation, and anchor trenches.

3. Stockpiling:

   The Contractor shall stockpile the materials in appropriate stockpiles as approved by the CQA Engineer. The Contractor shall use equipment and methods as necessary to maintain the moisture content of soils stockpiled (excluding topsoil) at or near their optimum moisture content.

   Stockpiles shall be properly sloped and the surfaces sealed by the Contractor at the end of each working day, or during the day in the event of heavy rain, to the satisfaction of the Engineer.

4. The Contractor shall protect all existing facilities and structures including, but not limited to, existing utilities, monitoring wells, signs, grade stakes, etc. during the grading and stockpiling operations.

5. All excavations shall be made in the dry and in such a manner and to such widths as will give ample room for properly constructing and inspecting the structures and/or piping they are to contain and for such sheeting, timbering, pumping, and drainage as may be required.

6. The Contractor shall be responsible for the control of surface and subsurface water, when necessary.

7. Excavation slopes shall be flat enough to avoid sloughs and slides that will cause disturbance of the subgrade or damage of adjacent areas. Slides and overbreaks which occur due to negligence, carelessness, or improper construction techniques on the part of the Contractor shall be removed and disposed of by the Contractor as directed by the Engineer at no additional cost to the Owner.

8. The intersection of slopes with natural ground surfaces, including the beginning and ending of cut slopes, shall be uniformly rounded. All protruding roots and other vegetation shall be removed from slopes.

9. The bottom of all excavations for structures and pipes shall be examined by the CQA Engineer for bearing value and the presence of unsuitable material. If, in the opinion of the CQA Engineer, additional Excavation is required due to the low bearing value of the subgrade material, or if the in-place materials are soft,

yielding, pumping and wet, the Contractor shall remove such material to the required width and depth and replace it with thoroughly compacted structural fill, or material directed by the CQA Engineer. No payment will be made for subgrade disturbance caused by inadequate Dewatering or improper construction methods.

10. Any areas excavated below design subgrade elevations by the Contractor, unless directed by the CQA Engineer, shall be brought back to design elevations at no cost to the Owner. The Contractor shall place and compact such material in accordance with Section 02223, Embankment, of these Specifications.

11. The Contractor shall dispose of excess or unsuitable excavation materials on-site at location(s) approved by the Owner.

12. The Contractor shall properly level-off bottoms of all excavations. Proof-rolling shall be conducted with appropriate equipment.

13. Upon reaching subgrade elevations shown in excavation areas, the Contractor shall scarify subgrade soils to a minimum depth of 6" and obtain the CQA Engineer's approval of quality. If unsuitable materials are encountered at the subgrade elevation, perform additional excavations as approved by the CQA Engineer to remove unsuitable materials.

14. Overexcavation and Backfill:

    a. Where subgrade materials are determined to be unsuitable, such materials shall be removed by the Contractor to the lengths, widths, and depths approved by the Engineer and CQA Engineer in advance and backfilled with suitable material in accordance with Section 02223, Embankment, of these Specifications.

    b. No additional payment will be made for such overexcavation and backfill 1 foot or less than the finished subgrade as this is considered superficial.

    c. Where overexcavation of unsuitable material is greater than 1 foot beneath the finished subgrade, payment shall be made on a unit price basis for overexcavation and backfill and the measured quantity shall include the entire excavation quantity below the finished subgrade elevations. The unit price for overexcavation and backfill shall include disposal of unsuitable materials.

15. All cuts shall be brought to the grade and cross section shown on the Contract Drawings, or established by the Engineer, prior to final inspection.

16. The Contractor shall protect finished lines and grades of completed excavation against excessive erosion, damage from trafficking, or other causes and shall repair any damage at no additional cost to the Owner.

17. Trench Excavation:

    a. All pipe Excavation and trenching shall be done in strict accordance with these Specifications, all applicable parts of the OSHA Regulations, 29 CFR 1926, Subpart P, and other applicable regulations. In the event of any conflicts in this information, safe working conditions as established by the appropriate OSHA guidelines shall govern.

    b. The minimum trench widths shall be as indicated on the Contract Drawings. Enlargements of the trench shall be made as needed to give ample space for operations at pipe joints. The width of the trench shall be limited to the maximum dimensions shown on the Contract Drawings, except where a wider trench is needed for the installation of and work within sheeting and bracing.

    c. Except where otherwise specified, excavation slopes shall be flat enough to avoid slides which will cause disturbance of the subgrade, damage to adjacent areas, or endanger the lives or safety of persons in the vicinity.

    d. Hand excavation shall be employed wherever, in the opinion of the Engineer, it is necessary for the protection of existing utilities, poles, trees, pavements, obstructions, or structures.

    e. No greater length of trench in any location shall be left open, in advance of pipe laying, than shall be authorized or directed by the Engineer and, in general, such length shall be limited to approximately one hundred (100) feet.

    f. Pipe Bedding: All pipe bedding shall be as shown on the Contract Drawings, unless otherwise specified herein.

18. Sheeting and Bracing:

    a. The Contractor shall furnish, place, and maintain such sheeting and bracing which may be required to support sides of Excavation or to protect pipes and structures from possible damage and to provide safe working conditions in accordance with current OSHA requirements. If the Engineer is of the opinion that at any point sufficient or proper supports have not been provided, he may order additional supports put in at the sole expense of the Contractor. The Contractor shall be responsible for the adequacy of all sheeting and bracing used and for all damage resulting

from sheeting and bracing failure or from placing, maintaining, and removing it.

b. The Contractor shall exercise caution in the installation and removal of sheeting to insure that excessive or unusual loadings are not transmitted to any new or existing structure. The Contractor shall promptly repair at his expense any and all damage that can be reasonably attributed to sheeting installation or removal.

c. All sheeting and bracing shall be removed upon completion of the work.

19. If grading operations are suspended for any reason whatsoever, partially completed cut and fill slopes shall be brought to the required slope and the work of seeding and mulching or other required erosion and sedimentation control operations shall be performed at the Contractor's sole expense.

END OF SECTION

SECTION 02223

EMBANKMENT

Embankment: Embankment is the on-site compacted fill that provides the foundation and the berms for the containment area, the subgrade for some access roadways and structures, and backfill around structures and piping.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete Embankment including borrowing, hauling, screening, discing, drying, compaction, control of surface and subsurface water, final grading, sealing, and all necessary and incidental items as detailed or required to complete the Embankment, all in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Erosion and Sedimentation Control	02270
CQA Manual	Attached

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) are hereby made a part of these Specifications.

ASTM D 698	Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3).
ASTM D 1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
ASTM D 2167	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.

ASTM D 2216	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
ASTM D 2488	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
ASTM D 2937	Standard Test Method for Density of Soil in Place by the Drive Cylinder Method.
ASTM D 4643	Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method.
ASTM D 4959	Standard Test Method for Determination of Water (Moisture) Content of Soil by Direct Heating Method.
ASTM D 6938	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

4. Quality Assurance:

Quality Assurance during placement of Embankment will be provided by the Owner as described in the accompanying Project CQA Manual.

5. Definitions:

a Embankment: Shall include construction of all site earthwork including roadways, subgrade, perimeter berm embankments, including preparation of the areas upon which materials are to be placed. Embankment may also be referred to as structural and/or controlled fill. All Embankment materials may be either (off-site) Select Borrow or (on-site) Borrow unless otherwise noted on Contract Drawings or specified by the Engineer.

b. Prepared Subgrade: The ground surface after clearing, grubbing, stripping, excavation, scarification, and/or compaction, and/or proof rolling to the satisfaction of the CQA Engineer.

c. Well-Graded: A mixture of particle sizes that has no specific concentration or lack thereof of one or more sizes. Well-graded does not define any numerical value that must be placed on the coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters. Well-graded is used to define a material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.

d. Unclassified Fill: The nature of materials to be used is not identified or described herein but must be approved by the Engineer prior to use.

B. MATERIALS

1. Embankment materials shall consist of clean well-graded natural soil classified as SW, SP, SM, SC, ML, CL, MH, or CH (ASTM D 2488) containing no topsoil or other deleterious material. Soils placed within 2 feet of the landfill subgrade shall be classified as SM, SC, ML, CL, MH, or CH soils.

2. Stones or rock fragments shall not exceed one half the maximum lift thickness as compacted in any dimension. Isolated rocks shall be a maximum of 24-inches in any dimension.

C. SUBMITTALS

The Contractor shall submit the following to the CQA Engineer before approval is given to proceed:

1. Descriptive information on compaction equipment to be used for construction of Embankment.

2. Descriptive information on the location and source of any off-site borrow material to be used for Embankment, where applicable. Information shall include Standard Proctor curves (ASTM D698) for each borrow material.

D. CONSTRUCTION

1. The Contractor shall conduct Embankment activities in such a manner that erosion of disturbed areas and off-site sedimentation is absolutely minimized as outlined in Section 02270, Erosion and Sedimentation Control, of these Specifications.

2. All placement and compaction of Embankment shall be performed only when the CQA Engineer is informed by the Contractor of intent to perform such work.

3. Embankment shall be placed and compacted to the lines and grades shown on the Contract Drawings. Placement of Embankment outside the construction limits shall occur only as directed and approved by the Engineer.

   The Contractor will perform all surveys necessary to establish and verify lines and grades for all Embankment.

4. The Contractor shall protect all existing facilities including, but not limited to, utilities and monitoring wells.

5. Subgrade Preparation:

   a. The CQA Engineer shall inspect the exposed subgrade prior to placement of Embankment to assure that all rocks, topsoil, vegetation, roots, debris, or other deleterious materials have been removed.

   b. Prior to placement of Embankment, the exposed subgrade shall be proofrolled using a static smooth-drum roller, loaded tandem axle dump truck, or other suitable equipment in the presence of the CQA Engineer. Any soft or unsuitable materials revealed before or during the in-place compaction shall be removed as directed by the CQA Engineer and replaced with suitable Embankment.

6. Surfaces on which Embankment is to be placed, shall be scarified or stepped in a manner which will permit bonding of the Embankment with the existing surface.

7. The Contractor shall be responsible for preparing the materials for the Embankment, including but not limited to, in-place drying or wetting of the soil necessary to achieve the compaction criteria of these Specifications.

8. The Contractor shall be responsible for the control of surface and subsurface water, when necessary.

9. Embankment materials shall be placed in a manner permitting drainage and in continuous, approximately horizontal layers.

10. Compaction Requirements:

    a. The Contractor shall compact Embankment in accordance with the requirements shown in Table 1 of this section. If Embankment does not meet the specified requirements, the Contractor shall rework the material, as may be necessary and continue compaction to achieve these requirements, or remove and replace the material to achieve the specified requirements, at Contractor's expense.

    b. Each lift shall be compacted prior to placement of succeeding lifts. In confined areas, mechanical equipment, suitable for small areas and capable of achieving the density requirements, shall be required.

    c. Lift compaction shall be performed with an appropriately heavy, properly ballasted, penetrating-foot or smooth-drum vibratory compactor depending on soil type. Compaction equipment shall be subject to approval by the CQA Engineer.

11. Embankment that becomes excessively eroded, soft, or otherwise unsuitable shall be removed or repaired by the Contractor as directed by the CQA Engineer, at no cost to the Owner.

12. The exposed surface of Embankment shall be rolled with a smooth-drum roller at the end of each work day to protect from adverse weather conditions.

13. Where Embankment is to be placed and compacted on slopes that are steeper than 3:1, the subgrade shall be benched to a minimum depth of 6 inches and the Embankment shall be placed in horizontal lifts.

14. Backfilling for Structures and Piping:

    a. All structures, including manholes and pipes shall be backfilled with Embankment as shown in the Contract Drawings and as described in these Specifications.

    b. Where sheeting is used, the Contractor shall take all reasonable measures to prevent loss of support beneath and adjacent to pipes and existing structures when sheeting is removed. If significant volumes of soil cannot be prevented from clinging to the extracted sheets, the voids shall be continuously backfilled as rapidly as possible. The Contractor shall thereafter limit the depth below subgrade that sheeting will be driven in similar soil conditions or employ other appropriate means to prevent loss of support.

    c. When backfilling around structures, do not backfill until concrete has sufficiently cured (as determined by the CQA Engineer) and is properly supported. Place backfill in a manner to avoid displacement or damage of structures.

TABLE 1: REQUIRED EMBANKMENT PROPERTIES

ITEM	Required % Standard Proctor (ASTM D698)[2]	Required Moisture Content[3]	Maximum Lift Thickness (Compacted) (inches)
Embankment	95	As Required for Compaction	8
Embankment Beneath Structures and Roads[1]	98		8
Backfill Around Structures	95		8
Backfill in Pipe Trenches	95		6
Unclassified Fill	N/A	N/A	N/A

Notes:

1. Embankment beneath structures shall be considered to include a zone 10 feet out from the foundation of the structure extending down to the natural ground on a 45° slope. Embankment beneath roads shall be considered to include all embankment placed within 2 vertical feet of the final wearing surface and shall also include shoulders.
2. Determine field density using ASTM D 6938, ASTM D 1556, ASTM D 2167, or ASTM D 2937.
3. Determine field moisture content using ASTM D 6938, ASTM D 2216, ASTM D 4643, or ASTM D 4959.
4. The Engineer may allow exceptions to the above criteria for areas outside of the containment area which are not subject to significant long-term loads.

END OF SECTION

SECTION 02240

GEOTEXTILES

Geotextiles: For the proposed construction, a Type GT-S (Separator/Filter) Geotextile is specified. The Type GT-S Geotextile will be placed in some erosion control and drainage applications.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of Geotextiles including all necessary and incidental items as detailed or required for the Contractor to complete the installation in accordance with the Contract Drawings and these Specifications, except as noted below:

a. Geotextiles used as a Silt Fence is covered under Section 02270, Erosion and Sedimentation Control, of these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Erosion and Sedimentation Control	02270

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) and the American Association of State Highway and Transportation Officials (AASHTO) are hereby made a part of these specifications.

ASTM D 3786	Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics: Diaphragm Bursting Strength Tester Method.
ASTM D 4355	Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).

ASTM D 4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
ASTM D 4632	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile.
ASTM D 4833	Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
ASTM D 5261	Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
AASHTO M 288	Standard Specification for Geotextiles.

B. MATERIALS

1. General:

The materials supplied under these Specifications shall consist of new, first-quality products designed and manufactured specifically for the purpose of this work, which shall have been satisfactorily demonstrated, by prior use, to be suitable and durable for such purposes.

Labels on each roll of Geotextile shall identify the length, width, lot and roll numbers, and name of Manufacturer.

2. The Type GT-S Geotextile shall be a nonwoven spunbonded or nonwoven needlepunched synthetic fabric consisting of polyester or polypropylene manufactured in a manner approved by the Engineer. Woven fabrics may be used in certain applications if approved in advance by the Engineer.

3. All Geotextiles shall conform to the properties listed in Table 1 of this section.

C. SUBMITTALS

Prior to the installation of Geotextiles, the Contractor shall submit the following to the Engineer:

1. Mill Certificate and Sample: Prior to shipping to the site, the Contractor shall submit a mill certificate or affidavit signed by a legally authorized official of the Manufacturer for each type of Geotextile attesting that the Geotextiles meet the physical and manufacturing requirements stated in these Specifications. The Contractor shall also submit a sample of each Geotextile to be used. The samples shall be labeled with the product name and be accompanied by the Manufacturer's specifications.

2. Shipping, Handling, and Storage Instructions: The Manufacturer's plan for shipping, handling, and storage shall be submitted for review.

3. Seaming Procedures:

   Submit proposed seaming procedures including proposed method and equipment.

4. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into the construction.

D. CONSTRUCTION

1. Shipping, Handling, and Storage:

   All Geotextiles shall be shipped, handled, and stored in strict accordance with the Manufacturer's recommendations.

2. Installation:

   a. The surface receiving the Geotextiles shall be prepared to a relatively smooth condition, free of obstructions, standing water, excessive depressions, debris, and very soft, excessively wet, and/or loose pockets of soil. This surface shall be approved by the Engineer prior to Geotextile placement.

   b. Geotextiles shall be placed to the lines and grades shown on the Contract Drawings. At the time of installation, Geotextiles shall be rejected by the Engineer if they have defects, rips, holes, flaws, evidence of deterioration, or other damage.

   c. The Geotextiles shall be placed smooth and free of excessive wrinkles.

   d. On slopes, Geotextiles shall be anchored at the top and unrolled down the slope. In the presence of wind, all Geotextiles shall be weighted with sandbags or other material as approved by the Engineer. Geotextiles uplifted by wind may be reused upon approval by the Engineer.

4. Seams:

a. All Geotextile seams shall be continuously sewn or heat bonded with methods approved by the Engineer. Overlapping of seams may also be allowed if approved in advance by the Engineer. All seams must be approved by the Engineer.

b. On slopes of 6H:1V or steeper, all seams shall be oriented parallel to (in the direction of) the slope unless otherwise approved by the Engineer.

c. Seams to be sewn shall be sewn using a Type 401 stitch. One or two rows of stitching may be used. Each row of stitching shall consist of 4 to 7 stitches per inch. The minimum distance from the geotextile edge to the stitch line nearest to that edge (seam allowance) shall be 1.5 inches if a Type SSa (prayer or flat) seam is used. The minimum seam allowance for all other seam types shall be 1.0 inches.

d. Seams to be heat bonded shall be bonded using hot plate, hot knife, ultrasonic, or other approved devices.

5. Repair Procedures:

Any Geotextile that is torn, punctured, or otherwise damaged shall be repaired or replaced, as directed by the Engineer, by the Contractor at no additional cost to the Owner. The repair shall consist of a patch of the same type of Geotextile placed over the failed areas and shall overlap the existing Geotextile a minimum of 18 inches from any point of the rupture. Patches shall be spot sewn or heat bonded so as not to shift during cover placement.

6. Cover Placement:

Placement of cover over Geotextiles shall be performed in a manner as to ensure that the Geotextiles or underlying materials are not damaged. Cover material shall be placed such that excess tensile stress is not mobilized in the Geotextile.

TABLE 1: REQUIRED GEOTEXTILE PROPERTIES

PROPERTY	TEST METHOD	UNITS	VALUE[1]
			TYPE GT-S
Geotextile Construction (NW = Nonwoven) (W = Woven)	----------	----------	NW[2] or W[3]
Mass per Unit Area (Unit Weight)	ASTM D 5261	oz/yd^2	N/A
Ultraviolet Resistance (500 hrs)	ASTM D 4355	%	70
Strength Class[4]	AASHTO M 288	Class	2
Tensile Properties:	ASTM D 4632		
Grab Strength		lbs	160 (NW) 250 (W)
Grab Elongation		%	$\geq$ 50 (NW) < 50 (W)
Puncture Resistance	ASTM D 4833	lbs	55 (NW) 90 (W)
Trapezoidal Tear Strength	ASTM D 4533	lbs	55 (NW) 90 (W)
Burst Strength	ASTM D 3786	psi	200 (NW) 400 (W)
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Sieve	70+
Permittivity	ASTM D 4491	sec^{-1}	1.0

Notes:

1. Minimum Average Roll Value (MARV).
2. Nonwoven geotextiles that have been heat calendered are not acceptable, unless approved by the Engineer in advance.
3. Woven geotextiles shall be approved in advance by the Engineer. Woven geotextiles formed exclusively with slit film fibers are not acceptable.
4. AASHTO M 288 criteria includes the above listed requirements for: Tensile Properties, Puncture Resistance, Trapezoidal Tear Strength, and Burst Strength.

END OF SECTION

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SECTION 02258

VEGETATIVE SOIL LAYER

Vegetative Soil Layer (VSL): The Vegetative Soil Layer (VSL) is placed in the final cover system in order to support permanent vegetative cover.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of the VSL (including topsoil) for the landfill cover, including borrowing, hauling, spreading, and final grading and all necessary and incidental items as detailed or required to complete the VSL, all in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Drainage Geocomposite	02712
Geosynthetic Clay Liner	02776
LLDPE Geomembrane	02778
Revegetation	02930
CQA Manual	Attached

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) are hereby made a part of these Specifications.

ASTM D 2487 — Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).

4. Quality Assurance:

Quality Assurance during placement of Vegetative Soil Layer will be provided by the Owner as described in the accompanying Project CQA Manual.

B. MATERIALS

Soil that meets all of the following requirements shall be classified as select soil fill for use in construction of the VSL.

1. Soil shall be classified according to the Unified Soil Classification System (USCS) as SM, SC, CL-ML, ML, or CL (ASTM D 2487). Alternatives to these requirements must be approved in advance by the Engineer.

2. Select soil fill materials shall be reasonably free of gypsum, ferrous, and/or calcareous concretions and nodules, refuse, roots, or other deleterious substances.

3. Continuous and repeated visual inspection of the materials being used will be performed by the Contractor to ensure proper soils are being used. In addition, the CQA Engineer shall make frequent inspections of the placement operations and materials, and will consult with the Engineer.

4. The VSL shall be uniform, smooth, and free of debris, rock, plant materials, and other foreign material larger than 3 inches in diameter. The material should contain no sharp edges. This material must be capable of supporting growth of vegetative cover.

5. Topsoil: The upper 6 inches of VSL shall be natural or blended soil material capable of supporting the growth of vegetative cover.

C. SUBMITTALS

The Contractor shall submit the following to the CQA Engineer:

1. Before approval is given to proceed, the Contractor shall submit descriptive information on placement equipment to be used in construction of the VSL.

2. Survey Results:

   After completion of a segment of VSL, survey results shall be submitted for review prior to VSL acceptance.

D. CONSTRUCTION

1. Where VSL is placed directly over geosynthetics and/or piping; thus, extreme caution shall be exercised by the Contractor to prevent damage to these materials.

2. All placement and compaction of VSL shall be performed only when the CQA Engineer is informed by the Contractor of intent to perform such work.

3. VSL shall be placed over geosynthetics only after areas have been released by the Geosynthetics Installer and the CQA Engineer. VSL shall be placed as specified below:

   a. The VSL, including topsoil, shall be placed and spread using low ground pressure (6 psi or less) tracked equipment. The CQA Engineer shall approve the equipment used to place the VSL.

   b. Tracked equipment used to place and spread VSL shall operate on at least 1 foot of material overlying geosynthetics and/or piping. Sharp turning of tracked equipment on the VSL will not be permitted.

   c. On slopes of 6H:1V or steeper, VSL shall be placed and spread from the bottom up unless otherwise approved by the Engineer. No material shall be dumped down a slope.

   d. VSL shall be placed and compacted to the lines and grades shown on the Contract Drawings with the exception that a 0.15 foot overbuild at Contractor's expense is allowed. The Contractor will perform all surveys necessary to establish and verify lines and grades for all VSL.

   e. VSL shall be compacted by tracking the final lift with tracked equipment.

4. The VSL shall be spread in a manner that minimizes development of wrinkles or tension in the underlying geosynthetics. Any portion of the underlying geosynthetics that develops excessive wrinkles or crimp or is otherwise damaged shall be repaired by the Geosynthetics Installer at no expense to the Owner.

   a. VSL shall not be placed when conditions are warm enough to produce excessive wrinkles in the underlying geosynthetics. Likewise, VSL shall not be placed when conditions are cold enough to produce tension in the underlying geosynthetics.

   b. If during spreading, excessive wrinkles develop, the Contractor shall adjust placement and spreading methods, or cease until the underlying geosynthetics cool and wrinkles decrease in size.

   c. Wrinkles that exceed approximately 6 inches in height and cannot be eliminated by amended placement and spreading methods or underlying geosynthetics that become crimped shall be cut and repaired by the Geosynthetics Installer in a method approved by the Engineer.

5. Stockpiling of VSL on the final cover shall be subject to advance approval by the Engineer. Any hauling equipment (dump trucks, etc.) operating over geosynthetics shall have a minimum of 3 feet of separation between the vehicle

wheels and the Geomembrane.

6. The CQA Engineer may require removal of VSL and/or other underlying layers at the Contractor's sole expense to allow examination of the underlying geosynthetics and/or piping. Any damage to underlying layers or excessive wrinkling or crimping during placement of the VSL shall be repaired in accordance with the applicable section of these Specifications at the Contractor's sole expense.

7. After the specified thickness has been achieved and verified, the Contractor shall proceed immediately with seeding.

8. Surveying:

   After completion of a segment of VSL, the VSL shall be surveyed on 100 foot centers and at slope breaks (including all tops and toes of slope, points of grade change, etc.) to ensure:

   a. The specified thickness has been achieved. A hand auger or similar method may be used to check for thickness at each location.

   b. The top of the VSL slopes at grades specified on the Contract Drawings; and

   c. VSL placed more than 0.15 feet beyond the limits of the lines and grades as shown on the Contract Drawings will not be accepted and must be removed at the Contractor's sole expense if required by the Engineer.

   This work shall be performed at the Contractor's cost by a registered surveyor.

END OF SECTION

SECTION 02270

EROSION AND SEDIMENTATION CONTROL

Erosion and Sedimentation Control: Erosion and Sedimentation Control is a system of construction and engineered measures (devices, structures, practices, etc.) which act to minimize surface water induced erosion of disturbed areas and the resulting off-site sedimentation.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of and maintain Erosion and Sedimentation Control measures and related work in accordance with the Contract Drawings and these Specifications.

All Erosion and Sedimentation Control work shall be in accordance with the latest edition of the North Carolina Erosion and Sediment Control Planning and Design Manual as well as applicable regulations.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Geotextiles	02240
Rip Rap	02271
Rolled Erosion Control Products	02275
Storm Water Systems	02720
Revegetation	02930

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) are hereby made a part of these specifications.

ASTM D 3786 — Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics: Diaphragm Bursting Strength Tester Method.

ASTM D 4355	Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).
ASTM D 4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
ASTM D 4632	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile.
ASTM D 4833	Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.

B. MATERIALS

1. Permanent Sediment or Detention Basins:

Permanent sediment or detention basins shall be constructed as shown on the Contract Drawings.

2. Permanent Drainage Channels, Diversions, Swales, and Ditches:

Permanent drainage channels, diversions, swales, and ditches shall be constructed as shown on the Contract Drawings.

3. Silt Fence:

Silt fences shall be constructed as shown on the Contract Drawings and as needed, based on the Contractor's discretion and Engineer's approval. The silt fence is a permeable barrier erected within and downgradient of small disturbed areas to capture sediment from sheet flow. It is made of filter fabric buried at the bottom, stretched, and supported by posts and wire mesh backing. Silt fence shall conform to the following properties:

a. Posts: Posts shall be 1.33 lb/linear foot steel (preferred) or wood with a minimum length of 5 feet. Steel posts shall be "U" or "T"-type. Wood posts shall have a minimum diameter of 4-inches.

b. Filter Fabric: Filter fabric shall be a woven geotextile made specifically for sediment control. Filter fabric shall conform to the properties listed in Table 1 of this section.

4. Geotextiles:

Geotextiles shall conform to the requirements of Section 02240, Geotextiles, of these Specifications.

5. Filter Berms:

Filter berms shall be constructed as shown on the Contract Drawings.

6. Down Chutes and Pipes:

Down chutes and pipes shall be constructed as shown on the Contract Drawings.

7. Rip Rap:

Rip Rap shall conform to the requirements of Section 02271, Rip Rap, of these Specifications.

8. Rolled Erosion Control Products (RECPs):

Rolled Erosion Control Products (RECPs) shall conform to the requirements of Section 02275, Rolled Erosion Control Products, of these Specifications.

9. Other Work:

In addition to the Erosion and Sedimentation Control measures shown on the Contract Drawings, the Contractor shall provide adequate means to prevent any sediment from entering any storm drains, drop inlets, ditches, streams, or bodies of water downstream of any area disturbed by construction. Excavation materials shall be placed upstream of any trench or other excavation to prevent sedimentation of off-site areas. In areas where a natural buffer area exists between the work area and the closest stream or water course, this area shall not be disturbed. All paved areas shall be scraped and swept as necessary to prevent the accumulation of dirt and debris. Work associated with this provision shall be considered incidental to the project and no separate payment will be made.

10. Temporary and Permanent Ground Cover:

The Contractor shall provide temporary or permanent ground cover (or other acceptable measure(s)) adequate to restrain erosion on erodible slopes or other areas within 21 calendar days following completion of any phase of grading. The

Contractor shall provide permanent ground cover for all disturbed areas within 15 working days or 90 calendar days (whichever is shorter) following the completion of construction.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Submit a certification and summary of all required test results, prior to installation, that all Erosion and Sedimentation Control materials manufactured for the project have been produced in accordance with these Specifications.

2. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into construction.

D. CONSTRUCTION

1. Establishment of Erosion and Sedimentation Control Measues:

a. All Erosion and Sedimentation Control measures will be constructed according to the Contract Drawings and these Specifications.

b. Due to the nature of the work required by this Contract, it is anticipated that the location and nature of the Erosion and Sedimentation Control measures may need to be adjusted on several occasions to reflect the current phase of construction.

c. Erosion and Sedimentation Control measures shall be established prior to the work in a given area. Where such practice is not feasible, the Erosion and Sedimentation Control measure(s) shall be established immediately following completion of the clearing operation.

d. The construction schedule adopted by the Contractor will impact the placement and need for specific measures required for the control of erosion. The Contractor shall develop and implement such additional techniques as may be required to minimize erosion and prevent or correct the discharge of sediment outside the limits of construction (unless controlled by other on-site measure(s)).

e. The location and extent of Erosion and Sedimentation Control measures shall be revised at each phase of construction that results in a change in either the quantity or direction of surface runoff from construction areas. All deviations from the control provisions shown on the Contract Drawings shall have the prior approval of the Engineer.

2. Inspection and Maintenance of Erosion and Sedimentation Control Measures:

a. The Contractor shall furnish the labor, material, and equipment required for the inspection and maintenance of all Erosion and Sedimentation Control measures. Maintenance shall be scheduled as required for a particular measure to maintain the removal efficiency and intent of the measure.

b. All Erosion and Sedimentation Control measures shall be inspected at least once every seven calendar days and within 24 hours after any storm event of greater than 0.5 inches of rain per 24 hour period and appropriate maintenance conducted. A rain gauge shall be maintained on the site and a record of the rainfall amounts and dates shall be kept properly.

c. Maintenance shall include, but not be limited to:

(1) The removal and satisfactory disposal of trapped or deposited sediments from basins, traps, barriers, filters, and/or drainage features/devices;

(2) Replacement of filter fabrics used for silt fences upon loss of efficiency; and

(3) Replacement of any other components which are damaged or cannot serve the intended use.

d. The Contractor shall accept and maintain any existing sediments that are included in existing sediment traps or basins that accept or will accept stormwater flow and or sediment accumulation from all areas within the Contractor's limits of construction.

e. Sediments removed from Erosion and Sedimentation Control measures shall be disposed of in locations that will not result in off-site sedimentation as approved by the Engineer.

f. All Erosion and Sedimentation Control measures shall be maintained to the satisfaction of the Engineer until the site has been stabilized.

3. Finish Grading:

All disturbed areas shall be uniformly graded to the lines, grades, and elevations shown on the Contract Drawings. Finished surfaces shall be reasonably smooth, compacted, and free from irregular surface changes. Unless otherwise specified, the degree of finish shall be that ordinarily obtainable from either blade or scraper

operations. Areas shall be finished to a smoothness suitable for application of topsoil.

4. Revegetation:

Revegetation shall conform to the requirements of Section 02930, Revegetation, of these Specifications.

5. Cleanup:

a. The Contractor shall remove from the site all subsoil excavated from his work and all other debris including, but not limited to, branches, paper, and rubbish in all landscape areas, and remove temporary barricades as the work proceeds.

b. All areas shall be kept in a neat, orderly condition at all times. Prior to final acceptance, the Contractor shall clean up the entire landscaped area to the satisfaction of the Engineer.

TABLE 1: REQUIRED SILT FENCE FILTER FABRIC PROPERTIES

PROPERTY	TEST METHOD	UNITS	VALUE[1]
Grab Tensile Strength[2]	ASTM D 4632	lbs	100 x 100
Grab Elongation	ASTM D 4632	%	20 (Max.)
Trapezoidal Tear Strength[2]	ASTM D 4533	lbs	65 x 65
Burst Strength	ASTM D 3786	psi	300
Puncture Resistance	ASTM D 4833	lbs	65
Ultraviolet Resistance (500 hrs)	ASTM D 4355	%	80
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Sieve	30+
Permittivity	ASTM D 4491	sec^{-1}	0.05

Notes:
1. Minimum Average Roll Value (MARV).
2. Values for machine and cross machine direction (MD x XD), respectively.

END OF SECTION

SECTION 02271

RIP RAP

Rip Rap: This section includes all rip rap aprons and channel protection.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of Rip Rap for protection of earthen slopes against erosion as indicated, including all necessary and incidental items, in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Geotextiles	02240
Erosion and Sedimentation Control	02270

3. Reference Standards:

The latest revision of the following standards of the North Carolina Department of Transportation (NCDOT) are hereby made a part of these Specifications.

NCDOT Standard Specifications for Roads and Structures.

B. MATERIALS

1. Rip Rap: Rip Rap shall be of the size indicated on the Contract Drawings and shall conform to NCDOT Section 1042, Rip Rap Materials.

2. Geotextiles: Geotextiles shall conform to the requirements outlined in Section 02240, Geotextiles, of these Specifications.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Submit a certification and summary of all required test results prior to installation, that all Rip Rap has been produced in accordance with these Specifications.

2. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into construction.

D. CONSTRUCTION

1. Surface Preparation:

   a. Trim and dress all areas to conform to the Contract Drawings as indicated with tolerance of 2 inches from theoretical slope lines and grades.

   b. Bring areas that are below allowable minimum tolerance limit to grade by filling with compacted Embankment material similar to adjacent material.

   c. Geotextiles shall be placed as shown on the Contract Drawings and in accordance with Section 02240, Geotextiles, of these Specifications.

   d. Do not place any stone material on the prepared surface prior to inspection and approval to proceed from the Engineer.

2. Placing Rip Rap:

   Rip Rap shall be placed in accordance with NCDOT Section 868, Rip Rap.

END OF SECTION

SECTION 02275

ROLLED EROSION CONTROL PRODUCTS

Rolled Erosion Control Products: Rolled Erosion Control Products (RECPs) include erosion control blankets (ECB) and turf reinforcement mats (TRM) placed in channels and on slopes.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of all RECPs in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Erosion and Sedimentation Control	02270
Revegetation	02930

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) are hereby made a part of these specifications.

ASTM D 4355	Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).
ASTM D 6475	Standard Test Method for Measuring Mass per Unit Area of Erosion Control Blankets.
ASTM D 6524	Standard Test Method for Measuring the Resiliency of Turf Reinforcement Mats.
ASTM D 6525	Standard Test Method for Measuring Nominal Thickness of Permanent Erosion Control Products.

ASTM D 6566	Standard Test Method for Measuring Mass per Unit Area of Turf Reinforcement Mats.
ASTM D 6818	Standard Test Method for Ultimate Tensile Properties of Turf Reinforcement Mats.

B. MATERIALS

1. General:

The materials supplied under these Specifications shall consist of new, first-quality products designed and manufactured specifically for the purpose of this work, which shall have been satisfactorily demonstrated, by prior use, to be suitable and durable for such purposes.

Labels on each RECP shall identify the length, width, product name, and name of Manufacturer.

2. Erosion Control Blanket (ECB):

ECB shall consist of a machine-produced mat of straw or wood excelsior fiber covered on the top side with a photodegradable extruded plastic or woven biodegradable netting and sewn together with degradable thread. ECB shall also conform to the properties listed in Table 1 of this section. ECB shall be S75, as manufactured by North American Green, CURLEX I, as manufactured by American Excelsior Company, LANDLOK S1, as manufactured by Propex Fabrics, or approved equal.

3. Turf Reinforcement Mat (TRM):

TRM shall consist of a dense web of crimped and interlocking polypropylene fibers positioned between two biaxially oriented nets and mechanically bound together by parallel stitching with polypropylene thread. TRM shall be designed to accelerate seedling emergence, exhibit high resiliency, and possess strength and elongation properties to limit stretching in a saturated condition. TRM shall be stabilized against chemical and UV degradation which are normally found in a natural soil environment and shall have no biodegradable components. TRM shall also conform to the properties listed in Table 1 of this section. TRM shall be LANDLOK TRM 435, as manufactured by Propex Fabrics, or approved equal.

4. Anchors: Anchors for RECPs shall consist of machine made staples of No. 8 gauge new steel wire formed into a "U" shape. The size when formed shall be not less that 8 inches in length with a throat of not less than 1 inch in width. Longer anchors may be required for loose soils. Other anchors, such as metal pins or plastic pegs, may also be used if approved in advance by the Engineer.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Mill Certificate and Sample: Prior to shipping to the site, the Contractor shall submit a mill certificate or affidavit signed by a legally authorized official of the Manufacturer for each RECP attesting that each RECP meets the physical and manufacturing requirements stated in these Specifications. The Contractor shall also submit a sample of each RECP to be used. The sample shall be labeled with the product name and be accompanied by the Manufacturer's specifications.

2. Shipping, Handling, and Storage Instructions: The Manufacturer's plan for shipping, handling, and storage shall be submitted for review.

3. Installation Guidelines/Instructions: The Manufacturer's guidelines/instructions for installation shall be submitted for review.

4. Furnish copies of delivery tickets or other approved receipts as evidence for materials received that will be incorporated into the construction.

D. CONSTRUCTION

1. Shipping, Handling, and Storage:

All RECPs shall be shipped, handled, and stored in strict accordance with the Manufacturer's recommendations.

2. Installation - General:

a. Placing of RECPs shall be done immediately following seeding. Seeding shall be performed in accordance with Section 02930, Revegetation, of these Specifications.

b. RECPs shall be placed to the lines and grades shown on the Contract Drawings. The earth surface shall be smooth and free from stones, clods, or debris which will prevent the contact of the RECP with the soil. Care shall be taken to preserve the required line, grade, and cross section of the area.

c. RECPs shall be unrolled in the direction of the flow of water and shall be applied without stretching so that it will lie smoothly but loosely on the soil surface.

d. At the time of installation, RECPs shall be rejected, if they have defects, rips, holes, flaws, evidence of deterioration, or other damage.

e. The Engineer may require adjustments in the installation requirements to fit individual conditions.

3. Installation - Channels:

RECPs installed in channels shall be unrolled parallel to the direction of water flow. The first roll shall be centered longitudinally in the channel and anchored with staples. Subsequent rolls shall be installed outward to the edges of the channel and be lapped to allow installation of a common row of anchors. RECP ends shall be overlapped with the upstream ends on top ("shingled"). Refer to the Manufacturer's installation guidelines/instructions for installation details.

4. Installation - Slopes:

RECPs installed on slopes shall be oriented in vertical strips and anchored. Subsequent rolls shall be installed outward to the edge(s) of the original roll and be lapped to allow installation of a common row of anchors. RECP ends shall be shingled. Refer to the Manufacturer's installation guidelines/instructions for installation details.

5. Maintenance:

Maintenance of RECPs shall be in accordance with Section 02270, Erosion and Sedimentation Control, of these Specifications.

TABLE 1: REQUIRED ROLLED EROSION CONTROL PRODUCT PROPERTIES

PROPERTY	TEST METHOD	UNITS	VALUE[1]
Erosion Control Blanket (ECB)			
Mass per Unit Area	ASTM D 6475	lbs/yd^2	0.5 ± 10% (Straw) 0.7 ± 10% (Excelsior)
Tensile Strength[2]	ASTM D 6818	lbs/ft	50 x 65
Tensile Elongation	ASTM D 6818	%	20
Maximum Permissible Shear Stress (Un-Vegetated)	-----	lb/ft^2	1.55
Functional Longevity	-----	months	12
Turf Reinforcement Mat (TRM)			
Mass per Unit Area	ASTM D 6566	oz/yd^2	8
Thickness	ASTM D 6525	inches	0.35
Tensile Strength[2]	ASTM D 6818	lbs/ft	225 x 175
Tensile Elongation	ASTM D 6818	%	50 (max.)
Resiliency	ASTM D 6524	%	80
UV Resistance (1,000 Hours)	ASTM D 4355	%	80
Maximum Permissible Shear Stress (Long-Term Vegetated)	Large Scale	lb/ft^2	5

Notes:

1. Typical for ECB; Minimum Average Roll Value (MARV) for TRM.
2. Values for machine and cross machine direction (MD x XD), respectively.

END OF SECTION

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SECTION 02712

DRAINAGE GEOCOMPOSITE

Drainage Geocomposite (DGC): The Drainage Geocomposite (DGC) consists of a geonet drainage core and heat-bonded nonwoven geotextile. The purpose of the DGC is to rapidly transmit flow to collection piping.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of DGC, including all necessary and incidental items, in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Vegetative Soil Layer	02258
LLDPE Geomembrane	02778
Geosynthetic Clay Liner	02776
CQA Manual	Attached

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) and the Geosynthetic Research Institute (GRI) are hereby made a part of these specifications.

ASTM D 413	Standard Test Methods for Rubber Property - Adhesion to Flexible Substrate.
ASTM D 1505	Standard Test Method for Density of Plastics by the Density-Gradient Technique.
ASTM D 1603	Standard Test Method for Carbon Black in Olefin Plastics.

ASTM D 4218	Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds By the Muffle-Furnace Technique.
ASTM D 4355	Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).
ASTM D 4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
ASTM D 4632	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
ASTM D 4716	Standard Test Method for Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextile Related Products.
ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile.
ASTM D 4833	Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
ASTM D 5199	Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
ASTM D 5261	Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
ASTM D 5321	Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
ASTM D 6243	Standard Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method.
GRI GC7	Determination of Adhesion and Bond Strength of Geocomposites.

4. Quality Control:

The Contractor shall perform Quality Control tests in accordance with Table 3 of this section.

5. Quality Assurance:

Quality Assurance during installation of DGC will be provided by the Owner as described in the accompanying Project CQA Manual.

B. MATERIALS

1. General:

The materials supplied under these Specifications shall consist of new, first-quality products designed and manufactured specifically for the purpose of this work, which shall have been satisfactorily demonstrated, by prior use, to be suitable and durable for such purposes.

Labels on each roll of DGC shall identify the length, width, lot and roll numbers, and name of Manufacturer.

2. The geonet drainage core shall be manufactured by extruding polyethylene strands to form a three dimensional structure to provide planer water flow.

3. A nonwoven needlepunched geotextile, consisting of polyester or polypropylene and manufactured in a manner approved by the Engineer, shall be heat-bonded to the geonet drainage core. Roll edges shall have a maximum unbonded length of 6 inches, unless otherwise approved by the Engineer. Heat bonding shall be performed by the Manufacturer prior to shipping to the site.

4. The geonet drainage core shall contain UV inhibitors to prevent ultraviolet light degradation.

5. Final Cover Drainage Geocomposite:

Final Cover DGC shall have a nonwoven geotextile heat-bonded to both sides of the geonet drainage core. Physical properties of the DGC shall be as shown in Table 1 of this section.

C. SUBMITTALS

Prior to DGC installation, the Contractor shall submit the following to the CQA Engineer:

1. Mill Certificate and Sample: Prior to shipping to the site, the Contractor shall submit a mill certificate or affidavit signed by a legally authorized official of the Manufacturer for the DGC attesting that the DGC meets the physical and manufacturing requirements stated in these Specifications. The Contractor shall

also submit a sample of the DGC to be used. The sample shall be labeled with the product name and be accompanied by the Manufacturer's specifications.

2. Shipping, Handling, and Storage Instructions: The Manufacturer's plan for shipping, handling, and storage shall be submitted for review.

3. Seaming Procedures:

   Submit proposed seaming procedures including proposed method and equipment.

4. Quality Control Certificates: For DGC delivered to the site, quality control certificates, signed by the Manufacturer's quality assurance manager shall be provided which represent every roll of DGC. Each certification shall have the roll identification number(s), test methods, frequency, and test results. At a minimum, the test results and frequency of testing shall be as shown in Table 2 of this section.

5. Contractor Quality Control Test Results: The Contractor shall provide the results of required testing.

6. Furnish copies of delivery tickets or other approved receipts as evidence for materials received that will be incorporated into the construction.

D. CONSTRUCTION

1. Shipping, Handling, and Storage:

   All DGC shall be shipped, handled, and stored in strict accordance with the Manufacturer's recommendations.

2. Failing CQA Material Control Tests:

   DGC that is rejected upon testing shall be removed from the project site and replaced at Contractor's cost. Sampling and quality assurance testing of DGC supplied as replacement for rejected material shall be performed by the CQA Engineer at Contractor's cost.

3. Installation:

   a. The DGC shall be placed only on Geomembrane that has been approved by the Geomembrane Installer and accepted by the CQA Engineer. The Contractor shall remove debris, including sediment to the degree possible, from the Geomembrane prior to placement of the DGC.

b. DGC shall be placed to the lines and grades shown on the Contract Drawings. At the time of installation, the DGC shall be rejected, if it has defects, rips, holes, flaws, evidence of deterioration, or other damage. Isolated areas of up to 1 square yard where the geotextile has become delaminated from the geonet drainage core may be allowed by the CQA Engineer as long as there appears to be a good bond between the geotextile and the geonet in surrounding areas. Rolls where the geotextile appears to be easily delaminated from the geonet such as by foot or ATV traffic shall be rejected.

c. Orientation: If the DGC transmits flow in a predominant direction (typically along the roll length), then the DGC shall be installed with the predominant flow direction laid approximately perpendicular to contour lines (i.e. in the direction of the slope) or as specified by the Engineer. Otherwise, DGC shall be installed with the machine direction (along the roll length) generally in the direction of flow or as specified by the Engineer.

d. The DGC shall be placed smooth and free of excessive wrinkles.

e. The Contractor shall provide temporary anchorage of the DGC at the top of perimeter and interior berms during installation as necessary to prevent movement during construction. Such anchorage may include sandbags and the like, as approved by the CQA Engineer. Permanent bonding to the Geomembrane shall be prohibited.

4. Seams:

a. All seams constructed on slopes of 6H:1V or steeper or within 10 feet of the toe of a slope of 6H:1V or steeper shall be vertical seams, except where slope lengths exceed standard roll lengths and elsewhere as approved in advance by the Engineer. Where allowed by the Engineer, end seams on slopes of 6H:1V or steeper shall be staggered a minimum of 5 feet between adjacent rolls.

b. Geonet Drainage Core: The geonet drainage core shall be laid with a 3 inch minimum overlap seam along roll edges and a 6 inch minimum overlap seam along roll ends and shall be secured using plastic ties. Ties shall be placed every 5 feet along roll edges; every 12 inches along roll ends; and every 6 inches in the anchor trench.

c. Geotextile Component(s): Where applicable, the bottom geotextile of the DGC shall be overlapped with the same of the adjacent rolls. The top geotextile of the DGC shall be continuously sewn or heat bonded to the same of the adjacent rolls with methods approved by the Engineer.

(1) Seams to be sewn shall be sewn using a Type 401 stitch. One or two rows of stitching may be used. Each row of stitching shall consist of 4 to 7 stitches per inch. The minimum distance from the geotextile edge to the stitch line nearest to that edge (seam allowance) shall be 1.5 inches if a Type SSa (prayer or flat) seam is used. The minimum seam allowance for all other seam types shall be 1.0 inches.

(2) Seams to be heat bonded shall be bonded using hot plate, hot knife, ultrasonic, or other approved devices.

5. Repairs:

Any DGC that is torn, crushed, punctured, or otherwise damaged shall be repaired or replaced, as directed by the CQA Engineer, by the Contractor at no additional cost to the Owner. The repair shall consist of a patch of the same type of material, placed over the damaged area and shall overlap the existing material a minimum of 12 inches from any point of the damage. The patch shall be connected to the geonet drainage core of the damaged material using plastic cable ties at a 6 inch spacing and the upper geotextile of the patch shall be spot sewn or heat bonded to the upper geotextile of the damaged material. A geotextile patch, spot sewn or heat bonded to the damaged material, may be used where damage is to only that portion of the DGC.

6. Cover Placement:

Placement of materials over DGC shall be performed in a manner as to ensure that DGC and the underlying geosynthetics are not damaged; minimal slippage of DGC on the underlying geosynthetics occurs; no excess tensile stresses occur in the DGC; and that no portion of the DGC develops excessive wrinkles or crimp. Wrinkles that exceed approximately 6 inches in height and cannot be eliminated by amended placement and covering methods or DGC that becomes crimped shall be cut and repaired by the Geosynthetics Installer in a method approved by the Engineer.

TABLE 1: REQUIRED DRAINAGE GEOCOMPOSITE PROPERTIES

PROPERTY	TEST METHOD	UNITS	VALUE
Geonet:			
Thickness	ASTM D 5199	inches	0.25 (See Note 1)
Density	ASTM D 1505	g/cm^3	0.94
Carbon Black Content	ASTM D 1603/D 4218	%	2-3
Geotextile:			
Mass per Unit Area (Unit Wt.)	ASTM D 5261	oz/yd^2	6
Tensile Properties:	ASTM D 4632		
Grab Strength		lbs	160
Grab Elongation		%	$\geq$ 50
Puncture Resistance	ASTM D 4833	lbs	55
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Sieve	70+
Permittivity	ASTM D 4491	sec^{-1}	1.0
Ultraviolet Resistance (500 hrs)	ASTM D 4355	%	70
Geocomposite:			
Ply Adhesion	ASTM D 413/ GRI GC7	lb/inch	2.0 Typ. 1.0 Min. Avg.
Transmissivity: (Final Cover)	ASTM D 4716	$m^3/m/sec$	8.0×10^{-4} (See Note 2)
Interface Shear Strength (Peak)[3, 4] (Final Cover)	ASTM D 5321 ASTM D 6243 (GCL)	psf	55 psf (Load = 200 psf)

Notes:

1. A thicker geonet may be required depending on transmissivity requirements.
2. Final Cover:
   Conduct test for transmissivity at a normal compressive load of 1,000 psf and at a hydraulic gradient of 0.10 after a seating period of at least 24 hours. Boundary

conditions are soil (sand) interface on the upper geotextile and textured LLDPE geomembrane (or GCL) against the lower geotextile.

3. DGC shall have adequate adhesion against adjacent materials under low normal loads to achieve the successful installation of overlying components without slippage.
4. The specified interface shear strength requirement is based on a finished slope no steeper than 6H:1V. Steeper slopes will require evaluation by the Engineer.

TABLE 2: REQUIRED MANUFACTURER QUALITY CONTROL TESTS

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
Geonet:		
Thickness	ASTM D 5199	50,000 ft^2
Density	ASTM D 1505	50,000 ft^2
Carbon Black Content	ASTM D 1603/D 4218	50,000 ft^2
Geotextile:		
Mass Per Unit Area	ASTM D 5261	200,000 ft^2
Tensile Properties	ASTM D 4632	200,000 ft^2
Puncture Resistance	ASTM D 4833	200,000 ft^2
Apparent Opening Size (AOS)	ASTM D 4751	600,000 ft^2
Permittivity	ASTM D 4491	600,000 ft^2
UV Resistance	ASTM D 4355	600,000 ft^2
Geocomposite:		
Ply Adhesion	ASTM D 413/ GRI GC7	100,000 ft^2
Transmissivity[1]	ASTM D 4716	100,000 ft^2 (See Note 2)

Notes:

1. Conduct transmissivity tests in accordance with the criteria given in Table 1.
2. The required Manufacturer's quality control testing for transmissivity may be reduced to one test per resin lot or one test per 500,000 ft^2 (whichever provides

the larger number of tests) if the minimum measured transmissivity is at least 50% greater than specified.

TABLE 3: REQUIRED CONTRACTOR QUALITY CONTROL TESTS

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
Interface Shear Strength	ASTM D 5321 ASTM D 6243 (GCL)	(See Note 1)

Notes:

1. Test each interface to be used on this project using representative samples of materials to be supplied under normal loads indicated and using test parameters as specified by the Engineer. For this project, interfaces to be tested are:

   A. Textured LLDPE-GM (30 mil) or GCL against existing cover soils (intermediate cover);
   B. Drainage Geocomposite against textured LLDPE-GM (30 mil) or GCL; and
   C. Vegetative Soil Layer against Drainage Geocomposite.

   If there are material differences in the surface of any of the geosynthetic materials from one side to the other, then all possible combinations of interfaces shall be tested. This testing shall be performed at Contractor cost by an independent GAI accredited laboratory and submitted to the Engineer for review prior to shipping. Upon review of test results, the Engineer may allow exceptions to the above criteria.

   For tests involving textured geomembranes, the laboratory shall also report the asperity height (GRI GM12) for the material samples used in the actual direct shear tests.

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SECTION 02720

STORM WATER SYSTEMS

Storm Water Systems: Storm Water Systems shall include all piping, pipe fittings, and other appurtenances designated to convey stormwater.

A. DESCRIPTION

1. General:

The contractor shall furnish all labor, material, and equipment to complete installation of Storm Water Systems in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Erosion and Sedimentation Control	02270
Rip Rap	02271

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM), the American Association of State Highway and Transportation Officials (AASHTO), and the North Carolina Department of Transportation (NCDOT) are hereby made a part of these specifications.

ASTM C 76	Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
ASTM C 150	Standard Specification for Portland Cement.
ASTM D 1248	Standard Specification for Polyethylene Plastics Molding and Extrusion Materials For Wire and Cable.
ASTM D 2321	Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.

ASTM D 3350	Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
AASHTO M 36	Specification for Corrugated Steel Pipe.
AASHTO M 252	Specification for Corrugated Polyethylene Drainage Tubing, 3 to 10 Inch Diameter.
AASHTO M 294	Specification for Corrugated Polyethylene Pipe, 12 to 36 Inch Diameter.
NCDOT	Standard Specifications for Roads and Structures and Roadway Standard Drawings.

B. MATERIALS

1. Reinforced Concrete Pipe (RCP):

   a. All reinforced concrete pipe shall be manufactured in accordance with ASTM C 76, Wall Type B or C, and shall be of the class that equals or exceeds the pipe class as shown on the Contract Drawings. All pipe shall be aged at the manufacturing plant for at least fourteen (14) days before delivery to the job site.

   b. Minimum pipe laying lengths shall be four (4) feet.

   c. Joints for reinforced concrete pipe shall have tongue and groove or bell and spigot ends with leak-resistant mastic joint sealant. Joint sealant shall be ConSeal type, or approved equal.

2. Corrugated Metal Pipe (CMP):

   a. Corrugated metal pipe and fittings shall be of the sizes shown or specified and shall conform to every aspect of AASHTO M 36.

   b. Corrugated metal pipe shall be fabricated from galvanized steel sheets. Corrugation profile shall be 2⅔ inch crest to crest and ½ inch crest to valley, and sheet thickness shall be 16 gage/.064 inch minimum.

   c. Pipe sections shall be helically corrugated with each pipe end rerolled to obtain no less than two (2) annular corrugations.

   d. Coupling Bands: CMP shall be firmly joined by coupling bands in accordance with the manufacturer's recommendations. These bands shall

be not more than two nominal sheet thicknesses lighter than the thickness of the pipe to be connected and in no case lighter than 0.052 inches.

e. All CMP utilized for permanent installation shall have gasketed joints.

f. Asphaltic or bituminous coatings shall be applied in conformance with the manufacturer's requirements, as applicable.

3. Corrugated Polyethylene (CPE) Pipe:

CPE pipe and fittings shall be of the sizes and type shown on the Contract Drawings and shall conform to every aspect of AASHTO M 252 (3 to 10 inch diameters) or AASHTO M 294 (12 to 36 inch diameters). All Type S CPE pipe shall have watertight joints.

4. Flared End Sections:

Flared end sections shall be reinforced and shall be fabricated from the same materials meeting the same requirements as the pipe to which they are connected. All reinforced concrete and corrugated metal flared end sections shall meet the requirements of the NCDOT. Corrugated polyethylene flared end sections shall be as recommended by the pipe manufacturer.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Submit a certification and summary of all required test results, prior to installation, that all Storm Water Systems have been produced in accordance with these Specifications.

2. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into construction.

D. CONSTRUCTION

1. All piping shall be installed by skilled workmen and in accordance with the best standards for piping installation. Proper tools and appliances for the safe and convenient handling and installation of the pipe and fittings shall be used.

2. All pieces shall be carefully examined for defects, and no piece shall be installed which is known to be defective. If any defective piece should be discovered after having been installed, it shall be removed and replaced at the Contractor's expense.

3. Excavation and backfilling of pipe trenches shall be as described in Section 02222, Excavation and Section 02223, Embankment, respectively, of these Specifications.

4. Following proper preparation of the trench subgrade, pipe and fittings shall be carefully lowered into the trench so as to prevent dirt and other foreign substances from gaining entrance into the pipe and fittings. Proper facilities shall be provided for lowering sections of pipe into trenches. No materials shall be dropped or dumped into the trench.

5. Water shall be kept out of the trench until jointing and backfilling are completed. When work is not in progress, open ends of pipe, fittings, and valves shall be securely closed so that no water, earth, or other substance will enter the pipes, fittings, or valves. Pipe ends left for future connections shall be valved, plugged, or capped, and anchored as required.

6. All piping shall be erected to accurate lines and grades with no abrupt changes in line or grade.

7. The full length of each section of pipe shall rest solidly upon the bed of the trench, with recesses excavated to accommodate bells, couplings, joints, and fittings. Before joints are made, each pipe shall be well bedded on a solid foundation. No pipe shall be brought into position until the preceding length has been thoroughly bedded and secured in place. Pipe that has the grade or joint disturbed after laying shall be taken up and relaid by the Contractor at his own expense.

8. The laying of reinforced concrete pipe shall conform to the current recommendations of the American Concrete Pipe Association for Installation Type 1 or 2.

END OF SECTION

SECTION 02776

GEOSYNTHETIC CLAY LINER (GCL)

Geosynthetic Clay Liner (GCL): The GCL serves as the primary hydraulic barrier within the final cover system.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of GCL in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Drainage Geocomposite	02712
CQA Manual	Attached

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) are hereby made a part of these specifications.

ASTM D 5887	Standard Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter.
ASTM D 5890	Standard Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners.
ASTM D 5891	Standard Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners.
ASTM D 5993	Standard Test Method for Measuring Mass per Unit of Geosynthetic Clay Liners.

ASTM D 6243	Standard Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method.
ASTM D 6496	Standard Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners.
ASTM D 6768	Standard Test Method for Tensile Strength of Geosynthetic Clay Liners.

4. Quality Control:

The Contractor shall perform Quality Control tests in accordance with Table 3 of this section.

5. Quality Assurance:

Quality Assurance during installation of GCL will be provided by the Owner as described in the accompanying Project CQA Manual.

6. Manufacturer Qualifications:

The GCL shall be furnished by a Manufacturer that has previously produced a minimum of 10,000,000 square feet of the material for use in similar projects.

7. Warranties:

a. General: Should a defect occur, which is covered under warranty, the Warrantor shall bear all costs for repair and/or relocation and replacement of the GCL.

b. Workmanship: The Contractor shall furnish the Owner a warranty from the GCL Installer which warrants their workmanship to be free of defects on a prorata basis for five (5) years after the final acceptance of the Work. This warranty shall include but not be limited to overlapped seams, anchor trenches, attachments to appurtenances, and penetration seals, as applicable.

c. Manufacturer's Warranty: The Contractor shall furnish the Owner a warranty from the GCL Manufacturer for the materials used. The material warranty shall be for defects or failures related to manufacture on a prorata basis for five (5) years after date of shipment.

B. MATERIALS

1. General:

The GCL shall consist of bentonite encased, top and bottom, with 6 oz./square yard non-woven geotextiles needle-punched together for reinforcement. GCL with a lighter non-woven geotextile or a woven geotextile on one side may be considered by the Engineer as long as all other criteria are met. Needle-punched GCL shall be essentially free of broken needles and fragments of needles that would negatively effect the performance of the final product. The materials supplied under these Specifications shall be first quality products designed and manufactured specifically for the purposes of this work.

The GCL shall be supplied in rolls which have a minimum width of 14 feet. The roll length shall be maximized to provide the largest manageable sheet for the fewest overlaps. Labels on the roll shall identify the length, width, lot and roll numbers, name of Manufacturer, proper direction of unrolling, and minimum recommended overlap.

2. Needle Detection and Removal Procedures:

The GCL Manufacturer shall use continuous needle detection and removal devices (e.g. metal detectors and magnets) in the manufacture of needle-punched GCL.

3. Physical Properties:

Physical properties of GCL shall be as shown in Table 1 of this section.

C. SUBMITTALS

The Contractor shall submit the following to the CQA Engineer:

1. Pre-Installation Requirements:

Prior to GCL installation, the Contractor shall submit the following:

a. Mill Certificate and Sample: Prior to shipping to the site, the Contractor shall submit a mill certificate or affidavit signed by a legally authorized official of the Manufacturer for the GCL attesting that the GCL meets the physical and manufacturing requirements stated in these Specifications including needle detection and removal procedures. The Contractor shall also submit a sample of the GCL to be used. The sample shall be labeled with the product name and be accompanied by the Manufacturer's specifications.

b. Qualifications:

(1) Submit list of equipment and personnel proposed for the Project. Include equipment type and quantities. Include personnel experience on similar projects.

(2) Submit resume and references of Installation Supervisor to be assigned to the Project, including data and duration of employment and pertinent experience information.

c. Shipping, Handling, and Storage Instructions: The Manufacturer's recommendations for shipping, handling, and storage shall be submitted for review.

d. Delivery Date: Submit notification of the scheduled delivery date for the materials.

e. Installation Procedures and Drawings:

Submit installation procedures and (shop) drawings for carrying out the work. Procedures addressed by the Contractor shall include but not be limited to material installation, repair, and protection to be provided in the event of rain. Submit drawings showing typical details including pipe penetrations (if applicable). Following review, these procedures and drawings will be used for installation of the GCL. Any deviations from these procedures and drawings must be approved by the Engineer and CQA Engineer.

f. Quality Control Certificates: For GCL delivered to the site, quality control certificates, signed by the Manufacturer's quality assurance manager shall be provided which represent every roll of GCL. Each certificate shall have the roll identification number(s), test methods, frequency, and test results. At a minimum, the test results and frequency of testing shall be as shown in Table 2 of this section. Each certificate shall also include a certification that each roll of GCL has been continually checked by the Manufacturer for needles and that any needles detected have been removed.

g. Contractor Quality Control Test Results: The Contractor shall provide the results of required testing.

h. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into the construction.

2. Post-Installation Requirements:

Upon completion of GCL installation the Contractor shall submit the following:

a. A certificate stating that the GCL has been installed in accordance with the Drawings, Specifications, and the Manufacturer's recommendations.

b. Completed Manufacturer's and Workmanship Warranties.

Finalization of payment for GCL installation shall not be made until the above submittals have been reviewed by the CQA Engineer.

D. CONSTRUCTION

1. Shipping , Handling, and Storage:

The GCL shall be shipped, handled, and stored in strict accordance with the Manufacturer's recommendations.

2. Failing CQA Material Control Tests:

GCL that is rejected upon testing shall be removed from the project site and replaced at Contractor's cost. Sampling and CQA testing of GCL supplied as replacement for rejected material shall be performed by the CQA Engineer at Contractor's cost.

3. Installation of GCL:

a. The surface receiving the GCL shall be prepared to a relatively smooth condition, free of obstructions, standing water, excessive depressions, debris, and very soft, excessively wet, and/or loose pockets of soil. This surface shall be approved by the CQA Engineer prior to GCL placement.

b. GCL shall be placed to the lines and grades shown on the Contract Drawings. At the time of installation, GCL shall be rejected by the CQA Engineer if it has defects, rips, holes, flaws, evidence of deterioration, or other damage.

c. The GCL shall not be placed during precipitation. Any material that becomes hydrated shall be removed and replaced at Contractor expense.

d. The GCL shall be placed smooth and free of excessive wrinkles.

e. Where horizontal seams are required on sloped surfaces, the panels shall be placed such that the "upstream" panel forms the upper panel and

overlaps the "downstream" panel in order to minimize infiltration potential. All seams constructed on slopes of 6H:1V or steeper shall be vertical seams, except where slope lengths exceed standard roll lengths and elsewhere as approved in advance by the Engineer.

f. All vertical panels placed on slopes of 6H:1V or steeper shall extend a minimum of 5 feet beyond the grade break with a slope flatter than 6H:1V.

g. The GCL shall be laid with a 6 inch minimum overlap seam along roll edges and a 12 inch minimum overlap seam along roll ends. Granular sodium bentonite shall be added between all overlapped seams at a rate of approximately 0.25 lbs/linear foot. As an alternative to the addition of bentonite along roll edges, GCL with slits cut in one of the geotextiles may be used if approved in advance by the Engineer.

h. GCL shall be temporarily secured in a manner approved by the CQA Engineer prior to placement of overlying materials.

i. Any GCL that is torn, punctured, or otherwise damaged shall be repaired or replaced as directed by the CQA Engineer, by the Contractor at no additional cost to the Owner. The repair shall consist of a patch of GCL placed over the damaged areas and shall overlap the existing GCL a minimum of 12 inches from any point of the damage.

j. GCL shall be covered with the overlying materials or otherwise protected from hydration due to rainfall (i.e. temporary tarps, scrap geomembrane, etc.) within 24 hours of GCL placement, or sooner if rain is imminent.

k. Penetrations: All penetrations of GCL shall be made in accordance with the Contract Drawings and/or as directed by the Engineer.

4. Cover Placement:

Placement of materials over GCL shall be performed in a manner as to ensure that GCL and the underlying geosynthetics are not damaged; minimal slippage of GCL on the underlying geosynthetics occurs; no excess tensile stresses occur in the GCL; and that no portion of the GCL develops excessive wrinkles or crimp. Wrinkles that exceed approximately 6 inches in height and cannot be eliminated by amended placement and covering methods or GCL that becomes crimped shall be cut and repaired by the Geosynthetics Installer in a method approved by the Engineer.

TABLE 1: REQUIRED GCL PROPERTIES

PROPERTY	TEST METHOD	UNITS	VALUE
Clay:			
Bentonite Swell Index	ASTM D 5890	ml/2g	24
Bentonite Fluid Loss	ASTM D 5891	ml	$\leq$ 18
GCL:			
Bentonite Content	ASTM D 5993	psf	0.75 (@ 0% moisture)
Tensile Strength	ASTM D 6768	lbs/in	30
Peel Strength	ASTM D 6496	lbs/in	5.3 Min. Avg.
Hydraulic Conductivity	ASTM D 5887	cm/sec	$\leq 5 \times 10^{-9}$
Internal Shear Strength[1] (Hydrated) (Peak)	ASTM D 6243	psf	500
Interface Shear Strength (Hydrated) (Peak)[2, 3]	ASTM D 6243	psf	55 psf (Load = 200 psf)

Notes:

1. Peak value measured at a normal load of 200 psf after a minimum 24 hour hydration period.
2. GCL shall have adequate adhesion against adjacent materials under low normal loads to achieve the successful installation of overlying components without slippage.
3. The specified interface shear strength requirement is based on a finished slope no steeper than 6H:1V. Steeper slopes will require evaluation by the Engineer.

TABLE 2: REQUIRED MANUFACTURER QUALITY CONTROL TESTS

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
Clay:		
Bentonite Swell Index	ASTM D 5890	50 tons
Bentonite Fluid Loss	ASTM D 5891	50 tons
GCL:		
Bentonite Content	ASTM D 5993	5,000 yd^2
Tensile Strength	ASTM D 6768	25,000 yd^2
Peel Strength[1]	ASTM D 6496	5,000 yd^2
Hydraulic Conductivity	ASTM D 5887	30,000 yd^2
Internal Shear Strength[2] (Hydrated)	ASTM D 6243	Periodic

Notes:

1. Conduct peel strength tests in accordance with the criteria given in Table 1.
2. Conduct shear strength tests in accordance with the criteria given in Table 1.

TABLE 3: REQUIRED CONTRACTOR QUALITY CONTROL TESTS

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
Interface Shear Strength	ASTM D 6243	(See Note 1)

Notes:

1. Test each interface to be used on this project using representative samples of materials to be supplied under normal loads indicated and using test parameters as specified by the Engineer. For this project, interfaces to be tested are:

   A. Textured LLDPE-GM (30 mil) or GCL against existing cover soils (intermediate cover);
   B. Drainage Geocomposite against textured LLDPE-GM (30 mil) or GCL; and
   C. Vegetative Soil Layer against Drainage Geocomposite.

   If there are material differences in the surface of any of the geosynthetic materials from one side to the other, then all possible combinations of interfaces shall be tested. This testing shall be performed at Contractor cost by an independent GAI accredited laboratory and submitted to the Engineer for review prior to shipping. Upon review of test results, the Engineer may allow exceptions to the above criteria.

   For tests involving textured geomembranes, the laboratory shall also report the asperity height (GRI GM12) for the material samples used in the actual direct shear tests.

END OF SECTION

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SECTION 02778

LLDPE GEOMEMBRANE

LLDPE Geomembrane (LLDPE-GM): The LLDPE Geomembrane serves as the primary hydraulic barrier in the final cover system.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of LLDPE-GM including all necessary and incidental items as detailed or required to complete the installation in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Vegetative Soil Layer	02258
Drainage Geocomposite	02712
CQA Manual	Attached

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) and the Geosynthetic Research Institute (GRI) are hereby made a part of these Specifications.

ASTM D 792	Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
ASTM D 1004	Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
ASTM D 1505	Standard Test Method for Density of Plastics by the Density-Gradient Technique.
ASTM D 1603	Standard Test Method for Carbon Black in Olefin Plastics.

ASTM D 5199	Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
ASTM D 5321	Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
ASTM D 5596	Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
ASTM D 5820	Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes.
ASTM D 5994	Standard Test Method for Measuring Core Thickness of Textured Geomembrane.
ASTM D 6392	Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.
ASTM D 6693	Standard Test Method for Determining Tensile Properties of Nonreinforced Flexible Polyethylene and Nonreinforced Polypropylene Geomembranes.
GRI GM9	Cold Weather Seaming of Geomembranes.
GRI GM12	Asperity Measurement of Textured Geomembranes Using a Depth Gage.
GRI GM17	Standard Specification for Test Properties, Testing Frequency and Recommended Warranty for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes.
GRI GM19	Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes.

4. Quality Control:

   a. The Contractor shall perform Quality Control tests in accordance with Table 2 of this section.

   b. The Geomembrane Installer shall follow the procedures and requirements described in the accompanying Project CQA Manual during installation of

LLDPE-GM including performing and documenting trial seams, nondestructive and destructive Quality Control tests, and repairs.

5. Quality Assurance:

Quality Assurance during installation of LLDPE-GM will be provided by the Owner as described in the accompanying Project CQA Manual.

6. Manufacturers Qualifications:

The Manufacturer shall have previously demonstrated his ability to produce the required LLDPE-GM by having successfully manufactured a minimum of 5,000,000 ft^2 of LLDPE-GM for hydraulic containment purposes.

7. Installer Qualifications:

a. Installation of the LLDPE-GM shall be performed by an Installer that has installed a minimum of 5,000,000 ft^2 of LLDPE-GM (or similar material) within the past five (5) years in similar landfill installations.

b. All Installation Supervisors assigned to the Project shall have previously managed the installation of at least 2,000,000 ft^2 of LLDPE-GM (or similar material) using the same techniques to be used on site.

c. All seaming equipment operators shall have demonstrated performance on previous geomembrane installations and/or documented training.

8. Warranties:

a. General: Should a defect occur, which is covered under warranty, the Warrantor shall bear all costs for repair and/or relocation and replacement of the LLDPE-GM.

b. Workmanship: The Contractor shall furnish the Owner a warranty from the Installer of the LLDPE-GM which warrants their workmanship to be free of defects on a prorata basis for five (5) years after the final acceptance of the Work. This warranty shall include but not be limited to all field seams, anchor trenches, attachments to appurtenances, and penetration seals, as applicable.

c. Manufacturer's Warranty: The Contractor shall furnish the Owner a warranty from the LLDPE-GM Manufacturer for the materials used. The material warranty shall be for defects or failures related to manufacture on a prorata basis for five (5) years after the date of shipment.

B. MATERIALS

1. General:

The materials supplied under these Specifications shall consist of new, first-quality products designed and manufactured specifically for the purpose of this work, which shall have been satisfactorily demonstrated, by prior use, to be suitable and durable for such purposes. The LLDPE-GM and LLDPE-GM Manufacturer shall be approved by the Engineer.

The LLDPE-GM shall be supplied in rolls which shall have a minimum width of 22 feet. The roll length shall be maximized to provide the largest manageable sheet for the fewest seams. Labels on the roll shall identify the thickness, length, width, lot and roll numbers, and name of Manufacturer.

2. LLDPE-GM Materials:

a. Textured LLDPE-GM shall be 30 mils thick. Resin and sheet properties of LLDPE-GM shall meet or exceed the requirements of GRI GM17 and Table 1 of this section.

b. Materials classified as Very Flexible Polyethylene (VFPE) which otherwise meet the requirements of this section are also acceptable.

3. Extrusion Resin/Typical Extrudate:

Extrusion resin/typical extrudate used for extrusion seaming of LLDPE-GM shall be linear low density polyethylene (LLDPE). Physical properties shall be the same as the LLDPE-GM sheet. The extrudate's additives shall be thoroughly dispersed throughout the rod or bead. The extrudate shall be free of contamination by moisture or foreign matter and shall be recommended for use with the associated sheet material.

4. Texturing:

Textured LLDPE-GM, where required, shall be fabricated using coextrusion or impingement methods. Texturing shall not be created by lamination, structuring, or embossing. Texturing applied to LLDPE-GM using impingement methods shall be bonded securely to the parent LLDPE-GM. All texturing shall be uniform in appearance and coverage on the finished sheet. Textured LLDPE-GM shall be textured on both sides of the sheet.

C. SUBMITTALS

The Contractor shall submit the following to the CQA Engineer:

1. Pre-Installation Requirements:

Prior to LLDPE-GM installation, the Contractor shall submit the following:

a. Mill Certificate and Sample: Prior to shipping to the site, the Contractor shall submit a mill certificate or affidavit signed by a legally authorized official of the Manufacturer for the LLDPE-GM attesting that the LLDPE-GM meets the physical and manufacturing requirements stated in these Specifications. The Contractor shall also submit a sample of the LLDPE-GM to be used. The sample shall be labeled with the product name and be accompanied by the Manufacturer's specifications.

b. Qualifications:

(1) Submit list of equipment and personnel proposed for the Project. Include equipment type and quantities. Include personnel experience on similar projects.

(2) Submit resume and references of Installation Supervisor to be assigned to the Project, including data and duration of employment and pertinent experience information.

(3) Submit resumes and references of installation personnel who will perform seaming operations, including dates and durations of employment and pertinent experience information.

c. Shipping, Handling, and Storage Instructions: The Manufacturer's plan for shipping, handling, and storage shall be submitted for review.

d. Delivery Date: Submit notification of the scheduled delivery dates for the materials.

e. Installation Procedures and Drawings:

Submit installation procedures and (shop) drawings for carrying out the work.

(1) Installation procedures to be addressed shall include but not be limited to material installation, repair, and protection to be provided in the event of rain or strong winds.

(2) Shop drawings shall have LLDPE-GM sheet layout with proposed size, number, position, and sequence of placing all panels, and indicating the location of all field seams. Shop drawings shall also show complete details and/or methods for anchoring the LLDPE-

GM, making field seams, and making seals around pipes and structures penetrating the LLDPE-GM (if applicable).

Following review, these procedures and drawings shall be used for installation of the LLDPE-GM. Any deviations from these procedures and drawings must be approved by the Engineer and CQA Engineer.

f. Quality Control Certificates: For LLDPE-GM delivered to the site, quality control certificates, signed by the Manufacturer's quality assurance manager shall be provided which represent every roll of LLDPE-GM. Each certificate shall have the roll identification number(s), test methods, frequency, and test results. At a minimum, the test results and frequency of testing shall meet or exceed the requirements of GRI GM17.

g. Contractor Quality Control Test Results: The Contractor shall provide the results of required testing.

h. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into the construction.

2. Post-Installation Requirements:

Upon completion of the LLDPE-GM installation, the Contractor shall submit the following:

a. Certificate stating that the LLDPE-GM has been installed in accordance with the Drawings, Specifications, and the Manufacturer's recommendations.

b. Completed Manufacturer's and workmanship warranties.

c. Record Information: Record information shall include but not be limited to:

(1) CQC Documentation: Includes trial seam logs, panel placement logs, panel seaming logs, non-destructive seam testing report forms, field destructive seam testing report forms, and repair logs.

(2) As-Built Drawing: Includes the requirements listed in Paragraph D.8 (Surveying) of this Specification.

Finalization of payment for LLDPE-GM installation shall not be made until the above submittals have been reviewed by the CQA Engineer.

D. CONSTRUCTION

1. Shipping, Handling, and Storage:

The LLDPE-GM shall be shipped, handled, and stored in strict accordance with the Manufacturer's recommendations.

2. Failing CQA Material Control Tests:

LLDPE-GM that is rejected upon testing shall be removed from the project site and replaced at Contractor's cost. Sampling and CQA testing of LLDPE-GM supplied as replacement for rejected material shall be performed by the CQA Engineer at Contractor's cost.

3. Subgrade Preparation:

a. The surface of the subgrade shall be smooth, uniform, free from sudden changes in grade (such as vehicular ruts), rocks or stones greater than ½ inch in size, debris, and deleterious materials. During actual placing and seaming of the LLDPE-GM, the subgrade shall be kept free of all standing water. If the subgrade below the LLDPE-GM becomes excessively wet and unstable as determined by the CQA Engineer, it shall be dried and recompacted, and replaced if needed.

b. Before an individual panel of LLDPE-GM is installed; the Contractor and Installer shall verify in writing and submit to the CQA Engineer:

(1) Lines and grades are in conformance with the Drawings and Specifications.

(2) The surface area to be lined has been rolled and compacted, free of irregularities and abrupt changes in grade.

4. LLDPE-GM Placement:

a. Weather Conditions:

LLDPE-GM placement shall not proceed at an ambient temperature below 32° F or above 100° F unless otherwise authorized, in writing, by the Engineer. Installation of LLDPE-GM at temperatures below 32° F, if authorized by the Engineer, shall follow GRI GM9. LLDPE-GM placement shall not be performed during precipitation, excessive moisture, in an area of ponded water, or in excessive winds. Any portion of LLDPE-GM or subgrade damaged due to weather conditions shall be repaired at the Contractor's cost.

b. Method of Placement:

(1) Each panel of the LLDPE-GM shall be installed in accordance with the approved shop drawings prepared by the Contractor. The layout shall be designed to keep field seaming of the LLDPE-GM to a minimum and consistent with proper methods of LLDPE-GM installation.

(2) Panels shall be oriented perpendicular to the line of the slope crest (i.e., down and not across slope).

(3) The LLDPE-GM shall be placed smooth and free of excessive wrinkles.

(4) LLDPE-GM rolls shall be placed using proper spreader and rolling bars with cloth slings. If a sheet must be displaced a distance greater than its width, a slip sheet shall be used.

(5) The CQA Engineer shall inspect each panel, after placement and prior to seaming, for damage and/or defects. Defective or damaged panels shall be replaced or repaired, as approved by the CQA Engineer and as described in this section.

(6) The Installer shall avoid dragging the LLDPE-GM on rough soil subgrades.

(7) All LLDPE-GM shall be anchored as shown on the Contract Drawings and consistent with Manufacturer's recommendations.

(8) Personnel working on the LLDPE-GM shall not smoke, wear damaging shoes, or involve themselves in any activity that may damage the LLDPE-GM, in the opinion of the CQA Engineer.

(9) The LLDPE-GM shall be properly weighted to avoid uplift due to wind.

(10) Vehicular traffic across the LLDPE-GM shall not be allowed, except that four-wheel (or greater) all-terrain vehicles (ATVs) with low ground pressure may be allowed if approved in advance by the Engineer. The Contractor shall submit proposed equipment and procedures for use of ATVs to the CQA Engineer as part of his submittals. If ATVs are allowed by the Engineer, each ATV shall be operated such that no sudden stops, starts, or turns are made.

(11) All damage shall be recorded and located on the record drawings.

(12) The LLDPE-GM shall be kept free of debris, unnecessary tools, and materials. In general, the LLDPE-GM area shall remain neat in appearance.

c. Pipe Penetrations:

All pipe penetrations through the LLDPE-GM shall be as shown in the Contract Drawings. Alternative penetration details may be approved by the Engineer and CQA Engineer.

5. Field Seams:

a. Individual panels of LLDPE-GM shall be laid out and overlapped by a minimum of 4 inches prior to seaming. The area to be seamed shall be cleaned and prepared in accordance with the Manufacturer's recommendations.

b. Dual or single track hot wedge methods shall be used for straight seams.

c. Extrusion fillet methods shall be used to seam cross seam tees, patches, repairs, and penetration boots. All extrudate shall be free of dirt, dry, and protected from damage. To limit overgrinding, the amount of grinding exposed after an extrusion seam is completed shall be less than ¼ inch.

d. The seaming equipment used shall be capable of continuously monitoring and controlling the temperatures in the zone of contact where the machine is actually fusing the LLDPE-GM so as to ensure that changes in environmental conditions will not affect the integrity of the seam.

e. All seams shall have a seam number that corresponds with the panel layout numbers. The numbering system shall be used in the development of the record drawings. Seam numbers shall be derived from the combination of the two panel numbers that are to be seamed together.

f. Where horizontal seams are required on sloped surfaces, the panels shall be placed such that the "upstream" panel forms the upper panel and overlaps the "downstream" panel in order to minimize infiltration potential. All seams constructed on slopes of 6H:1V or steeper shall be vertical seams, except where slope lengths exceed standard roll lengths and elsewhere as approved in advance by the Engineer. Where approved, end seams on slopes of 6H:1V or steeper shall be staggered a minimum of 5 feet and shall be made at an angle of approximately 45 degrees.

g. All panels placed on slopes of 6H:1V or steeper shall extend a minimum of 5 feet beyond the grade break with a slope flatter than 6H:1V.

h. All seams shall extend to the full extent of the anchor trench (where applicable).

i. Unless otherwise approved by the Engineer, all "T" seams (i.e., the result of three panels placed together) shall be staggered a minimum of 3 feet along either seam and shall be covered with a patch.

j. No junctions of four or more panels shall be allowed unless approved by the Engineer.

k. If extrusion seaming equipment is stopped for longer than one minute, it shall be purged to remove heat-degraded extrudate. All purged extrudate shall be placed on a sacrificial sheet and disposed of.

l. To prevent moisture buildup during seaming, it may be necessary to place a movable protective layer of plastic directly below each overlap of LLDPE-GM that is to be seamed.

m. If required, a firm substrate shall be provided by using a flat board or similar hard surface directly under the seam overlap to achieve proper support.

n. All seams (including repairs) shall meet or exceed the requirements of GRI GM19 and Table 3 of this section.

o. No overlying material shall be placed over the LLDPE-GM until approved by the CQA Engineer.

6. Anchor Trench:

a. The anchor trench shall be constructed as shown on the Contract Drawings and as specified herein. The anchor trench shall be maintained by the Contractor.

b. Slightly rounded corners shall be provided in the trench to avoid sharp bends in the LLDPE-GM.

c. The anchor trench shall be adequately drained to prevent water ponding and softening to adjacent soils. The anchor trench shall be backfilled with controlled fill material and compacted to 90% standard Proctor dry density (ASTM D 698).

d. If the anchor trench is located in a clay susceptible to desiccation, the amount of trench open at any time shall be limited to one day of LLDPE-GM installation capacity.

7. Repair Procedures:

a. Any portion of the LLDPE-GM exhibiting signs of defect or failing a nondestructive or a destructive test, shall be repaired by the Geomembrane Installer. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure shall be made by the CQA Engineer. The procedures available include:

(1) Patching - Apply a new piece of LLDPE-GM sheet over, and at least 6-inches beyond the limits of a defect. The patch shall be extrusion seamed to the underlying LLDPE-GM. This method should be used to repair holes, tears, destructive test locations, undispersed raw materials, contamination by foreign matter, dents, pinholes, and pressure test holes.

(2) Capping - Apply a new strip of LLDPE-GM along the length of a delineated faulty seam. The cap strip shall extend at least 6-inches beyond the limit of the seam and the edges shall be extrusion seamed to the underlying LLDPE-GM. This method should be used to repair lengths of extrusion or hot wedge seams.

(3) Replacement - The faulty seam is removed and replaced.

b. In addition, the following provisions shall be satisfied:

(1) Surfaces of the LLDPE-GM which are to be repaired shall be abraded no more than one hour prior to the repair;

(2) All surfaces must be clean and dry at the time of the repair;

(3) All seaming equipment used in repairing procedures must be approved;

(4) The repair procedures, materials, and techniques shall be approved in advance of the specific repair by the CQA Engineer;

(5) Extrusion seaming of flaps of dual track hot wedge seams is not acceptable. A patch or cap strip shall be used; and

(6) Patches or caps shall extend at least 6-inches beyond the edge of the defect, and all patch corners shall be rounded.

8. Surveying:

a. After completion of a segment of LLDPE-GM, the Contractor shall survey LLDPE-GM to obtain the following information:

(1) Location and numbering of all panels/seams.

(2) Location of all repairs/patches;

(3) Location of all destructive test locations; and

(4) Location of all pipe penetrations and other appurtenances (if applicable).

b. No overlying materials shall be placed before survey information is obtained.

c. The Contractor shall provide the CQA Engineer with updated survey information when requested by the CQA Engineer to verify that the required information is being obtained.

9. Cover Placement:

Placement of materials over LLDPE-GM shall be performed in a manner as to ensure that LLDPE-GM and the underlying geosynthetics are not damaged; minimal slippage of LLDPE-GM on the underlying geosynthetics occurs; no excess tensile stresses occur in the LLDPE-GM; and that no portion of the LLDPE-GM develops excessive wrinkles or crimp. Wrinkles that exceed approximately 6 inches in height and cannot be eliminated by amended placement and covering methods or LLDPE-GM that becomes crimped shall be cut and repaired by the Geosynthetics Installer in a method approved by the Engineer.

TABLE 1: REQUIRED LLDPE-GM PROPERTIES

PROPERTY	TEST METHOD	UNITS	VALUE
Interface Shear Strength (Peak)[1, 2, 3]	ASTM D 5321	psf	55 psf (Load = 200 psf)

Notes:

1. Textured LLDPE-GM shall have adequate adhesion against adjacent materials under low normal loads to achieve the successful installation of overlying components without slippage.
2. Note that the required values for textured LLDPE-GM may require an aggressively textured sheet.
3. The specified interface shear strength requirement is based on a finished slope no steeper than 6H:1V. Steeper slopes will require evaluation by the Engineer.

TABLE 2: REQUIRED CONTRACTOR QUALITY CONTROL TESTS

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
Interface Shear Strength	ASTM D 5321	(See Note 1)

Notes:

1. Test each interface to be used on this project using representative samples of materials to be supplied under normal loads indicated and using test parameters as specified by the Engineer. For this project, interfaces to be tested are:

   A. Textured LLDPE-GM (30 mil) or GCL against existing cover soils (intermediate cover);
   B. Drainage Geocomposite against textured LLDPE-GM (30 mil) or GCL; and
   C. Vegetative Soil Layer against Drainage Geocomposite.

   If there are material differences in the surface of any of the geosynthetic materials from one side to the other, then all possible combinations of interfaces shall be tested. This testing shall be performed at Contractor cost by an independent GAI accredited laboratory and submitted to the Engineer for review prior to shipping.

Upon review of test results, the Engineer may allow exceptions to the above criteria.

For tests involving textured geomembranes, the laboratory shall also report the asperity height (GRI GM12) for the material samples used in the actual direct shear tests.

TABLE 3: REQUIRED SEAM STRENGTH PROPERTIES

PROPERTY	TEST METHOD	VALUE	
		Hot Wedge Seams	**Extrusion Fillet Seams**
30 mil			
Shear Strength[1]	ASTM D 6392	45 lbs/inch	
Shear Elongation at Break[2]		50%	
Peel Strength[1]		38 lbs/inch	34 lbs/inch
Peel Separation (Incursion)		≤ 25%	
Locus-of-Break		See Note 3	

Notes:

1. Values listed for shear and peel strengths are for 4 out of 5 test specimens; the 5th specimen can be as low as 80% of the listed values.
2. Omit elongation measurements when performing field tests.
3. Regarding the locus-of-break patterns of the different seaming methods in shear and peel, the following are unacceptable break codes per their description in ASTM D 6392 (in this regard, SIP is an acceptable break code):

   Hot Wedge: AD and AD-BRK with > 25% Separation
   Extrusion Fillet: AD1, AD2, and AD-WLD (unless strength is achieved).

END OF SECTION

SECTION 02930

REVEGETATION

Revegetation: Revegetation includes permanent Revegetation of all site areas disturbed by the Contractor whether inside the Contract Limits or not.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete Revegetation in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Vegetative Soil Layer	02258
Erosion and Sedimentation Control	02270
Rolled Erosion Control Products	02275

3. Warranty:

The Contractor shall be responsible for the satisfactory establishment and growth of a permanent stand of vegetation for a period of one year following the final seeding as judged by the Engineer. During this period, the Contractor shall be responsible for the maintenance items described in Paragraph D.4 (Maintenance) of this Specification.

B. MATERIALS

1. Limestone: Unless otherwise defined by specific soil tests, supply agricultural grade ground limestone conforming to the current "Rules, Regulations, and Standards of the Fertilizer Board of Control."

2. Fertilizer: Unless otherwise defined by specific soil tests, supply commercial fertilizer of 10-10-10 analysis, meeting applicable requirements of State and Federal law. Do not use cyanamic compounds of hydrated lime. Deliver fertilizer in original containers labeled with content analysis.

3. Grass Seed: Supply fresh, clean, new-crop seed as specified in Table 1 of this section. Do not use seed which is wet, moldy, or otherwise damaged. Deliver seed in standard sealed containers labeled with producer's name and seed analysis, and in accord with US Department of Agriculture Rules and Regulations under Federal Seed Act.

4. Mulch: Supply clean, seed-free, threshed straw of oats, wheat, barley, rye, beans, or other locally available mulch material.

   a. Do not use mulch containing a quantity of matured, noxious weed seeds or other species that will be detrimental to seeding, or provide a menace to surrounding land.

   b. Do not use mulch material which is fresh or excessively brittle, or which is decomposed and will smother or retard growth of grass.

5. Binder: Supply emulsified asphalt or synthetic binder.

6. Water: Supply potable, free of substances harmful to growth.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Results of soil tests performed and proposed modifications, if any, to the specified requirements.

2. Certificates for each grass seed mixture, stating botanical and common name, percentage by weight, and percentages of purity, germination, and weed seed. Certify that each container of seed delivered is fully labeled in accordance with Federal Seed Act and equals or exceeds specification requirements.

3. Copies of invoices for fertilizer, showing grade furnished and total quantity applied.

D. CONSTRUCTION

1. The Contractor shall establish a smooth, healthy, uniform, close stand of grass from the specified seed. Prior to Revegetation, the Contractor shall adequately test the soils to be revegetated to ensure the adequacy of the specified requirements. Any modifications to these requirements deemed necessary after the review of soil test results, shall be at the Contractor's sole expense. The Engineer will perform the observations to determine when successful Revegetation is achieved.

2. Soil Preparation:

a. Limit preparation to areas which will be planted soon after preparation.

b. Loosen surface to minimum depth of four (4) inches.

c. Remove stones, sticks, roots, rubbish and other extraneous matter over three (3) inches in any dimension.

d. Spread lime uniformly over designated areas at the rate specified in Table 1 of this section.

e. After application of lime, prior to applying fertilizer, loosen areas to be seeded with double disc or other suitable device if soil has become hard or compacted. Correct any surface irregularities in order to prevent pocket or low areas which will allow water to stand.

f. Distribute fertilizer uniformly over areas to be seeded at the rate specified in Table 1 of this section.

(1) Use suitable distributor.

(2) Incorporate fertilizer into soil to depth of a least two (2) inches.

(3) Remove stones or other substances which will interfere with turf development or subsequent mowing.

g. Grade seeded areas to smooth, even surface with loose, uniformly fine texture.

(1) Roll and rake, remove ridges and fill depressions, as required to meet finish grades.

(2) Fine grade just prior to planting.

3. Seeding:

a. Use approved mechanical power driven drills or seeders, mechanical hand seeders, or other approved equipment.

b. Distribute seed evenly over entire area at the rate specified in Table 1 of this section.

c. Stop work when work extends beyond most favorable planting season for species designated, or when satisfactory results cannot be obtained because of drought, high winds, excessive moisture, or other factors.

d. Resume work only when favorable condition develops, or as directed by the Engineer.

e. Lightly rake seed into soil followed by light rolling or cultipacking.

f. Immediately protect seeded areas against erosion by mulching or placing Rolled Erosion Control Products in accordance with Section 02275 of these Specifications, where applicable.

(1) Spread mulch in a continuous blanket at the rate specified in Table 1 of this section.

(2) Immediately following spreading mulch, secure with evenly distributed binder at the rate specified in Table 1 of this section.

4. Maintenance:

The Contractor shall be responsible for maintaining all seeded areas through the end of his warranty period. The Contractor shall provide, at his expense, protection of all seeded areas against damage at all times until acceptance of the work. Maintenance shall include, but not be limited to, the following items:

a. Regrade and revegetate all eroded areas until adequately stabilized by grass.

b. Remulch with new mulch in areas where mulch has been disturbed by wind or maintenance operations sufficiently to nullify its purpose. Anchor as required to prevent displacement.

c. Replant bare areas using same materials specified.

TABLE 1: SEEDING SCHEDULE

MATERIAL	SEED TYPE	APPLICATION RATE[1]
Lime	-----	4,000 lbs/acre
Fertilizer	-----	1,000 lbs/acre
Seed		
Permanent:	Tall Fescue	80 lbs/acre
	Pensacola Bahiagrass	50 lbs/acre
	Sericea Lespedeza[2]	30 lbs/acre
	Kobe Lespedeza	10 lbs/acre
	Common Bermuda[3]	25 lbs/acre
	Seasonal Nurse Crop	See Note 4
Temporary:	See Note 5	See Note 5
Mulch	-----	4,000 - 5,000 lbs/acre
Binder	-----	150 gallons/acre

Notes:

1. Application rates and/or chemical analysis shall be confirmed or established by a soil test(s).
2. From September 1 - March 1, use unscarified Sericea seed.
3. Use hulled Bermuda seed from April through October and unhulled Bermuda seed from November through March.
4. Use seasonal nurse crop in accordance with seeding dates as stated below:

April 15 - August 15	10 lbs/acre German Millet or 15 lbs/acre Sudangrass
August 16 - April 14	25 lbs/acre Rye (grain).

5. For temporary seeding, follow the guidelines of the NC Erosion and Sediment Control Planning and Design Manual.

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Construction Quality Assurance Manual

Washington County C&D Landfill
Roper, North Carolina

Prepared for:

Washington County Public Utilities
Roper, North Carolina

January 2010

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WASHINGTON COUNTY C&D LANDFILL

CONSTRUCTION QUALITY ASSURANCE MANUAL

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SECTION 1.0
GENERAL

1.1 INTRODUCTION

This Construction Quality Assurance (CQA) Manual has been prepared to provide the Owner, (Design) Engineer, and CQA Engineer the means to govern the construction quality and to satisfy landfill certification requirements under current solid waste management regulations.

More specifically, this CQA Manual addresses the soils and/or geosynthetics components of the landfill subgrade and final cover system. The final cover system on top slopes consists of a LLDPE geomembrane or GCL, overlying granular and geosynthetic drainage material with collection piping, and overlying vegetative soil layer. The final cover system on side slopes consists of a vegetative soil layer.

The CQA Manual is divided into the following sections:

- Section 1.0 General
- Section 2.0 CQA Documentation
- Section 3.0 Earthwork CQA
- Section 4.0 Final Cover System CQA
- Section 5.0 Geomembrane CQA
- Section 6.0 Drainage Geocomposite CQA
- Section 7.0 Geosynthetic Clay Liner CQA

1.2 DEFINITIONS RELATING TO CONSTRUCTION QUALITY

1.2.1 Construction Quality Assurance (CQA)

In the context of this Manual, Construction Quality Assurance is defined as a planned and systematic program employed by the Owner to assure conformity of the final cover system installation with the project drawings and the project specifications. CQA is provided by the CQA Engineer as a representative of the Owner and is independent from the Contractor and all manufacturers. The CQA program is designed to provide adequate confidence that items or services meet contractual and regulatory requirements and will perform satisfactorily in service.

1.2.2 Construction Quality Control (CQC)

Construction Quality Control refers to actions taken by manufacturers, fabricators, installers, and/or the Contractor to ensure that the materials and the workmanship meet the requirements of the project drawings and the project specifications. The manufacturer's specifications and quality control (QC) requirements are included in this CQA Manual by reference only. A complete updated version of each geosynthetic component manufacturer's QC Plan shall be incorporated as part of the Contractor's CQC Plan.

1.2.3 CQA Certification Document

At the completion of construction, a certification document will be prepared by the CQA Engineer and submitted to State Solid Waste Regulators. The certification report will include all QC testing performed by the Geosynthetics Manufacturers, all CQC testing performed by the Geosynthetic Installers, and all CQA testing performed by the CQA Engineer.

1.2.4 Discrepancies Between Documents

The Contractor is instructed to bring discrepancies to the attention of the CQA Engineer who shall then notify the Engineer for resolution. The Engineer has the sole authority to determine resolution of discrepancies existing within the Contract Documents (this may also require the approval of State Solid Waste Regulators). Unless otherwise determined by the Engineer, the more stringent requirement shall be the controlling resolution.

1.3 PARTIES TO CONSTRUCTION QUALITY ASSURANCE

1.3.1 Description of the Parties

The parties to Construction Quality Assurance and Quality Control include the Owner, Engineer, Contractor, Geosynthetics Manufacturer, Geosynthetics Installer, CQA Engineer, Geosynthetics CQA Laboratory, and Soils CQA Laboratory.

1.3.1.1 Owner

The Owner is Washington County, who owns and/or is responsible for the facility.

1.3.1.2 Engineer

The Engineer is responsible for the engineering design, drawings, and project specifications for the final cover system. The Engineer is an official representative of the Owner. The Engineer serves as communications coordinator for the project, initiating the meetings outlined in **Section 1.7**. The Engineer will also be responsible for proper resolution of all quality issues that arise during construction. The Engineer is Richardson Smith Gardner & Associates, Inc.

1.3.1.3 Contractor

The Contractor is responsible for the construction of the final cover systems. The Contractor is responsible for the overall CQC on the project and coordination of submittals to the CQA Engineer. Additional responsibilities of the Contractor are defined by the project specifications.

1.3.1.4 Geosynthetics Manufacturer

The Geosynthetics Manufacturer(s) is (are) responsible for the production of the geosynthetic components used in landfill construction. The Manufacturer(s) is (are) responsible for Quality Control (QC) during manufacture of the geosynthetic components, certification of the properties of the geosynthetic components, and field installation criteria.

1.3.1.5 Geosynthetics Installer

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

1.3.1.6 CQA Engineer

The CQA Engineer is a representative of the Owner, is independent from the Contractor, and is responsible for observing, testing, and documenting activities related to the CQA of the soil and geosynthetic components of the final cover system. The CQA Engineer may make field observations and review submittals for the Engineer and is responsible for notifying the Owner and Engineer of all quality issues that arise during construction. The CQA Engineer is also responsible for issuing a facility certification report, sealed by a Professional Engineer registered in The State of North Carolina.

1.3.1.7 Geosynthetics CQA Laboratory

The Geosynthetics CQA Laboratory is a party, independent from the Owner, that is responsible for conducting tests on conformance samples of geosynthetics used in the final cover system. The Geosynthetics CQA Laboratory service cannot be provided by any party involved with the manufacture, fabrication, or installation of any of the geosynthetic components. The services of the Geosynthetics CQA Laboratory are coordinated by the CQA Engineer and are paid for by the Owner.

1.3.1.8 Soils CQA Laboratory

The Soils CQA Laboratory is a party, independent from the Owner, that is responsible for conducting geotechnical tests on conformance samples of soils and aggregates used in structural fills and the final cover system. The services of the Soils CQA Laboratory are coordinated by the CQA Engineer and are paid for by the Owner.

1.3.2 Qualifications of the Parties

The following qualifications are required of all parties involved with the manufacture, fabrication, installation, transportation, and CQA of all materials for the final cover system. Where applicable, these qualifications must be submitted by the Contractor to the Owner and Engineer for review and approval.

1.3.2.1 Contractor

Qualifications of the Contractor are specific to the construction contract and independent of this CQA Manual.

1.3.2.2 Geosynthetics Manufacturers

Each Geosynthetics Manufacturer must satisfy the qualifications presented in the project specifications.

1.3.2.3 Geosynthetic Installer(s)

The Geosynthetic Installer(s) will be trained and qualified to install the geosynthetics components of the final cover system. Each Geosynthetics Installer must meet the requirements of the project specifications and be approved by the Engineer.

1.3.2.4 CQA Engineer

The CQA Engineer will act as the Owner's Quality Assurance Representative. The CQA Engineer will perform CQA testing to satisfy the requirements of this CQA Manual and will prepare the CQA certification document. The CQA Engineer will have experience in the CQA aspects of the construction and testing of landfill final cover systems, and be familiar with ASTM and other related industry standards. The activities of the CQA Engineer will be performed under the supervision of a Registered Professional Engineer.

1.3.2.5 Geosynthetics CQA Laboratory

The Geosynthetics CQA Laboratory should be certified by the Geosynthetics Accreditation Institute, will have experience in testing geosynthetics, and be familiar with ASTM, GRI, and other applicable test standards. The Geosynthetics CQA Laboratory will be capable of providing test results within 24 hours or a reasonable time after receipt of samples depending on the test(s) to be conducted, as agreed to at the outset of the project by affected parties, and will maintain that standard throughout the installation.

1.3.2.6 Soils CQA Laboratory

The Soils CQA Laboratory will have experience in testing structural fill and aggregates, and be familiar with ASTM and other applicable test standards. The Soils CQA Laboratory will be capable of providing test results within 24 hours or a reasonable time after receipt of samples depending on the test(s) to be conducted, as agreed to at the outset of the project by affected parties, and will maintain that standard throughout the installation.

1.4 SCOPE OF CONSTRUCTION QUALITY ASSURANCE MANUAL

The scope of this CQA Manual includes the CQA of the soils and geosynthetic components of the final cover system for the subject facility. The CQA for the selection, evaluation, and placement of the soils is included in the scope.

1.5 UNITS

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

1.6 REFERENCES

The CQA Manual includes references to the most recent version of the test procedures of the American Society of Testing and Materials (ASTM) and/or the Geosynthetic Research Institute (GRI). **Appendix A** contains a list of these procedures.

1.7 CQA MEETINGS

To facilitate the specified degree of quality during installation, clear, open channels of communication are essential. To that end, meetings are critical.

1.7.1 Geosynthetics CQA Meeting

A CQA Meeting will be held at the site prior to placement of the geosynthetics. At a minimum, the meeting will be attended by the Engineer, the CQA Engineer, the Contractor, and the Geosynthetic Installation Superintendent(s).

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

This meeting should include all of the activities referenced in the project specifications.

The meeting will be documented by the Engineer and minutes will be transmitted to all parties. The Soil Liner CQA Meeting and the Geosynthetics CQA Meeting may be held as one meeting or separate meetings, depending on the direction of the Engineer.

1.7.2 CQA Progress Meetings

Progress meetings will be held between the Engineer, the CQA Engineer, the Contractor, the Geosynthetic Installation Superintendent(s), and representatives from any other involved parties at the frequency dictated in the project specifications or, at a minimum, once per month during active construction. These meetings will discuss current progress, planned activities for the next week, and any new business or revisions to the work. The CQA Engineer will log any problems, decisions, or questions arising at this meeting in his daily or periodic reports. Any matter requiring action which is raised in this meeting will be reported to the appropriate parties. These meetings will be documented by the Engineer and minutes will be transmitted to affected parties.

1.7.3 Problem or Work Deficiency Meetings

A special meeting will be held when and if a problem or deficiency is present or likely to occur. At a minimum, the meeting will be attended by the Engineer, the CQA Engineer, the Contractor, and representatives from any other involved parties. The purpose of the meeting is to define and resolve the problem or work deficiency as follows:

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

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

1.8 CONTROL VERSUS RECORD TESTING

1.8.1 Control Testing

In the context of this CQA Manual, Control Tests are those tests performed on a material prior to its actual use in construction to demonstrate that it can meet the requirements of the project plans and specifications. Control Test data may be used by the Engineer as the basis for approving alternative material sources.

1.8.2 Record Testing

Record Tests are those tests performed during the actual placement of a material to demonstrate that its in-place properties meet or exceed the requirements of the project drawings and specifications.

SECTION 2.0
CQA DOCUMENTATION

2.1 DOCUMENTATION

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

The CQA Engineer will provide the Owner and Engineer with his daily and weekly progress reports including signed descriptive remarks, data sheets, and logs to verify that required CQA activities have been carried out. These reports will also identify potential quality assurance problems. The CQA Engineer will also maintain at the job site a complete file of project drawings, reports, project specifications, a CQA Manual, checklists, test procedures, daily logs, and other pertinent documents.

2.2 DAILY CQA REPORT

The CQA Engineer's reporting procedures will include preparation of a daily report which, at a minimum, will include the following information, where applicable:

- a unique identifying sheet number for cross referencing and document control;
- date, project name, location, and other identification;
- data on weather conditions;
- a reduced-scale Site Plan showing all proposed work areas and test locations;
- descriptions and locations of ongoing construction;
- descriptions and specific locations of areas, or units, of work being tested and/or observed and documented;
- locations where tests and samples were taken;
- a summary of test results;
- calibrations or recalibrations of test equipment, and actions taken as a result of recalibration;
- off-site materials received, including quality verification documentation;

- decisions made regarding acceptance of units of work, and/or corrective actions to be taken in instances of substandard quality;

- summaries of pertinent discussions with the Contractor and/or Geosynthetic Installers; and

- the CQA Engineer's signature.

The daily report must be completed at the end of each CQA Engineer's shift, prior to leaving the site. This information will be submitted weekly to and reviewed by the Owner and Engineer.

2.3 CQA PROGRESS REPORTS

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

- a unique identifying sheet number for cross-referencing and document control;

- the date, project name, location, and other information;

- a summary of work activities during the progress reporting period;

- a summary of construction situations, deficiencies, and/or defects occurring during the progress reporting period;

- summary of all test results, failures and retests, and

- signature of the CQA Engineer.

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

2.4 CQA PHOTOGRAPHIC REPORTING

Photographs will be taken by the CQA Engineer at regular intervals during the construction process and in all areas deemed critical by the CQA Engineer.

These photographs will serve as a pictorial record of work progress, problems, and mitigation activities. These records will be presented to the Engineer upon completion of the project.

In lieu of photographic documentation, videotaping may be used to record work progress,

problems, and mitigation activities. The Engineer may require that a portion of the documentation be recorded by photographic means in conjunction with videotaping.

2.5 DEFICIENCIES

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

2.6 DESIGN AND/OR PROJECT TECHNICAL SPECIFICATION CHANGES

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

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

2.7 FINAL CQA REPORT

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

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

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

At a minimum, the items shown in **Table 2.1** will be included in the Final CQA Report. Note that some items may not be applicable to all projects.

2.8 STORAGE OF RECORDS

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

TABLE 2.1: FINAL CQA REPORT GENERAL OUTLINE

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SECTION 3.0
EARTHWORK CQA

3.1 INTRODUCTION

This section of the CQA Manual addresses earthwork (excavation and embankment) and outlines the soils CQA program to be implemented with regard to material approval, subgrade approval, field control and record tests, and resolution of problems.

3.2 EMBANKMENT MATERIAL APPROVAL

All material to be used as compacted embankment shall be approved in advance by the CQA Engineer. Approval is based upon successful completion of CQA control testing outlined below. Such testing can be performed either during excavation and stockpiling or from existing stockpiles prior to use.

3.2.1 Control Tests

The procedure for CQA testing during excavation and stockpiling (including existing stockpiles) is outlined below.

Each load of soil will be examined either at the borrow source or the stockpile area. Any unsuitable material will be rejected or routed to separate stockpiles consistent with its end use. Appropriate entries will be made in the daily log.

During stockpiling operations, control tests, as shown on **Table 3.1**, will be performed by the CQA Engineer prior to placement of any compacted embankment.

3.3 SUBGRADE APPROVAL

The CQA Engineer will verify that the compacted embankment subgrade is constructed in accordance with the project specifications.

3.4 EARTHWORK CONSTRUCTION

3.4.1 Construction Monitoring

A. Earthwork shall be performed as described in the project specifications.

B. Only soil previously approved by the CQA Engineer (see **Section 3.2**) shall be used in construction of the compacted embankment. Unsuitable material will be removed prior to acceptance by the CQA Engineer.

C. All required field density and moisture content tests shall be completed before the overlying lift of soil is placed. The surface preparation (e.g. wetting, drying,

scarification, etc.) shall be completed before the CQA Engineer will allow placement of subsequent lifts.

D. The CQA Engineer will monitor protection of the earthwork during and after construction.

3.4.2 Control Tests

The control tests, as shown on **Table 3.2**, will be performed by the CQA Engineer prior to placement of compacted embankment.

3.4.3 Record Tests

The record tests, as shown on **Table 3.2**, will be performed by the CQA Engineer during placement of compacted embankment.

3.4.3.1 Record Test Failure

Recompaction of the failed area shall be performed and retested until the area meets or exceeds requirements outlined in the specifications.

3.4.4 Judgmental Testing

During construction, the frequency of control and/or record testing may be increased at the discretion of the CQA Engineer when visual observations of construction performance indicate a potential problem. Additional testing for suspected areas will be considered when:

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

3.5 DEFICIENCIES

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

TABLE 3.1: CQA TESTING PROGRAM FOR EMBANKMENT MATERIAL APPROVAL

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
CONTROL TESTS:		
Visual Classification	ASTM D 2488	Each Soil
Moisture-Density Relationship	ASTM D 698	5,000 CY per Each Soil

TABLE 3.2: CQA TESTING PROGRAM FOR COMPACTED EMBANKMENT

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
CONTROL TESTS: (See **Table 3.1**)		
RECORD TESTS:		
Lift Thickness	-----	Each Lift
In-Place Density	ASTM D 6938[1]	20,000 ft^2 per lift & 1 per 500 LF/lift of Berms (< 200 ft. base width)
Moisture Content	ASTM D 6938[2]	20,000 ft^2 per lift & 1 per 500 LF/lift of Berms (< 200 ft. base width)
Verification of Subgrade Soil Type (Soil w/in 2 Vertical Feet of Finished Subgrade Elevations)	ASTM D 2488	5,000 ft^2

Notes:

1. Optionally use ASTM D 1556, ASTM D 2167, or ASTM D 2937. For every 10 nuclear density tests perform at least 1 density test by ASTM D 1556, ASTM D 2167, or ASTM D 2937 as a verification of the accuracy of the nuclear testing device.
2. Optionally use ASTM D 2216, ASTM D 4643, or ASTM D 4959. For every 10 nuclear moisture tests perform at least 1 moisture test by ASTM D 2216, ASTM D 4643, or ASTM D 4959 as a verification of the accuracy of the nuclear testing device.
3. Conduct subgrade verification using hand augured boring or test pit.

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SECTION 4.0
FINAL COVER SYSTEM CQA

4.1 INTRODUCTION

This section of the CQA Manual addresses the landfill gas (LFG) components, drainage aggregate and piping, and the vegetative soil layer of the final cover system. By reference to **Sections 5.0, 6.0, and 8.0** of this CQA Manual, this section also addresses the geomembrane, drainage geocomposite, and GCL that are included in the final cover system. This section outlines the CQA program to be implemented with regard to material approval, construction monitoring, and resolution of problems.

4.2 FINAL COVER SYSTEM MATERIAL APPROVAL

The CQA Engineer shall verify that the following are provided and installed in accordance with the project drawings, specifications, and this CQA Manual.

4.2.1 Drainage Pipe

A. Receipt of Contractor's submittals on drainage pipe.

B. Review of submittals for drainage pipe for conformity to the project specifications.

4.2.2 LFG System Components

A. Receipt of Contractor's submittals on LFG system components.

B. Review of submittals for LFG system components for conformity to the project specifications.

4.2.3 Aggregates

A. Receipt of Contractor's submittals on aggregates.

B. Review of submittals for aggregates for conformity to the project specifications.

C. Conduct material control tests in accordance with **Table 4.1**.

4.2.4 Geosynthetic Clay Liner

The CQA program for GCL is presented in **Section 7.0** of this CQA Manual.

4.2.5 Geomembrane

The CQA program for geomembranes is presented in **Section 5.0** of this CQA Manual.

4.2.6 Drainage Geocomposite

The CQA program for drainage geocomposite is presented in **Section 6.0** of this CQA Manual.

4.2.9 Vegetative Soil Layer

A. Review the proposed source of vegetative soil layer for conformance with the project specifications.

B. Conduct material control tests in accordance with **Table 4.1**.

4.3 FINAL COVER SYSTEM INSTALLATION

The CQA Engineer will monitor and document the construction of all final cover system components for compliance with the project specifications. Monitoring the construction work for the components of the final cover system includes the following:

- verify location and depth of LFG wells/vents;
- verify location of all piping;
- monitoring the minimum vertical buffer maintained between field equipment and geosynthetics/piping; and
- monitoring that the placement of the final cover system components does not fold or damage the geosynthetics or other underlying layers.

4.4 DEFICIENCIES

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

TABLE 4.1: CQA TESTING PROGRAM FOR FINAL COVER SYSTEM

COMPONENT	PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
CONTROL TESTS:			
Coarse Aggregate:	Gradation	ASTM C 136	5,000 CY
Vegetative Soil Layer:	Visual Classification	ASTM D 2488	Each Load
	Grain Size Analysis	ASTM D 422	5,000 CY
	Atterberg Limits	ASTM D 4318	5,000 CY

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SECTION 5.0
GEOMEMBRANE CQA

5.1 INTRODUCTION

This section of the CQA Manual addresses the geomembrane component of the final cover system and outlines the CQA program to be implemented with regard to manufacturer and installer approval, material approval, subgrade approval, field and laboratory control and record tests, repairs, and resolution of problems.

5.2 GEOMEMBRANE MANUFACTURER AND INSTALLER APPROVAL

The Contractor shall submit the qualifications of the Geomembrane Manufacturer and the Geomembrane Installer, as described in the specifications, to the CQA Engineer for approval.

5.3 GEOMEMBRANE MATERIAL APPROVAL

5.3.1 Geomembrane Product Data

The CQA Engineer will review the Contractor's submittals for conformance with the project specifications.

5.3.2 Shipment And Storage

During shipment and storage, all geomembrane will be protected as required by the project specifications. The CQA Engineer will observe rolls upon delivery at the site.

5.3.3 Quality Control Certificates

Upon delivery, the CQA Engineer will:

- verify that the Manufacturer's quality control certificates have been provided at the specified frequency and that each certificate identified the rolls or sheets related to it; and
- review the Manufacturer's quality control certificates and verify that the certified properties meet the project technical specifications.

5.3.4 Material Control Tests

Samples for material control tests, as shown on **Table 5.1**, will be obtained by the CQA Engineer at the indicated frequencies upon delivery of the geomembrane. Alternatively, samples may be randomly obtained at the manufacturing site by the CQA Engineer or representatives of the Geosynthetics CQA Laboratory.

Unless otherwise specified, samples will be 3 feet long by the roll or sheet width. The CQA Engineer will mark the machine direction on the samples with an arrow.

All material control tests will be performed by the Geosynthetics CQA Laboratory.

All control test results must be available at the site prior to the deployment of all geomembrane. The CQA Engineer will examine all results from laboratory conformance testing.

5.3.4.1 Material Control Test Failure

The following procedure will apply whenever a sample fails a material control test:

A. The Geomembrane Installer will replace the roll or sheet of geomembrane that is in nonconformance with the project specifications with a roll or sheet that meets project specifications.

B. The Geomembrane Installer will remove conformance samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll or sheet on both sides of the failed roll or sheet. These two samples must both conform to project specifications. If either of these samples fail, then the next numerical roll or sheet will be tested until a passing roll or sheet is found. This additional conformance testing will be at the expense of the Geomembrane Installer. If either of the two closest rolls or sheets fail, the Engineer will dictate the frequency of additional testing.

The CQA Engineer will document actions taken in conjunction with material control test failures.

5.4 GEOMEMBRANE INSTALLATION

5.4.1 Handling

The Geosynthetic Installer will handle all geomembrane in such a manner as required by the project specifications.

5.4.2 Earthwork

5.4.2.1 Surface Preparation

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

to the Engineer.

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

5.4.2.2 Anchorage System

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

5.4.3 Geomembrane Placement

5.4.3.1 Field Panel Identification

The CQA Engineer will document that the Geomembrane Installer labels each field panel with an "identification code" (number or letter-number consistent with the layout plan) agreed upon by the Geomembrane Installer and CQA Engineer at the Geosynthetics CQA Meeting (see **Section 1.7.2**).

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

5.4.3.2 Field Panel Placement

5.4.3.2.1 Location: The CQA Engineer will verify that field panels are installed at the location indicated in the Geomembrane Installer's layout plan, as approved or modified in **Section 5.4.3.1**.

5.4.3.2.2 Installation Schedule: The CQA Engineer will evaluate every change in the schedule proposed by the Geomembrane Installer and advise the Engineer on the acceptability of that change.

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

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

5.4.3.2.4 Damage: The CQA Engineer will visually observe each panel, after placement and prior to seaming, for damage. The CQA Engineer will advise the Engineer which panels, or portion of panels, should be rejected, repaired, or accepted. Damaged panels or portions of damaged panels which have been rejected will be marked and their removal from the work area recorded by the CQA Engineer. Repairs will be made according to procedures described in this section.

As a minimum, the CQA Engineer will document that:

- the panel is placed in such a manner that it is unlikely to be damaged; and
- any tears, punctures, holes, thin spots, etc. are either marked by the Geomembrane Installer for repair or the panel is rejected.

5.4.4 Field Seaming

5.4.4.1 Seam Layout

The Geomembrane Installer will provide the CQA Engineer with a seam layout drawing, i.e., a drawing of the area to be lined showing all expected seams. The CQA Engineer and Engineer will review the seam layout drawing and verify that it is consistent with the accepted state of practice and this CQA Manual.

A seam numbering system compatible with the panel numbering system will be agreed upon at the Geosynthetics CQA Meeting (see **Section 1.7.2**). An on-going written record of the seams and repair areas shall be maintained by the Geomembrane Installer with weekly review by the CQA Engineer.

5.4.4.2 Requirements of Personnel

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

5.4.4.3 Seaming Equipment and Products

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

5.4.5 Field Seam Control Tests

5.4.5.1 Trial Seams

A. Prior to production seaming, after four (4) hours of continuous seaming, and/or when significant changes in geomembrane or ambient temperature occurs, the Geomembrane Installer shall perform trial seams to verify that seaming conditions and procedures are adequate. Trial seams shall be performed by each operator of extrusion welders and by the primary operator of each wedge welder using seaming equipment to be used in production seaming.

B. Trial seams shall be made on appropriate sized pieces of identical or equivalent geomembrane material.

C. Hot wedge trial seams shall be approximately 72" x 12" with the seam centered lengthwise. Extrusion fillet trial seams shall be approximately 36" x 12" with the seam centered lengthwise. A minimum of four coupons shall be tested in peel and shear (two each) (ASTM D 6392) by the Geomembrane Installer using a field tensiometer. All coupons shall meet the minimum seam strength requirements as shown in the project specifications.

D. Each trial seam shall be assigned a number and the test results recorded in the appropriate log by the Geomembrane Installer. The CQA Engineer will observe all trial seams and compile all trial seam logs.

5.4.6 Field Seam Record Tests

5.4.6.1 Nondestructive Seam Continuity Testing

The Geomembrane Installer shall test and document all seams continuously over their full length using one of the following nondestructive seam tests. This testing shall be performed simultaneously with geomembrane deployment as the work progresses and not at the completion of all field seaming.

A. Vacuum Testing shall conform to ASTM D 5641 requirements.

B. Air Pressure Testing (for double seam with an enclosed space) shall conform to ASTM D 5820 requirements and the requirements listed in **Table 5.2**.

The CQA Engineer will observe the nondestructive testing on a full time basis to ensure conformance with this CQA Manual and the project specifications.

5.4.6.2 Field Destructive Seam Testing

A. The Geomembrane Installer shall obtain 12" x 30" (or longer as needed) samples of field seams with the seam centered lengthwise, suitable for testing, at an average frequency of one sample per 500 linear feet of seam. The sample shall be cut into two equal-length pieces, one for field destructive seam testing by the Geosynthetics Installer and one given to the CQA Engineer as an archive sample. The date, time, equipment, seam number, and seaming parameters will be marked on each sample and recorded by the CQA Engineer.

B. The Geomembrane Installer shall perform and document field destructive seam testing using a field tensiometer which has been calibrated within the prior 6 months (calibration information shall be provided to the CQA Engineer). A minimum of three (3) coupons each will be tested in peel and shear (ASTM D 6392). Coupons shall meet the minimum seam strength requirements as shown in the project specifications.

C. The CQA Engineer or the Owner may require additional random samples to be taken for testing in areas which visually appear defective and not in accordance with the project requirements.

D. All holes in the geomembrane resulting from destructive seam sampling shall be immediately repaired in accordance with repair procedures described in this manual.

5.4.6.3 Geosynthetics CQA Laboratory Destructive Testing

A. The Geomembrane Installer shall obtain 12" x 30" (or longer as needed) samples of field seams with the seam centered lengthwise, suitable for testing, at an average frequency of one sample per day to confirm field destructive seam tests. The sample shall be cut into two equal-length pieces, both to be given to the CQA Engineer for laboratory destructive seam testing and as an archive sample. The date, time, equipment, seam number, and seaming parameters will be marked on each sample and recorded by the CQA Engineer.

B. Laboratory destructive test samples will be packaged and shipped to the

Geosynthetics CQA Laboratory by the CQA Engineer in a manner that will not damage the test sample.

C. A minimum of five (5) coupons each will be tested in peel and shear (ASTM D 6392) by the Geosynthetics CQA Laboratory. Coupons shall meet the minimum seam strength requirements as shown in the project specifications.

D. All geomembrane destructive test samples that fail to meet project specifications will be saved and sent to the CQA Engineer for observation.

E. The CQA Engineer will review laboratory test results as soon as they become available.

5.4.6.4 Field Seam Record Test Failure

For noncomplying tests, the CQA Engineer will:

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

5.4.6.5 Defining Extent of Field Seam Record Test Failure

All defective seam test failures must be bounded by acceptable destructive tests. The CQA Engineer will document repair actions taken in conjunction with all seam test failures.

5.4.7 Repairs & Verification

5.4.7.1 Repair Procedures

A. All repair procedures shall be in accordance with the project specifications. The CQA Engineer will observe all repair procedures.

B. All surfaces shall be clean and dry at the time of the repair.

C. After an extrusion seam is made, no more than ¼ inch of abrasion shall be visible beyond the weld.

5.4.7.2 Repair Verification

A. Each repair shall be numbered and logged by the Geomembrane Installer.

B. Each repair shall be non-destructively tested by the Geomembrane Installer using the methods described above. Repairs which pass non-destructive testing shall be taken as an indication of an adequate repair.

C. Repairs more than 150 feet long may be of sufficient length to require destructive test sampling, at the discretion of the CQA Engineer. A failed test indicates that the repair shall be redone and retested until passing test results are achieved.

5.5 LINER SYSTEM ACCEPTANCE

The geomembrane component of the liner system will be accepted by the Owner when:

- the installation is finished;
- verification of the adequacy of all seams and repairs, including associated testing, is complete;
- CQA Engineer provides the Engineer with a final copy of the nondestructive test documentation, repair information, and as-built drawings, as submitted by the Geomembrane Installer;
- CQA Engineer provides the Engineer with a certification, submitted by the Geomembrane Installer that the geomembrane was installed in accordance with the Geomembrane Manufacturer's recommendations as well as the project drawings and project specifications; and
- all documentation of the installation is completed including the CQA Engineer's final report.

5.6 MATERIALS IN CONTACT WITH GEOMEMBRANES

The quality assurance procedures indicated in this subsection are only intended to assure that the installation of these materials does not damage the geomembrane. All reasonable measures to protect the geomembrane and provide additional quality assurance procedures are necessary to assure that systems built with these materials will be constructed to ensure proper performance.

5.6.1 Soils

Prior to placement, the CQA Engineer will visually confirm that all soil materials to be placed against the geomembrane comply with project specifications. The Geomembrane Installer will provide the CQA Engineer a written surface acceptance certificate in accordance with **Section 5.4.2**. All soil materials shall be placed and compacted in accordance with project specifications.

5.6.2 Sumps and Appurtenances

The CQA Engineer will verify that:

- installation of the geomembrane in appurtenance areas, and connection of the geomembrane to appurtenances have been made according to the project specifications;
- extreme care is taken while seaming around appurtenances since neither nondestructive nor destructive testing may be feasible in these areas; and
- the geomembrane or appurtenances have not been visibly damaged while making connections to appurtenances.

5.7 DEFICIENCIES

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

TABLE 5.1: CQA TESTING PROGRAM FOR GEOMEMBRANE MATERIAL APPROVAL

PROPERTY	TEST METHOD	TEST FREQUENCY
Thickness	ASTM D 5199/D 5994	100,000 ft^2 or 1 per Lot[1]
Density	ASTM D 1505/D 792	100,000 ft^2 or 1 per Lot[1]
Carbon Black Content	ASTM D 1603	100,000 ft^2 or 1 per Lot[1]
Carbon Black Dispersion	ASTM D 5596	100,000 ft^2 or 1 per Lot[1]
Tensile Properties:	ASTM D 6693 (Type IV)	
Tensile Strength at Yield		100,000 ft^2 or 1 per Lot[1]
Tensile Strength at Break		100,000 ft^2 or 1 per Lot[1]
Elongation at Yield		100,000 ft^2 or 1 per Lot[1]
Elongation at Break		100,000 ft^2 or 1 per Lot[1]
Tear Resistance	ASTM D 1004	100,000 ft^2 or 1 per Lot[1]

Notes:

1. Whichever provides the larger number of tests.

TABLE 5.2 AIR PRESSURE TEST REQUIREMENTS

MATERIAL	MIN. PRESSURE (PSI)	MAX. PRESSURE DROP (PSI) AFTER 5 MINUTES
30 Mil LLDPE	15	3

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SECTION 6.0
DRAINAGE GEOCOMPOSITE CQA

6.1 INTRODUCTION

This section of the CQA Manual addresses drainage geocomposite (DGC) and outlines the CQA program to be implemented with regard to material approval, material control tests, repairs, and resolution of problems.

6.2 DGC MATERIAL APPROVAL

6.2.1 DGC Product Data

The CQA Engineer will review the Contractor's submittals for conformance with the project specifications.

6.2.2 Shipment And Storage

During shipment and storage, all DGC will be protected as required by the project specifications. The CQA Engineer will observe rolls upon delivery at the site.

6.2.3 Quality Control Certificates

Upon delivery, the CQA Engineer will:

- verify that the Manufacturer's quality control certificates have been provided at the specified frequency and that each certificate identified the rolls related to it; and

- review the Manufacturer's quality control certificates and verify that the certified properties meet the project technical specifications.

6.2.4 DGC Material Control Tests

Samples for material control tests, as shown on **Table 6.1**, will be obtained by the CQA Engineer at the indicated frequencies upon delivery of the DGC. Alternatively, samples may be randomly obtained at the manufacturing site by the CQA Engineer or representatives of the Geosynthetics CQA Laboratory.

Unless otherwise specified, samples will be 3 feet long by the roll width. The CQA Engineer will mark the machine direction on the samples with an arrow.

All material control tests will be performed by the Geosynthetics CQA Laboratory.

All test results must be available at the site prior to the deployment of all DGC. The CQA

Engineer will examine all results from laboratory testing.

6.2.4.1 Material Control Test Failure

The following procedure will apply whenever a sample fails a material control test:

A. The Geosynthetic Installer will replace the roll of DGC that is in nonconformance with the project specifications with a roll that meets project specifications.

B. The Geosynthetic Installer will remove samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll on both sides of the failed roll. These two samples must both conform to project specifications. If either of these samples fail, then the next numerical roll will be tested until a passing roll is found. This additional testing will be at the expense of the Geosynthetic Installer. If either of the two closest rolls fail, the Engineer will dictate the frequency of additional testing.

The CQA Engineer will document actions taken in conjunction with material control test failures.

6.3 DGC INSTALLATION

6.3.1 Handling And Placement

The Geosynthetic Installer will handle and place all DGC in such a manner as required by the project specifications.

6.3.2 Stacking And Joining

When several layers of DGC are stacked, care should be taken to ensure that stacked DGC are placed in the same direction. Stacked DGC will never be laid in perpendicular directions to the underlying DGC (unless otherwise specified by the Engineer). The CQA Engineer will observe the stacking of DGC.

Adjacent rolls of DGC will be joined according to construction drawings and project specifications.

6.3.3 Repairs

Any holes or tears in the DGC will be repaired in accordance with the project specifications. The CQA Engineer will observe any repair.

6.3.4 Placement Of Overlying Materials

All soil materials located on top of DGC shall be placed in accordance with the project specifications.

6.4 DEFICIENCIES

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

TABLE 6.1: CQA TESTING PROGRAM FOR DGC MATERIAL APPROVAL

PROPERTY	TEST METHOD	TEST FREQUENCY
CONTROL TESTS:		
Thickness (geonet only)	ASTM D 5199	100,000 ft^2 or 1 per Lot[1]
Density (geonet only)	ASTM D 1505	100,000 ft^2 or 1 per Lot[1]
Ply Adhesion	ASTM D 413/ GRI GC7	100,000 ft^2 or 1 per Lot[1]
Transmissivity	ASTM D 4716[2]	1 per Resin Lot

Notes:

1. Whichever provides the larger number of tests.
2. Conduct tests for transmissivity in accordance with the conditions given in the project specifications.

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SECTION 7.0
GEOSYNTHETIC CLAY LINER (GCL) CQA

7.1 INTRODUCTION

This section of the CQA Manual addresses geosynthetic clay liner (GCL) and outlines the CQA program to be implemented with regard to material approval, material control tests, repairs, and resolution of problems.

7.2 GCL MANUFACTURER AND INSTALLER APPROVAL

The Contractor shall submit the qualifications of the GCL Manufacturer and the GCL Installer, as described in the specifications, to the CQA Engineer for approval.

7.3 GCL MATERIAL APPROVAL

7.3.1 GCL Product Data

The CQA Engineer will review the Contractor's submittals for conformance with the project specifications.

7.3.2 Shipment And Storage

During shipment and storage, GCL will be protected as required by the project specifications. The CQA Engineer will observe rolls upon delivery at the site.

7.3.3 Quality Control Certificates

Upon delivery, the CQA Engineer will:

- verify that the Manufacturer's quality control certificates have been provided at the specified frequency and that each certificate identified the rolls related to it; and
- review the Manufacturer's quality control certificates and verify that the certified properties meet the project technical specifications.

7.3.4 GCL Material Control Tests

Samples for material control tests, as shown on **Table 7.1**, will be obtained by the CQA Engineer at the indicated frequencies upon delivery of the GCL. Alternatively, samples may be randomly obtained at the manufacturing site by the CQA Engineer or representatives of the Geosynthetics CQA Laboratory.

Unless otherwise specified, samples will be 3 feet long by the roll width. The CQA

Engineer will mark the machine direction on the samples with an arrow.

All material control tests will be performed by the Geosynthetics CQA Laboratory.

All test results must be available at the site prior to the deployment of all GCL. The CQA Engineer will examine all results from laboratory testing.

7.3.4.1 Material Control Test Failure

The following procedure will apply whenever a sample fails a material control test:

A. The Geosynthetic Installer will replace the roll of GCL that is in nonconformance with the project specifications with a roll that meets project specifications.

B. The Geosynthetic Installer will remove samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll on both sides of the failed roll. These two samples must both conform to project specifications. If either of these samples fail, then the next numerical roll will be tested until a passing roll is found. This additional testing will be at the expense of the Geosynthetic Installer. If either of the two closest rolls fail, the Engineer will dictate the frequency of additional testing.

The CQA Engineer will document actions taken in conjunction with material control test failures.

7.4 GCL INSTALLATION

7.4.1 Handling And Placement

The Geosynthetic Installer will handle and place all GCL in such a manner as required by the project specifications.

7.4.2 Seams And Overlaps

All GCL will be seamed or overlapped in accordance with project specifications or as approved by the CQA Engineer and Engineer.

7.4.3 Repairs

Any holes or tears in the GCL will be repaired in accordance with the project specifications. The CQA Engineer will observe any repair.

7.4.4 Placement Of Overlying Materials

All soil materials located on top of the GCL shall be placed in accordance with the project specifications.

7.5 DEFICIENCIES

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

TABLE 7.1: CQA TESTING PROGRAM FOR GCL MATERIAL APPROVAL

PROPERTY	TEST METHOD	TEST FREQUENCY
CONTROL TESTS:		
Hydraulic Conductivity	ASTM D 5084/D 5887	100,000 ft^2 or 1 per Lot[1]
Bentonite Content	ASTM D 5993 (@ 0% moisture)	100,000 ft^2 or 1 per Lot[1]
Peel Strength	ASTM D 6496	100,000 ft^2 or 1 per Lot[1]

Notes:

1. Whichever provides the larger number of tests.

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Appendix A

Reference List of Test Methods

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CQA MANUAL
APPENDIX A: REFERENCE LIST OF TEST METHODS

American Society American Society of Testing and Materials (ASTM):

ASTM C 136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
ASTM D 413	Standard Test Methods for Rubber Property - Adhesion to Flexible Substrate.
ASTM D 422	Standard Test Method for Particle Size Analysis of Soils.
ASTM D 698	Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3).
ASTM D 792	Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
ASTM D 1004	Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
ASTM D 1505	Standard Test Method for Density of Plastics by the Density-Gradient Technique.
ASTM D 1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
ASTM D 1603	Standard Test Method for Carbon Black in Olefin Plastics.
ASTM D 2167	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
ASTM D 2216	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
ASTM D 2434	Standard Test Method for Permeability of Granular Soils (Constant Head).
ASTM D 2488	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
ASTM D 2937	Standard Test Method for Density of Soil in Place by the Drive Cylinder Method.

ASTM D 3042	Standard Test Method for Insoluble Residue in Carbonate Aggregates.
ASTM D 4318	Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
ASTM D 4632	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
ASTM D 4643	Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method.
ASTM D 4716	Standard Test Method for Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextile Related Products.
ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile.
ASTM D 4833	Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
ASTM D 4959	Standard Test Method for Determination of Water (Moisture) Content of Soil by Direct Heating Method.
ASTM D 5084	Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.
ASTM D 5199	Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
ASTM D 5596	Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
ASTM D 5641	Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.
ASTM D 5820	Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes.
ASTM D 5887	Standard Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter.

ASTM D 5993	Standard Test Method for Measuring Mass per Unit of Geosynthetic Clay Liners.
ASTM D 5994	Standard Test Method for Measuring Core Thickness of Textured Geomembrane.
ASTM D 6392	Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.
ASTM D 6496	Standard Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners.
ASTM D 6693	Standard Test Method for Determining Tensile Properties of Nonreinforced Flexible Polyethylene and Nonreinforced Polypropylene Geomembranes.
ASTM D 6938	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

Geosynthetic Research Institute (GRI):

GRI GC7	Determination of Adhesion and Bond Strength of Geocomposites.

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Operations Manual

Washington County Landfill Facility
Roper, North Carolina

Prepared for:

Washington County Public Utilities
Roper, North Carolina

January 2010

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WASHINGTON COUNTY LANDFILL FACILITY

OPERATIONS MANUAL

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SECTION 1.0
GENERAL FACILITY OPERATIONS

1.1 OVERVIEW

This Operations Manual was prepared for operations of the Washington County Landfill facility (Permit No. 94-04) located near Roper. This document discusses the operation of the following landfill units and other solid waste management activities:

- C&D landfill;
- Used tire storage area;
- White goods and scrap metal handling area;
- Yard waste processing area; and
- Mobile home deconstruction area.

Refer to **Drawing S1** (Existing Site Conditions) for the location of existing and proposed landfill units and other solid waste management activities.

The County may also add roll-off or other suitable containers for recyclables and/or municipal solid waste (MSW). Areas in the vicinity of the white goods/scrap metal handling area would be used for this purpose.

Another proposed use of the site is the installation of a firing range for the County Sheriff's Department. As shown on **Drawing S1**, the firing range is to be located at the south end of the closed MSW landfill unit. The direction of fire will be toward the west where a soil berm is currently being placed.

1.2 CONTACT INFORMATION

All correspondence and questions concerning the operation of the Washington County Landfill should be directed to the appropriate County and State personnel listed below. For fire or police emergencies dial 911.

1.2.1 Washington County

Washington County Landfill
718 Landfill Road
Roper, NC 27970
P.O. Box 1007
Plymouth, NC 27962
Phone/Fax: (252) 793-5615

Landfill Operator:	Carl Critcher
Public Utilities Director:	Lou Manring ((252) 793-7545)

1.2.2 North Carolina Department of Environment and Natural Resources

North Carolina DENR - Fayetteville Regional Office (FRO)
225 Green Street, Suite 714
Fayetteville, NC 28301
Phone: (910) 486-1541
Fax: (910) 486-0707

North Carolina DENR - Raleigh Central Office (RCO)
401 Oberlin Road, Suite 150
Raleigh, NC 27605
Phone: (919) 508-8400
Fax: (919) 715-3605

North Carolina DENR - Washington Regional Office (W1RO)
943 Washington Square Mall
Washington, NC 27889
Phone: (252) 946-6481
Fax: (252) 975-3716

North Carolina DENR - Wilmington Regional Office (W2RO)
127 Cardinal Drive Extension
Wilmington, NC 28405
Phone: (910) 796-7215
Fax: (910) 350-2004

Division of Waste Management (DWM) - Solid Waste Section:

Field Operations Branch Head:	Mark Poindexter (RCO)
Eastern District Supervisor:	Dennis Shackelford (FRO)
Waste Management Specialist:	Ray Williams (W2RO)

Division of Land Resources - Land Quality Section:

Regional Engineer:	Pat McClain, P.E. (W1RO)

1.3 ACCESS CONTROL

Limiting access to the landfill facility is important for the following reasons:

- Unauthorized and illegal dumping of waste materials is prevented.
- Trespassing, and injury resulting therefrom, is discouraged.
- The risk of vandalism is greatly reduced.

Access to active areas of the landfill will be controlled by a combination of fences and natural

barriers, and strictly enforced operating hours. A landfill attendant will be on duty at all times when the facility is open for public use to enforce access restrictions (see also **Section 1.11**).

1.3.1 Physical Restraints

The site will be accessed by the existing entrance on Landfill Road. Scales and a scale house/office are provided at the entrance. All waste will have been weighed prior to being placed in the landfill. The entrance has a gate which will be securely locked during non-operating hours.

1.3.2 Security

Frequent inspections of gates and fences will be performed by landfill personnel. The County will arrange for a random security patrol of the main gate to further discourage trespassing. Evidence of trespassing, vandalism, or illegal operation will be reported to the Landfill Operator.

1.4 SIGNAGE

A prominent sign(s) containing the information required by the DWM will be placed at the landfill entrance. This sign(s) will provide information on operating hours, operating procedures, and acceptable wastes. Additional signage will be provided as necessary within the landfill complex to distinctly distinguish the roadway to the active landfill unit(s). Service and maintenance roads for use by operations personnel will be clearly marked and barriers (e.g., traffic cones, barrels, etc.) will be provided as required.

1.5 COMMUNICATIONS

Two way radio communication will be maintained between the active landfill unit(s) and the landfill scale house/office. The scale house/office has a telephone in case of emergency and for the conduct of day-to-day business. Emergency telephone numbers are displayed in the scale house/office.

1.6 FACILITY OPERATING HOURS

Normal hours of operation will be 8:30 A.M. to 4:30 P.M. Monday to Friday and 8:30 A.M. to 1:00 p.m. on Saturday. The facility will be closed on Sunday.

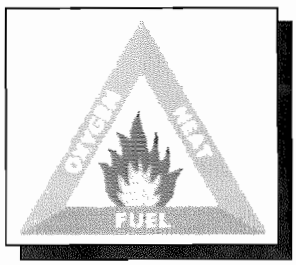
The County may elect to modify these hours from time to time.

1.7 FIRE CONTROL

Although no open burning of waste is allowed at the facility, the possibility of fire within the landfill or a piece of equipment must be anticipated in the daily operation of the landfill. Potential fire hazards include both surface conditions and subsurface conditions. Surface

conditions include equipment operations and newly placed waste. Subsurface conditions include existing waste previously landfilled.

1.7.1 Fire Triangle



The "triangle" illustrates the rule that in order to ignite and burn, a fire requires three (3) elements: heat, fuel, and oxygen. A fire is prevented or extinguished by "removing" any one of them. A fire naturally occurs when the elements are combined in the right mixture (e.g., more heat needed for igniting some fuels, unless there is concentrated oxygen). These principles are integral in the prevention and management of potential fire situations.

1.7.2 Equipment

A combination of factory installed fire suppression systems and/or portable fire extinguishers will be operational on all pieces of heavy equipment at all times. Potential fire hazards are created from the build-up of fine, dry dust particles on and around operational motors and control panels. The presence of these build-ups can cause overheating and potential fire if periodic equipment cleaning and maintenance are not practiced. Portable fire extinguishers should be maintained in a state of readiness on each piece of moving equipment and equipment should be cleaned periodically.

1.7.3 General Fire Management Strategies

Each fire situation is site specific; however, general strategies for active fire management include the following (in no particular order):

- Accelerated high temperature combustion (displacing fuel);
- Covering of the landfill burn area with soil (reduce oxygen);
- Covering of the burn area with foams (reduce oxygen);
- Flooding the burn area with water (reduce heat);
- Injecting an inert gas such as CO_2 (reduce oxygen); and
- Excavating the burning material (displacing fuel) and then extinguishing it in small controlled areas.

1.7.4 Fires within Disposal Areas

Fires within the landfill disposal areas will be limited by the use of daily/periodic cover as a fire break and control of "hot" loads entering the landfill. Landfill personnel at the scale house will turn away all trucks containing waste that is suspected to be hot. If a hot load is placed on the working face, then the load will be spread as thin as possible and daily cover soil will be immediately placed on the waste to extinguish the fire.

In general, fires that break out close to the surface of the disposal area should be excavated and smothered with cover material. Deep fires should be smothered out by placing moist soil on the surface and by constructing soil barriers around the fire. Where the smothering technique fails, the burning material must be excavated and smothered or quenched with water once the burning material is brought to the surface. Water is usually not effective unless it can be directly applied to the burning material.

1.7.5 Notification

The County will verbally notify the DWM (see **Section 1.2.2**) within 24 hours of discovery of a fire within any landfill disposal area. In addition, written documentation describing the fire, the actions carried out to extinguish the fire, and a strategy for preventing future occurrences will be provided to the DWM within 15 days following any such occurrence.

1.7.6 Coordination with Local Fire Department

A copy of this Operations Manual will be filed with the local fire department including all contact information for the facility.

1.8 LITTER CONTROL

The vegetative trees/bushes act as a barrier to keep litter contained within the site and a litter control crew will pick up litter around the site and on access roads routinely as required. Wind screens adjacent to active areas will be used as required to control windblown waste. Additionally, landfill staff will make operational changes as practical based on wind conditions that may spread litter.

1.9 SEVERE WEATHER CONDITIONS

Unusual weather conditions can directly affect the operation of the landfill facility. Some of these weather conditions and recommended operational responses are as follows.

1.9.1 Ice Storms

An ice storm can make access to the landfill dangerous, prevent movement or placement of daily cover, and, thus, may require closure of the landfill until the ice is removed or has melted.

1.9.2 Heavy Rains

Exposed soil surfaces can create a muddy situation in some portions of the landfill during rainy periods. The control of drainage and use of crushed stone on unpaved roads should provide all-weather access for the site and promote drainage away from critical areas. In areas where the aggregate surface is washed away or otherwise damaged, new aggregate

should be used for repair.

Intense rains can affect newly constructed drainage structures such as swales, diversions, cover soils, and vegetation. After such a rain event, inspection by landfill personnel will be initiated and corrective measures taken to repair any damage found before the next rainfall.

1.9.3 Electrical Storms

The open area of a landfill is susceptible to the hazards of an electrical storm. If necessary, landfilling activities will be temporarily suspended during such an event. To guarantee the safety of all field personnel, refuge will be taken in the on-site buildings or in rubber-tired vehicles.

1.9.4 Windy Conditions

Landfill operations during a particularly windy period may require that the working face be temporarily shifted to a more sheltered area. When this is done, the previously exposed face will be immediately covered with daily cover.

1.9.5 Violent Storms

In the event of hurricane, tornado, or severe winter storm warning issued by the National Weather Service, landfill operations may be temporarily suspended until the warning is lifted. Daily cover will be placed on exposed waste and buildings and equipment will be properly secured.

1.10 EQUIPMENT REQUIREMENTS

The County will maintain on-site equipment required to perform the necessary landfill activities. Periodic maintenance of all landfilling equipment, and minor and major repair work will be performed at designated maintenance zones outside of the landfill.

1.11 PERSONNEL REQUIREMENTS

At least one member of the landfill supervisory staff will be certified as a Manager of Landfill Operations (MOLO) by the Solid Waste Association of North America (SWANA). Each landfill employee will go through an annual training course (led by supervisory staff) and is certified by SWANA as Landfill Operations personnel. As part of this training, personnel learn to recognize loads which may contain prohibited wastes.

1.12 HEALTH AND SAFETY

All aspects of the landfill facility operations were developed with the health and safety of the operating staff, customers, and neighbors in mind. Prior to commencement of operations of the

facility, a member of the operating staff will be designated site safety officer. This individual, together with the facility's management will modify the site safety and emergency response program to remain consistent with SWANA and Occupational Safety and Health Administration (OSHA) guidance.

Safety equipment provided includes equipment rollover protective cabs, seat belts, audible reverse warning devices, hard hats, safety shoes, and first aid kits. Facility personnel will be encouraged to complete the American Red Cross Basic First Aid Course. Other safety requirements as designated by the County will also be implemented.

Facility employees will be routinely trained in health and safety by supervisory staff. All training will be documented. The following are some general recommendations for the health and safety of workers:

1.12.1 Personal Hygiene

The following items are recommended as a minimum of practice:

- Wash hands before eating, drinking, or smoking.
- Wear personal protective equipment as described in **Section 1.12.2.**
- Wash, disinfect, and bandage ANY cut, no matter how small it is. Any break in the skin can become a source of infection.
- Keep fingernails closely trimmed and clean (dirty nails can harbor pathogens).

1.12.2 Personal Protective Equipment

Personal Protective Equipment (PPE) must be evaluated as to the level of protection necessary for particular operating conditions and then made available to facility employees. The list below includes the PPE typically used and/or required in a solid waste management facility workplace.

- Safety shoes with steel toes.
- Noise reduction protection should be used in areas where extended exposure to continuous high decibel levels are expected.
- Disposable rubber latex or chemical resistant gloves for handling and/or sampling of waste materials.
- Dust filter masks.

Following use, PPE's should be disposed of or adequately cleaned, dried, or readied for reuse.

1.12.3 Mechanical Equipment Hazard Prevention

All equipment should be operated with care and caution. All safety equipment such as horns, backup alarms, and lights should be functional. A Lockout-Tagout program will

be used to identify equipment in need or under repair and insure that operation is "off-limits" prior to maintenance or repair. All operators will be trained in the proper operation of equipment.

1.12.4 Employee Health and Safety

Some general safety rules are:

- Consider safety first when planning and conducting activities.
- Review the equipment O&M manual(s) prior to attempting repairs/changes.
- Remember the buddy system for repair of mechanical equipment.
- Post emergency contact phone numbers.
- Provide easy and visible access to the Right to Know materials.
- Provide easy and visible access to the first aid kit and fire extinguishers.

1.12.5 Physical Exposure

Facility personnel may come in contact with the fluids, solids, and airborne constituents found at the facility. Routine training should be conducted regarding the individual and collective materials used at the facility and their associated hazards. Training concerning safe work practices around these potential exposures should cover the use of equipment and proper disposal procedures.

1.12.6 Material Safety Data Sheets

Material Safety Data Sheets (MSDS) will be collected on every waste (if available) that enters the facility. Information will also be made available for all chemicals stored on site for use by the facility. MSDS sheets shall be stored in a location with all other Right to Know information for the site.

1.13 UTILITIES

Electrical power, water, telephone, and a restroom are provided at the landfill scale house/office.

1.14 RECORD KEEPING PROGRAM

The County will maintain the following records in an operating record at the landfill:

A. Current permit(s);
B. Inspection reports;
C. Audit and compliance records;
D. Annual landfill reports;
E. Waste inspection records (see **Section 2.4**);
F. Daily tonnage records - including source of generation;
G. Waste determination records;

H. Quantity, location of disposal, generator, and special handling procedures for all special wastes disposed of at the site;
I. List of generators and haulers that have attempted to dispose of restricted wastes;
J. Employee training procedures and records of training completed;
K. All ground water monitoring and surface water quality information (See the current **Water Quality Monitoring Plan**) including:
   1. Monitoring well construction records;
   2. Sampling dates and results;
   3. Statistical analyses; and
   4. Results of inspections, repairs, etc.
L. All closure and post-closure information, where applicable, including:
   1. Notification of intent to close;
   2. Testing;
   3. Certification; and
   4. Recording.
M. Cost estimates or financial assurance documentation.
N. A notation of the date and time of cover placement.
O. Documentation of mobile home deconstruction (see **Appendix B**).

The operating record will be kept up to date by the Landfill Operator or his designee. It will be presented upon request to the DWM for inspection. A copy of this Operations Manual will be kept at the landfill and will be available for use at all times.

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SECTION 2.0
WASTE HANDLING OPERATIONS

2.1 OVERVIEW

This section describes the required waste handling operations for the Washington County Landfill facility. In addition to the C&D waste disposed of at this facility, the County also processes scrap tires, white goods/scrap metal, yard and wood wastes, and performs deconstruction of mobile homes. These materials are stored at the landfill facility until there are sufficient quantities for pick up by various recycling contractors.

2.2 ACCEPTABLE WASTES

2.2.1 C&D Landfill Unit

Only the following wastes generated within the approved service area may be disposed of in the C&D landfill unit:

- Construction and Demolition (C&D) Solid Waste: as defined in 15A NCAC 13B.0532(8) means solid waste resulting solely from construction, remodeling, repair, or demolition operations on pavement and buildings or structures. C&D waste does not include municipal and industrial wastes that may be generated by the on-going operations at buildings or structures.
- Land Clearing and Inert Debris Landfill: as defined in 15A NCAC 13B.0101(54) means a facility for the disposal of land-clearing waste, concrete, brick, concrete block, uncontaminated soil, gravel and rock, untreated and unpainted wood, and yard trash.
- Land Clearing Waste: as defined in 15A NCAC 13B.0101(53) means solid waste which is generated solely from land-clearing activities, limited to stumps, trees, limbs, brush, grass, and other naturally occurring vegetative material.
- Asphalt: in accordance with NCGS 130A-294(m).
- Other Wastes as Approved by the Solid Waste Section of the Division of Waste Management.

In addition, the asbestos as described in **Section 2.5.3** and may also be disposed of in the C&D landfill unit.

2.3 PROHIBITED WASTES

2.3.1 C&D Landfill Unit

Only wastes as defined in **Section 2.2.1** above may be accepted for disposal in the C&D landfill unit. Prohibited wastes include waste exclusions listed in 15A NCAC 13B 0.0542 as follows:

- Wastewater treatment sludge. Wastewater treatment sludge may be accepted, with the approval of the DWM, for utilization as a soil conditioner and incorporated into or applied onto the vegetative soil layer component of the final cover system. In this case, the sludge will be applied at no greater than agronomic rates and to a maximum depth of six inches.
- Containers such as tubes, drums, barrels, tanks, cans, and bottles unless they are empty and perforated to ensure that no liquid, hazardous, or municipal solid waste is contained therein;
- Garbage as defined in G.S. 130A-290(a)(7);
- Hazardous waste as defined in G.S. 130A-290(a)(8), to also include hazardous waste from conditionally exempt small quantity generators;
- Industrial solid waste unless a demonstration has been made and approved by the DWM that the landfill meets the requirements of Rule .0503(2)(d)(ii)(A);
- Liquid wastes;
- Medical waste as defined in G.S. 130A-290(a)(18);
- Municipal solid waste as defined in G.S. 130A-290(a)(18a);
- Polychlorinated biphenyls (PCB) wastes as defined in 40 CFR 761;
- Radioactive waste as defined in G.S. 104E-5(14);
- Septage as defined in G.S. 130A-290(a)(32);
- Sludge as defined in G.S. 130A-290(a)(34);
- Special wastes as defined in G.S. 130A-290(a)(40);
- White goods as defined in G.S. 130A-290(a)(44); and
- Yard trash as defined in G.S. 130A-290(a)(45).

The following wastes cannot be received if separate from C&D waste:

- lamps or bulbs including but not limited to halogen, incandescent, neon or fluorescent;
- lighting ballast or fixtures;
- thermostats and light switches;
- batteries including but not limited to those from exit and emergency lights and smoke detectors;
- lead pipes;
- lead roof flashing;
- transformers;
- capacitors; and
- copper chrome arsenate (CCA) and creosote treated woods.

Waste accepted for disposal in the C&D landfill unit must be readily identifiable as C&D waste and must not have been shredded, pulverized, or processed to such an extent that the composition of the original waste cannot be readily ascertained except as specified as follows:

- C&D waste that has been shredded, pulverized, or otherwise processed may be accepted for disposal from a facility that has received a permit from an authorized

regulatory authority which specifies such activities are inspected by the authority, and whose primary purpose is recycling and reuse of the C&D material. For this case, a waste screening plan and waste acceptance plan will be prepared and made available to the DWM upon request.

The County will not dispose of C&D waste that is known to be generated within the boundaries of a unit of local government that by ordinance:

(A) Prohibits generators or collectors of C&D waste from disposing that type or form of C&D waste.
(B) Requires generators or collectors of C&D waste to recycle that type or form of C&D waste.

2.4 WASTE SCREENING PROGRAMS

In order to assure that prohibited wastes are not entering the landfill facility, screening programs have been implemented at the landfill. Waste received at both the scale house entrance and waste taken to the working face is inspected by trained personnel. These individuals have been trained to spot indications of suspicious wastes, including: hazardous placarding or markings, liquids, powders or dusts, sludges, bright or unusual colors, drums or commercial size containers, and "chemical" odors. Screening programs for visual and olfactory characteristics of prohibited wastes are an ongoing part of the landfill operation.

2.4.1 Waste Receiving and Inspection

All vehicles must stop at the scale house located at the entrance of the facility and visitors are required to sign-in. All waste transportation vehicles are weighed and the content of the load assessed. The scale attendant(s) requests from the driver of the vehicle a description of the waste it is carrying to ensure that unacceptable waste is not allowed into the landfill. The attendant(s) then visually checks the vehicle as it crosses the scale. Signs informing users of the acceptable and unacceptable types of waste are posted at the scale house. Once passing the scales, the vehicles are routed to the appropriate landfill unit or other area (white goods/scrap metal handling area, etc.) as appropriate.

Vehicles are randomly selected for screening on a regular basis, depending on personnel available. At least one vehicle per week, but not less than 1% by weight of the waste stream entering the landfill (based on the previous week's total), will be randomly selected by inspection personnel. A random truck number and time will be selected (e.g., the third load after 10:00 a.m.) on the day of inspections. However, if something looks suspicious is spotted in any waste load, that load is inspected further.

Vehicles selected for inspection are directed to an area of intermediate cover adjacent to the working face where the vehicle will be unloaded. Waste is carefully spread using suitable equipment. An attendant trained to identify wastes that are unacceptable at the landfill inspects the waste discharged at the screening site. If unacceptable waste is

found, including wastes generated from outside of the service area, the load will be isolated and secured by berming off the area. For unacceptable wastes that are non-hazardous, the Landfill Operator will then notify officials of the DWM (see **Section 1.2.2**) within 24 hours of attempted disposal of any waste the landfill is not permitted to receive in order to determine the proper course of action. For unacceptable wastes that are hazardous, the Hazardous Waste Contingency Plan outlined in **Section 2.4.2** will be followed. The hauler is responsible for removing unacceptable waste from the landfill property.

If no unacceptable waste is found, the load will be pushed to the working face and incorporated into the daily waste cell. All random waste inspections will be documented by landfill staff using the waste screening form provided in **Appendix A**.

In addition to random waste screening described above, waste unloaded on the active face will be inspected by the equipment operators, trained to spot unacceptable wastes, before and during spreading and compaction. Any suspicious looking waste is reported immediately to the designated primary inspector for further evaluation.

2.4.2 Hazardous Waste Contingency Plan

In the event that identifiable hazardous waste or waste of questionable character is detected at the landfill, appropriate equipment, protective gear, personnel, and materials as necessary will be employed to isolate the wastes. The DWM will be notified immediately (see **Section 1.2.2**) that an attempt was made to dispose of hazardous waste at the landfill. If the vehicle attempting disposal of such waste is known, all attempts will be made to prevent that vehicle from leaving the site or, if the vehicle has left the site, immediate notice will be served on the owner of the vehicle that hazardous waste, for which they have responsibility, has been disposed of at the landfill.

The County will assist the DWM as necessary and appropriate in the removal and disposition of the hazardous waste and in the prosecution of responsible parties. If needed, the hazardous waste will be covered with either on-site soils or other tarping material until such time when an appropriate method can be implemented to properly handle the waste. The cost of the removal and disposing of the hazardous waste will be charged to the owner of the vehicle involved. Any vehicle owner or operator who knowingly dumps hazardous waste in the landfill may be barred from using the landfill.

Should an incident where hazardous waste is found at the landfill occur, the event will be documented by landfill staff using the waste screening form provided in **Appendix A**.

Records of information gathered as part of the waste screening programs will be maintained at the landfill site during its active life and as long as required by the County and the DWM.

2.5 WASTE DISPOSAL

2.5.1 Access

Traffic will be clearly directed to the appropriate active access road. The location of access roads during waste placement will be determined by operations personnel in order to reflect waste placement strategy. Additionally, access will be maintained for site monitoring locations.

2.5.2 General Procedures

Waste transportation vehicles will arrive at the working face at random intervals. There may be a number of vehicles unloading waste at the same time, while other vehicles are waiting. In order to maintain control over the unloading of waste, a certain number of vehicles will be allowed on the working face at a time. The actual number will be determined by the truck spotter. This procedure will be used in order to minimize the potential of unloading unacceptable waste and to control disposal activity. Operations at the working face will be conducted in a manner which will encourage the efficient movement of transportation vehicles to and from the working face, and to expedite the unloading of waste.

The approach to the working face will be maintained such that two or more vehicles may safely unload side by side. A vehicle turn-around area large enough to enable vehicles to arrive and turn around safely with reasonable speed will be provided adjacent to the unloading area. The vehicles will back to a vacant area near the working face to unload. Upon completion of the unloading operation, the transportation vehicles will immediately leave the working face area. Personnel will direct traffic necessary to expedite safe movement of vehicles.

Waste unloading at the landfill will be controlled to prevent disposal in locations other than those specified by site management. Such control will also be used to confine the working face to a minimum width, yet allow safe and efficient operations. The width and length of the working face will be maintained as small as practical in order to maintain the appearance of the site, control windblown waste, and minimize the amount of cover required each day. Normally, only one working face will be active on any given day, with all deposited waste in other areas covered by either periodic, intermediate, or final cover, as appropriate.

The procedures for placement and compaction of solid waste include: unloading of vehicles, spreading of waste into 2 foot lifts, and compaction on relatively flat slopes (i.e. 5H:1V max.) using a landfill compactor and a minimum number of three full passes.

Wind screens adjacent to the working face may be used as required to control windblown waste.

The use of portable signs with directional arrows and portable traffic barricades will facilitate the unloading of wastes to the designated disposal locations. These signs and barricades will be placed along the access route to the working face of the landfill or other designated areas which may be established.

2.5.3 Special Waste Management

2.5.3.1 Asbestos Management

The County may dispose of asbestos within the C&D landfill unit. Asbestos will only be accepted if it has been processed and packaged in accordance with State and Federal (40 CFR 61) regulations. Asbestos will arrive at the site in vehicles that contain only the asbestos waste and only after advance notification by the generator.

Once the hauler brings the asbestos to the landfill, the hauler will be directed to the designated asbestos disposal area by operations personnel. The designated disposal area will be prepared by operations personnel by leveling a small area using a dozer or loader. Prior to disposal, the landfill operators will stockpile cover soil near the designated asbestos disposal area. The volume of soil stockpiled will be sufficient to cover the waste and to provide any berms, etc. to maintain temporary separation from other landfill traffic.

Once placed in the prepared area, the asbestos waste will be covered with a minimum of 18 inches of cover soil placed in a single lift. The surface of the cover soil will be compacted and graded using a tracked dozer or loader. The landfill compactor will be prohibited from operating over asbestos disposal areas until at least 18 inches of cover are in-place.

The landfill staff will record the approximate location and elevation of the asbestos waste once cover is in-place. The Landfill Operator will then review pertinent disposal and location information to assure compliance with regulatory requirements and enter the information into the Operating Record.

Once disposal and recording for asbestos waste is completed, the disposal area may be covered with waste. No excavation into designated asbestos disposal areas will be permitted.

2.5.4 Periodic Cover

At the completion of waste placement each week, or sooner if the area of exposed waste exceeds one-half acre in size, a 6-inch layer of earthen material or other material as approved by the DWM will be placed over the exposed waste. This periodic cover is intended to control vectors, fire, odors, and blowing debris.

2.5.5 Intermediate Cover

A 12 inch layer of soil cover should be placed on all waste surfaces that have not received waste in 30 days but are below final elevation. This intermediate cover should be seeded immediately and graded such that all precipitation run-off is channeled to the surface water systems.

2.5.6 Height Monitoring

Approximately every month, the landfill staff will monitor landfill top and side slope elevations with a level. When such elevations approach design grades, the final top-of-waste grades will be staked to limit over-placement of waste.

2.6 WHITE GOODS/SCRAP METAL HANDLING AREA

A white goods/scrap metal handling area is located to the north of the scale house. The operation of the white goods/scrap metal handling area is as follows:

Within the white goods/scrap metal handling area, white goods and scrap metal are stockpiled on a concrete pad up to about 10 feet high over an approximate 280 foot by 30 foot area. Once the stockpile reaches capacity, a recycler removes Freon and hauls the white goods and scrap metal off-site to be recycled.

2.7 USED TIRE STORAGE AREA

Used tires are collected at an area near the landfill scale house and placed in up to two tire trailers. Once one or more trailers are full, the trailer(s) are picked up by a recycling contractor.

2.8 YARD WASTE PROCESSING AREA

The operation of the yard waste processing area is as follows:

Acceptable wood and yard wastes are stockpiled to an approximate height of 10 feet over an area of approximately 1 acre. At that time a contractor is brought in to grind the waste. The ground waste is typically delivered to the Domtar Paper Mill in Plymouth for use as boiler fuel. Alternatively, ground waste can be used around the site, primarily for surface stabilization, or placed in windrows to be given to the public or otherwise used in the future.

Unacceptable wastes found in this area, if not otherwise prohibited, will be routed to the C&D landfill.

2.9 DECONSTRUCTION OF MOBILE HOMES

The deconstruction of mobile homes is handled in an area adjacent to the C&D landfill. A description of the process is provided in **Appendix B**.

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SECTION 3.0
ENVIRONMENTAL MANAGEMENT

3.1 OVERVIEW

This section reviews the overall environmental management tasks required for the successful operation of the landfill facility.

3.2 SURFACE WATER CONTROL

As used herein, the definition of "surface water" is water which results from precipitation or site run-on that has not contacted the waste.

Proper control of surface water at the landfill will accomplish the following goals:

- Prevent the run-on of surface water into the landfill unit(s) or the active face(s);
- Limit the erosion caused by surface waters; and
- Limit sediments carried off-site by surface waters.

Separate erosion and sedimentation control plans have been provided for the various landfill units. These plans describe both short and long term engineered features and practices for preventing erosion and controlling sedimentation at this site. The following is a brief discussion of some of these features and practices, focusing more on the landfill units.

3.2.1 Surface Water Run-On Control

The perimeter berms and/or perimeter channels around the landfill unit(s) are designed to prevent the run-on of surface water from adjacent land into the landfill. Additional structures such as diversion berms, channels, down pipes, etc. carry surface water away from the landfill.

3.2.2 Erosion Control

The serviceability of the landfill relies heavily on soil berms, barrier layers, and agricultural layers that are readily eroded by flowing water. Erosion control provisions incorporated in the landfill include the following:

- The slope of the working face must be no steeper than 5H:1V where practical to limit erosion of the periodic cover.
- Intermediate cover that has been exposed for more than 30 days must be seeded immediately and repaired when erosion features are identified.

- Drainage breaks (diversion berms) are provided on the final cover to limit the flow length of run-off.

- Water collected by each drainage break is routed to stormwater drainage channels or down pipes so that the run-off volume does not accumulate going down the slope.

- The vegetative soil layer placed over the final cover must be seeded immediately.

Additional erosion control measures have been taken within the drainage channels and at points of stormwater discharge. All final cover should be inspected regularly for erosion damage and promptly repaired.

3.2.3 Sedimentation Control

Stormwater run-off from the landfill unit(s) is conveyed to one of the on site basins and/or traps. These basins and/or traps should be inspected regularly for sediment build-up or erosion damage. The basins and/or traps should be cleaned out when sediment fills the lower half of the basin. Due to the sandy soils at the site, sedimentation is expected to be minimal.

3.3 WATER QUALITY MONITORING

The monitoring program and procedures outlined in the current Water Quality Monitoring Plan will be followed for the monitoring of site groundwater monitoring wells and surface water monitoring locations. The results of the water quality monitoring program will be placed in the facility operating record as described in **Section 1.14**.

3.4 LANDFILL GAS (LFG) MANAGEMENT

Due to a number of factors (the limited depth to groundwater, the sandy soils around the perimeter of the landfill, the distance to site structures, and the existence of wetlands around much of the property), no perimeter monitoring of gas from the C&D landfill is proposed.

Upon closure of the landfill, LFG control will consist of passive wells/vents installed in the final cover.

3.5 VECTOR CONTROL

Due to the nature of the waste disposed in this landfill unit, vector control is not anticipated to be of concern. Note that the use of periodic cover will discourage animals from nesting in the waste.

3.6 ODOR CONTROL

Due to the nature of the waste disposed in this landfill unit, odor control is not anticipated to be of concern. However, if odor control becomes a problem, additional measures (such as additional cover over wastes such as drywall) will be taken to ensure odor control.

3.7 DUST CONTROL

Dust has not historically been an issue at the landfill primarily due to the sandy soils at the site. If needed in the future, the County will take measures to control dust.

3.8 LEACHATE SEEPS

Leachate seeps can occur due to a variety of circumstances. The goal in dealing with leachate seeps is to prevent seepage from leaving the limits of waste disposal areas and to minimize the potential for reoccurrence. If evidence of leachate seeps is observed, the County will take the following actions. Depending on the circumstances, various combinations of actions may be appropriate.

1. If leachate is observed outside of the limits of waste disposal areas, notify the DWM (see **Section 1.2.2**).
2. Contain the flow of leachate using soil berms and/or excavation.
3. Excavate the area of seepage to attempt to allow flow into the underlying waste (i.e. break-up soil layers that may be causing the seep.).
4. For contained leachate that will not flow into underlying waste, a pump may be required to route the leachate to a tanker truck.
5. The use of soil (particularly clay) to plug the seepage may also be successful in the case where flows are minor.
6. Remove and dispose of impacted cover soils accordingly.
7. Repair landfill cover as necessary.

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Appendix A

Waste Screening Form

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Washington County Department of Public Utilities
Washington County C&D Landfill
Permit No. 94-04
(252) 793-5615

WASTE SCREENING FORM

Day / Date: _____ Time Weighed in: _____
Truck Owner: _____ Driver Name: _____
Truck Type: _____ Vehicle ID / Tag No: _____
Weight _____ Tare: _____
Waste Generator / Source: _____

Reason Load Inspected: Random Inspection _____ Staff Initials _____
Detained at Scales _____ Staff Initials _____
Detained by Operating Staff _____ Staff Initials _____

Inspection Location: _____

Approved Waste Determination Form Present? Yes _____ No _____ N/A _____

Description of Load: _____

Load Accepted (signature) _____ Date _____
Load Not Accepted (signature) _____ Date _____

Reason Load Not Accepted (complete only if load not accepted)

Description of Suspicious Contents: Color _____ Haz. Waste Markings _____
Texture _____
Drums Present _____ Smell _____
Est. Cu. Yds. Present in Load _____
Est. Tons Present in Load _____

Washington County Emergency Management Contacted? Yes _____ No _____

Company or Authority Contacted? _____
Hazardous Materials Present: _____

Hauler Notified (if waste not accepted) Phone: Time Contacted:
Other Observations: _____

Final Disposition
Signed _____ Date _____
Waste Screening Inspector

Attach related correspondence to this form.
File completed form in Operating Record.

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Appendix B

Mobile Home Deconstruction

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Operations Manual
Appendix B: Mobile Home Deconstruction

Washington County Landfill Facility
Roper, North Carolina

Prepared for:

Washington County Public Utilities
Roper, North Carolina

January 2010

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WASHINGTON COUNTY LANDFILL FACILITY

OPERATIONS MANUAL
APPENDIX B: MOBILE HOME DECONSTRUCTION

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WASHINGTON COUNTY LANDFILL FACILITY

OPERATIONS MANUAL
APPENDIX D: MOBILE HOME DECONSTRUCTION

1.0 OVERVIEW

This portion of the Operations Manual was prepared for the Mobile Home Deconstruction Area located adjacent to the Washington County Construction and Demolition Debris (C&D) Landfill unit. The Mobile Home Deconstruction Area is strictly for the deconstruction of mobile homes in order to recycle materials from the mobile homes. Washington County plans to recycle as many varieties of materials as possible as end users are available. Initially, scrap metal recycling will be conducted. Once an end-user of another material (i.e. glass) is located, these other materials may be recycled. Any non-recyclable material will be disposed of appropriately by the County upon completion of the deconstruction process.

2.0 MOBILE HOME DECONSTRUCTION PROCESS

Mobile homes will be deconstructed using the following processes.

2.1 Access

Mobile home owners seeking disposal will contact the landfill facility and be placed on a waiting list. No more than TWO (2) mobile homes will be allowed on-site for deconstruction at one time. Once space is available for a mobile home, landfill personnel will contact the next owner on the waiting list. The owner will have a 48 hour window in which to contact the landfill facility with information regarding the delivery date and hauler. If owner cannot arrange delivery within this initial 48 hour period, the owner may make alternate arrangements for delivery and must notify the landfill facility a minimum of 48 hours prior to planned delivery. The delivered mobile home will not be weighed on the scales at time of delivery, but the owner will be charged based upon the size and dimensions of the mobile home.

If delivery is not made within 48 hours of the scheduled delivery date, the owners name will be placed on the waiting list and the owner will be notified. If an owner has more than one mobile home, they will be rotated with others on the waiting list.

2.2 Waste Disposal

All mobile homes must be free of garbage, household hazardous waste, and all other non-construction and demolition waste prior to acceptance by the landfill.

2.3 White Goods

White goods will be accepted with the mobile home. White goods will be removed and handled in accordance with all State and Federal regulations. Any white goods

containing CFC's will have them managed properly prior to removal of the white goods and deconstruction of the mobile home.

2.4 Asbestos

Since asbestos may be located in the building materials of mobile homes constructed prior to 1983, all mobile homes built before 1/1/1983 will be thoroughly sprayed with water (both interior and exterior) to minimize dust. Upon demolition of a mobile home constructed prior to 1983, the waste generated will be placed in the C&D landfill and covered with six inches of soil or approved alternate cover.

2.5 Deconstruction of Mobile Homes

Once accepted, the mobile home will be placed in the mobile home deconstruction area. Mobile home deconstruction will be dependant upon weather conditions and manpower availability and will ONLY take place in the deconstruction area. Prior to deconstruction, mobile homes constructed before 1983 will be thoroughly sprayed with water to minimize dust (as noted above). The home will then be deconstructed using a track-hoe. The track-hoe will tear the trailer apart and lay the pieces on the ground to be separated by landfill personnel. The personnel will separate the non-recyclable materials from the recyclable materials. Initially, scrap metal is planned for recycling. As other end-users for other materials are available, other materials may be separated for recycling. All material not planned for recycling will be placed in the C&D landfill before the end of the day in which the deconstruction takes place. Material from mobile homes constructed prior to 1983 will be covered prior to the end of the day. All recyclable materials will be stockpiled in the deconstruction area for future recycling. **NO OPEN FLAMES OR CUTTING WITH TORCHES WILL BE ALLOWED WITHIN 100 FEET OF THE C&D LANDFILL.**

2.6 Holding Time for Mobile Homes

All mobile homes must be deconstructed within 45 days from acceptance into the deconstruction area. Upon receipt at the landfill, the date shall be painted on the side or end of the mobile home, or on the frame, for identification purposes for Solid Waste Section personnel.

2.7 Holding Time for Recyclables

Once a recyclable material is removed from a mobile home, it may be stockpiled in the mobile home deconstruction area for up to 45 days. No materials shall be kept in this area for more than 45 days, nor shall they be stockpiled in other areas awaiting recycling.

3.0 RECORD KEEPING PROGRAM

The County shall maintain the following records related to the Mobile Home Deconstruction in an operating record at the landfill (see also **Section 1.14** of the Operations Manual):

A. Mobile Home Acceptance records including dates and description;
B. Owner and hauler information for each mobile home;
C. Date of deconstruction for each mobile home and materials to be recycled;
D. Date and disposal information for all recycled materials ton include location and vendor of recipient of recycled materials.
E. Date and certification of CFC's removed.

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Closure and Post-Closure Plan

Washington County C&D Landfill
Roper, North Carolina

Prepared for:

Washington County Public Utilities
Roper, North Carolina

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WASHINGTON COUNTY C&D LANDFILL

CLOSURE AND POST-CLOSURE PLAN

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SECTION 1.0
CLOSURE PLAN

1.1 OVERVIEW

This plan is intended to serve as a guide for the proposed closure. A formalized Closure Plan for each landfill unit (or incremental portion thereof) will be submitted to the Solid Waste Section of the North Carolina Department of Environment and Natural Resources Division of Waste Management (DWM) for approval prior to beginning closure construction.

1.2 MAXIMUM CLOSURE AREA AND WASTE CAPACITY

The following are the estimated areas and capacity for each C&D landfill unit to be closed under this plan.

Landfill Unit	Closure Area (Acres)	Gross Capacity (CY)[1]	Net (Waste) Capacity (CY/Tons)[1]
Phase 1	2.34	45,000	40,500 CY 19,777 Tons
Phase 2	0.93	20,159	16,691 CY 8,346 Tons
Total:	3.27	65,159	57,191 CY 28,123 Tons

Notes:
1. The volume and tonnage figures assumed for each landfill unit are based on the Phase 2 Facility and Engineering Plan. Refer to Table 1 of the Facility and Engineering Plan (**Attachment A**).

1.3 FINAL COVER SYSTEM

The components of the final cover system will consist of the following components (top-down):

Alternative Final Cover System (.0543 (c) (3)):

Top Slopes (Typically 5 to 10%):
- an 18-inch thick vegetative soil layer;
- a drainage geocomposite;
- a 30-mil textured LLDPE geomembrane or geosynthetic clay liner (GCL); and
- a 12-inch thick intermediate cover layer.

Side Slopes (Typically 4H:1V):

- a 24-inch thick vegetative soil layer.

The final cover system will be placed at a maximum slope of 4H:1V. Surface water control devices and landfill gas (LFG) wells/vents will also be incorporated into the final cover. The final cover surface will be vegetated upon completion of the final cover installation according to the project seeding specifications.

Technical specifications and construction quality assurance requirements for final cover system components can be found in **Attachments B and C**, respectively. Final cover system details are shown on **Drawings D1 and D2** (Details).

Placement of the vegetative soil layer over the cover geosynthetics must be done with care to avoid damage to these materials. This soil layer should be placed from the bottom up using a small dozer equipped with low ground contact pressure (6 psi or less) tracks. A minimum of 12 inches of soil should be maintained between the dozer tracks and the underlying geosynthetics. The soil buffer should receive no compaction other than that provided by the dozer tracks. Pans or other heavy equipment should not operate on the vegetative soil layer.

1.4 LANDFILL GAS SYSTEM

A landfill gas (LFG) system is provided in the final cover design. This system includes four collection wells or vents placed within the waste to capture and passively vent the gas. The collection wells or vents should be placed before any geosynthetics are placed. The location of LFG wells/vents are shown on **Drawing S3** (Site Development Plan - Final Cover Grading and Drainage).

1.5 SURFACE WATER SYSTEMS

Precipitation falling on the cover will infiltrate into the cover or run off the cover. Short-term the run-off runs down the surface of the intermediate cover. Long-term the run-off is collected in a series of drainage breaks built into the areas covered by final cover. These drainage breaks are provided along side slopes (side slope swales) and near the upper edge of the side slopes (cap diversion berms). Water captured by side slope swales or diversion berms is routed toward one of the down pipes. Flow in the down pipes is routed to the base of the landfill and to one of the site basins.

The locations of side slope swales, diversion berms, and down pipes are shown on **Drawing S3** (Site Development Plan - Final Cover Grading and Drainage).

1.5.1 Incremental Operation

During much of the life of the landfill, surface run-off will be handled by the intermediate cover system. Operations must strive to provide operational grading that encourages run-off from the intermediate cover to drain to the perimeter channels along the perimeter

berms or to areas covered by final cover. Corrugated polyethylene (CPE) piping and temporary soil berms may be installed if required to accomplish this run-off routing.

1.5.2 Required Maintenance

The surface water systems must be inspected annually and immediately after every major storm. Sediment build-up in the drainage features/devices must be cleaned out on a regular basis to promote run-off. Sediments removed can be used as periodic cover.

1.6 CLOSURE SCHEDULE

In general, closure activities will occur on the following schedule:

C&D Landfill Unit (15A NCAC 13B.0543(c)(5)):

- No later that 30 days after the date on which the C&DLF unit receives the known final receipt of wastes;
- No later than 30 days after the date that a 10 acre or greater area of waste, is within in 15 feet of final design grades; or
- No later than one year after the most recent receipt of wastes, if the C&DLF unit has remaining capacity.

Prior to beginning closure of any landfill unit, the County with notify the DWM that a notice of the intent to close the unit has been placed in the operating record.

All closure activities shall be completed within 180 days. Exemptions and extensions may be approved by the DWM.

1.7 CLOSURE VERIFICATION

The following procedures will be implemented following closure:

- A Construction Quality Assurance (CQA) report will be submitted to the DWM. This report will describe the observations and tests used before, during, and upon completion of construction to ensure that the construction materials meet the final cover design specifications and the construction and certification requirements. The CQA report will contain as-built drawings.
- A signed certification from a registered Professional Engineer verifying that closure has been completed in accordance with the closure plan will be submitted to the DWM.
- At least one sign notifying all persons of the closing of the landfill (or incremental

portions thereof) and that wastes are no longer accepted will be posted. Suitable barriers will be installed as necessary at former access points to prevent new waste from being deposited.

- Within 90 days, a survey plat, prepared by a registered Professional Land Surveyor, indicating the location and dimensions of landfill disposal areas, will be prepared.

- A notation will be recorded on the deed (through the County Register of Deed's Office) notifying any potential purchaser of the property that the land has been used as a landfill facility and that future use is restricted under the approved closure plan. A copy of the deed notation as recorded will be filed with the operating record and notification will be provided to the DWM.

SECTION 2.0
POST-CLOSURE PLAN

2.1 OVERVIEW

This Post-Closure Plan has been developed to outline steps to be taken to ensure the integrity of the landfill during its post-closure care period. The post-closure care period will last at least 30 years after final closure and, at a minimum, will consist of the following:

- Maintaining the integrity and effectiveness of final cover system;
- Performing groundwater and surface water monitoring; and
- Maintaining run-on/run-off controls.

No wastes will remain exposed after closure of the landfill. Access to the closed site by the public will not pose a health hazard.

2.2 POST-CLOSURE CONTACT

All correspondence and questions concerning the post-closure care of the landfill should be directed to:

Washington County Department of Public Utilities
396 Millpond Road
Roper, NC 27970
Phone: (252) 793-7545.

2.3 POST-CLOSURE USE

After filling operations cease at the landfill and the landfill is officially closed in accordance with the Closure Plan, the landfill will be maintained as a grassy hill. Washington County will maintain control of the property and prevent public access to it during the post-closure period.

There may be (an) access road(s) on the final cover to allow proper maintenance during post-closure. Precise location of the access road(s) will be determined as a part of operations. Low ground pressure and rubber tire vehicles will be used for maintenance. Additionally, the County will maintain access to all site monitoring locations through the post-closure period.

2.4 MAINTENANCE

2.4.1 <u>Repair of Security Control Devices</u>

All security control devices will be inspected and maintained as necessary to ensure access to the site is controlled. Locks, vehicular gates, and fencing will be replaced if

functioning improperly. Warning signs will be kept legible at all times and will be replaced if damaged by inclement weather or vandalism.

2.4.2 Erosion Damage Repair and Vegetation

If erosion of the final cover occurs during post-closure, the affected area will be repaired and revegetated as necessary. If necessary, rolled erosion control products (RECPs) will be used to expedite rapid revegetation of slopes and to secure topsoil in place. Revegetation (including fertilization and seeding) will be performed in accordance with the most recently approved erosion and sedimentation control plan and the North Carolina Erosion and Sediment Control Planning and Design Manual.

Mowing of the final cover surfaces will occur approximately once per year in order to help maintain a healthy stand of grasses and to cut down saplings and woody-stemmed plants.

2.4.3 Correction of Settlement, Subsidence, and Displacement

Minimum slopes of 5 percent will be maintained after settlement in order to prevent ponding and allow for proper drainage without infiltration. If vertical or horizontal displacement occurs due to differential settlement, cracks will be filled with appropriate material and final cover will be reestablished. Excessive vertical displacement is not anticipated.

2.4.4 Leachate Seeps

If evidence of leachate seeps is observed, the County will take the following actions. Depending on the circumstances, various combinations of actions may be appropriate.

1. If leachate is observed outside of the limits of waste disposal areas, notify the DWM.
2. Contain the flow of leachate using soil berms and/or excavation.
3. Excavate the area of seepage to attempt to allow flow into the underlying waste (i.e. break-up soil layers that may be causing the seep.).
4. For contained leachate that will not flow into underlying waste, a pump may be required to route the leachate to a tanker truck.
5. The use of soil (particularly clay) to plug the seepage may also be successful in the case where flows are minor.
6. Remove and dispose of impacted cover soils accordingly.
7. Repair landfill cover as necessary.

2.4.5 Repair of Run-On/Run-Off Control Structures

All drainage swales, ditches, and perimeter channels will be repaired, cleaned, or realigned in order to maintain their original condition. Any culverts that are damaged

will be repaired or replaced. Sediment basins/ponds will be cleaned out when sediment has reached design cleanout levels.

2.4.6 Landfill Gas System

The landfill gas system will be maintained by the County and operated in accordance with any site air quality permits.

If gas wells/vents do not function as a result of irregular settlement, accumulation of liquids (condensate, leachate, water), binding or corrosion, additional and/or replacement wells/vents can be installed if necessary.

2.4.7 Groundwater Monitoring Wells

Procedures outlined in the current Water Quality Monitoring (WQM) Plan or subsequent revision will take precedence; however, a brief description follows. All groundwater monitoring wells have been installed with concrete pads and protective casings to prevent accidental damage by vehicles and equipment. The wells are also equipped with a locking cap to discourage vandalism. Groundwater wells will be inspected regularly (at the time of sampling) to ensure integrity. Persons inspecting a well should look at the overall condition of the well, for signs of well tampering, and cracking or degradation of the concrete pad. Should a well require replacement, the defective well should be abandoned in accordance with specifications provided in the WQM Plan and a new well installed at a location that is approved by the DWM.

2.5 MONITORING PLAN

The closed unit will be monitored for a minimum of 30 years. Inspections of the closed landfill will be scheduled to ensure the integrity and effectiveness of the final cover system, surface water systems, groundwater monitoring system, landfill gas system, and to protect human health and the environment.

2.5.1 Inspection Frequencies

Inspections to be conducted by the County during the post-closure care period will occur regularly as shown in **Table 2.1**.

2.5.2 Inspection Activities

Inspections will include examination of the security control devices for signs of deterioration or vandalism to ensure access to the site is limited to authorized persons. Each disposal area will be checked to ensure the integrity of the final cover system is maintained, erosion damage is repaired, vegetative cover persists, and that cover settlement, subsidence, and displacement are minimal. Additionally, the condition of the groundwater monitoring system and permanent benchmarks will be checked.

A report of findings will be made to the responsible party, including recommendations for actions deemed necessary to ensure the site continues to meet the closure performance standard.

2.5.3 Record Keeping

Records of inspections and repairs will be kept on file by the County throughout the post-closure period.

2.6 ENGINEERING CERTIFICATION

Following completion of the post-closure care period, the County will notify the DWM that a certification, signed by a registered professional engineer, verifying that post-closure care has been completed in accordance with the post-closure plan, has been placed in the operating record.

TABLE 2.1: POST-CLOSURE INSPECTION FREQUENCIES

INSPECTION ACTIVITY	YEAR 1	YEARS 2-30
Security Control Devices	Quarterly	Quarterly
Vegetative Cover Condition	Quarterly[1]	Quarterly
Surface Water Systems	Quarterly[1]	Quarterly
Erosion Damage	Quarterly[1]	Quarterly
Cover Drainage System	Quarterly[1]	Semi-Annually
Cover Settlement, Subsidence, and Displacement	Quarterly[1]	Semi-Annually
Landfill Gas Wells/Vents	Quarterly[3]	Semi-Annually[3]
Groundwater Monitoring System	Semi-Annually	Semi-Annually[2]
Benchmark Integrity	Annually	Annually

Notes:
1. These items will be inspected after each large storm event (i.e. $\geq$ 1 inch in any 24 hours).
2. Or in accordance with groundwater monitoring schedule described in the current Water Quality Monitoring Plan.
3. Or in accordance with the current air quality permit(s), if applicable.

SECTION 3.0
CLOSURE/POST-CLOSURE COST ANALYSIS

3.1 OVERVIEW

The purpose of this section is to provide a written estimate in current dollars of costs associated with all activities specified in the written closure and post-closure plans which have been developed for the Washington County C&D Landfill.

3.2 ESTIMATED CLOSURE COSTS

Table 3.1 summarizes the estimated costs for complete closure of Phases 1 and 2 of the C&D landfill (the maximum area to be closed). The cost estimate is based on a third party providing the necessary services and includes labor in the unit prices given. The estimated closure costs will be reviewed and updated as required to reflect adjustments for inflation, increased costs in construction or materials, or any other adjustments to the Closure Plan.

3.3 ESTIMATED POST-CLOSURE COSTS

Table 3.2 summarizes the estimated costs for the post-closure care maintenance activities for Phases 1 and 2 of the C&D landfill. The cost estimate is based on a third party providing the necessary services and includes labor in the unit prices given. The estimated post-closure costs will be reviewed and updated as required to reflect adjustments for inflation, rising costs of anticipated post-closure care, or any other adjustments to the Post-Closure Plan.

3.4 FINANCIAL ASSURANCE MECHANISM

Washington County intends to continue to use the Local Government Financial Test (15A NCAC 13B.1628(e)(1)(f)) to demonstrate financial assurance for this facility.

TABLE 3.1: CLOSURE COST ESTIMATE[1]

ITEM	QUANTITY[2]	UNITS	UNIT COST	ITEM COST (2010 $)
Surface Preparation	3.3	Acre	$2,000	$6,600
Landfill Gas System	3.3	Acre	$3,000	$9,900
30 mil Textured LLDPE Geomembrane or Geosynthetic Clay Liner (GCL) (0.8 Ac.)	35,000	SF	$0.50	$17,500
Drainage Geocomposite (0.8 Ac.)	35,000	SF	$0.50	$17,500
Vegetative Soil Layer (24")	10,650	CY	$4.00	$42,600
Erosion Control (Diversion Berms, Down Pipes, Drainage Channels, Etc.)	3.3	Acre	$5,000	$16,500
Revegetation	3.3	Acre	$1,500	$4,950
Surveying	3.3	Acre	$2,000	$6,600
			Subtotal:	$122,150
Bonds, Mobilization, & Insurance			(4% of Subtotal):	$4,886
			Subtotal:	$127,036
			Contingency (10%):	$12,704
			Construction Subtotal:	**$139,740**
Engineering	3.3	Acre	$2,000	$6,600
CQA	3.3	Acre	$5,000	$16,500
			TOTAL:	**$162,840**

Notes:

1. Assumes closure of 3.3 acres (Phases 1 and 2).
2. Estimated quantities shown are in-place quantities.

TABLE 3.2: POST-CLOSURE COST ESTIMATE[1]

ITEM	QUANTITY	UNIT	UNIT COST	TOTAL (2010 $)
Site Inspection And Record Keeping	60	HR	$75	$4,500
Revegetation (5% Total Area)	0.3	Acre	$1,500	$450
Mowing (once per year)	3.3	Acre	$150	$495
Erosion Control	1	LS	$2,500	$2,500
Gates/Fences/Access	1	LS	$1,500	$1,500
Groundwater/Surface Water Monitoring & Reporting (4 Long-Term Wells/Points - Semi-Annual)	2	Event	$3,600	$7,200
			Subtotal:	$16,645
			Contingency (10%):	$1,665
			ANNUAL TOTAL:	**$18,310**
			30-YEAR TOTAL:	**$549,300**

Notes:

1. Assumes post-closure of 3.3 acres (C&D Phases 1 and 2).

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Erosion and Sedimentation Control Plan

Washington County C&D Landfill
Roper, North Carolina

Prepared for:

Washington County Public Utilities
Roper, North Carolina

January 2010

RICHARDSON SMITH GARDNER
ENGINEERING & GEOLOGICAL
14 N. BOYLAN AVENUE
RALEIGH, NORTH CAROLINA 27603
NC LIC. NO. C-0828 (ENGINEERING)

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WASHINGTON COUNTY C&D LANDFILL

EROSION AND SEDIMENTATION CONTROL PLAN

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APPENDICES
- Appendix A Erosion and Sedimentation Control Calculations
- Appendix B Erosion and Sedimentation Control Technical Specifications (see **Attachment B**)
- Appendix C Erosion and Sedimentation Control Plans and Details (see **Attachment G**)

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WASHINGTON COUNTY C&D LANDFILL

EROSION AND SEDIMENTATION CONTROL PLAN

1.0 NARRATIVE

1.1 Project Description

Washington County plans to construct Phase 2-6 of their C&D landfill at their existing landfill facility located off of Landfill Road near Roper. The construction and operation of the landfill will require the disturbance of approximately 14.3 acres which were previously permitted. This plan discusses erosion and sedimentation control measures used both initially and long-term on this project.

1.2 Contact Information

1.2.1 Engineer: For questions regarding this erosion and sedimentation control plan, please contact the following:

Richardson Smith Gardner & Associates, Inc.
Attn.: Pieter K. Scheer, P.E.
14 N. Boylan Ave.
Raleigh, NC 27607
Phone: (919) 828-0577
Fax: (919) 828-3899.

1.2.2 Owner: The owner of the site and the person to contact should sediment control issues arise during the land-disturbing activity is as follows:

Washington County Landfill
Attn.: Carl Critcher, Landfill Operator
718 Landfill Road
Roper, NC 27970
Phone/Fax: (252) 793-5615.

1.3 Existing Site Conditions

The proposed landfill expansion occupies a portion of a previously approved active borrow area. Existing ground surface elevations vary from approximately El. 28 (feet) at the top of the active landfill, decreasing to El. 4 to 5 in previously borrowed areas. Currently, portions of the site have been cleared for previously permitted borrow activities and portions remain wooded.

1.4 Adjacent Areas

The proposed site lies within County landfill property on all sides. To the north, east, and south of the clearing limits are low lying areas and wetlands. To the west is the County's current yard waste processing area and an open grass-covered field which is a designated site for handling disaster debris.

1.5 Site Soils Information

Within the proposed site, the soil is classified as Conetoe Loamy Fine Sand. The surficial soil in areas previously used for borrow soil consist of fairly clean fine sand. Borrow soils to be used as structural fill, etc. will come from either on or off-site borrow areas and will generally consist of sand (SW, SP, SM, or SC based on the Unified Soil Classification System). For purposes of runoff calculations soils were assumed to be in hydrologic soil group (HSG) "A".

2.0 DESIGN GUIDELINES AND PROCEDURES

The erosion and sediment control design for the landfill was conducted based on guidelines and procedures as set forth in the following references:

1. HydroCAD Software Solutions, LLC (2006), HydroCAD Stormwater Modeling System Owner's Manual - Version 8, Chocorua, NH.

2. North Carolina Division of Land Resources (2009 Update), North Carolina Erosion & Sediment Control Planning & Design Manual, Raleigh, NC.

3. Malcom, H. Rooney (1989 & 2003 Supplement), Elements of Urban Stormwater Design, NC State Univ., Raleigh, NC.

All stormwater flow volumes were calculated using the HydroCAD computer program (utilizing USDA-NRCS (SCS) methods) and/or the Rational Method based on at least the 25-year 24-hour storm event. This storm event, which is a requirement of current North Carolina solid waste regulations, exceeds the 10-year event required by current North Carolina Sediment Control regulations. Rainfall quantities and/or intensities used in the analyses were derived from an analysis of design storms for the site. Drainage areas were determined using a planimeter and/or AutoCAD on topographic sheets of the project area. For each drainage area, runoff curve numbers (SCS methods) and/or runoff coefficients (Rational Method) were selected based on ground cover conditions. Times of concentration were assumed as shown in the calculations.

3.0 EROSION AND SEDIMENTATION CONTROL MEASURES

The following erosion and sedimentation control measures are to be constructed as part of the initial and final construction of the landfill. Appendices A, B, and C to this plan include calculations, technical specifications, and plans and details for each of these measures,

respectively.

The following erosion and sedimentation control measures were designed using the final drainage areas which were found to represent a worst case for design.

3.1 Infiltration Basins

Three permanent infiltration basins will be located around the perimeter of the borrow area. Due to the presence of fairly clean sands, low areas of the site previously borrowed have been performing well in this fashion to date with little to no ponding occurring after rain events. The location of the basins is such that drainage is directed away from the landfill. Due to the infiltration potential of the borrow area as a whole, the fairly minimal runoff from the landfill should be easily handled.

3.2 Drainage Channels

Drainage channel calculations were conducted using a reformulation of Manning's Equation in a spreadsheet format. The calculations determine the normal depth of flow based on the peak discharge from the design storm (from HydroCAD) and assumed channel dimensions/slope(s). Both temporary and/or permanent channel linings were chosen, as appropriate, based on the calculated velocity and/or shear stress. Temporary channel linings (if specified) were designed based on the peak discharge from a 2-year 24-hour design storm.

3.3 Silt Fence

Silt fencing design was based on criteria set forth in E&SCP&DM, Section 6.62 including the limitation of 100 feet of fencing for each ¼ acre of drainage area. Silt fencing is shown wherever drainage is not directed to one of the infiltration basins.

3.4 Vegetative Stabilization

Vegetative stabilization will be in accordance with the seeding schedule in the project specifications (provided as an attachment to this plan). The seeding schedule was based on Table 6.11p of E&SCP&DM which is applicable to this site.

3.5 Cap Diversion Berms and Side Slope Swales

Cap diversion berms and side slope swales are to be placed along final cover side slopes to limit flow distances and to direct flow to one of the down pipes. The capacity and erosion potential of these swales was checked using the reformulation of Manning's Equation from EOUSD as stated above for design flows.

3.6 Down Pipes

Down Pipes were designed based on an analysis of inlet and outlet control under the influence of the design storm to determine the governing headwater condition. Down pipes will be adequately anchored to the landfill side slopes and each will be outleted to an energy dissipator at the base of the slope.

4.0 SCHEDULE FOR IMPLEMENTATION

All erosion control measures will be placed before any land disturbance or waste placement may begin in that portion of the site which drains to the erosion control measures. Vegetative stabilization of disturbed areas will be in accordance with the following requirements:

- Temporary or permanent ground cover (or other acceptable measure(s)) adequate to restrain erosion on erodible slopes or other areas will be stabilized within fifteen (15) working days or twenty-one (21) calendar days following completion of any phase of grading.

5.0 INSPECTION AND MAINTENANCE

All erosion and sedimentation control measures will be inspected at least once every seven calendar days and within 24 hours after any storm event of greater than 0.5 inches of rain per 24 hour period. A rain gauge will be maintained on the site and a record of the rainfall amounts and dates will be kept properly.

During inspections, any stormwater discharges from the site will be observed for stormwater discharge characteristics to evaluate the effectiveness of the erosion and sedimentation control measures incorporating Best Management Practices (BMPs). If visible sedimentation is leaving the disturbed limits of the site, corrective action will be taken immediately to control the discharge of sediments.

Repairs to erosion and sedimentation control measures will be made as needed and accumulated sediment removed if necessary. All sediments which are removed from erosion and sedimentation control measures will be disposed of in an approved manner at a location to be designated by the Engineer in such a manner that further erosion and sedimentation will not occur.

Appendix A

Erosion & Sedimentation Control Calculations

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WASHINGTON COUNTY C&D LANDFILL

EROSION AND SEDIMENTATION CONTROL PLAN
APPENDIX A: EROSION AND SEDIMENTATION CONTROL CALCULATIONS

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3.0 Drainage Areas and Curve Numbers

4.0 Drainage Channel Analysis
- DC-1
- Cap Diversion Berm
- Side Slope Swale

5.0 Down Pipe Analysis
- DP-1/DP-2

6.0 Infiltration Basin Analysis (HydroCAD Evaluation)

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PROJECT Washington County C&D Landfill

SUBJECT Drainage and E&SC Calculations - Overview

JOB NO. WASH-09-1
DATE 11/20/09
COMPUTED BY PKS
CHECKED BY

Objective

To design stormwater conveyance, detention, and erosion and sedimentation control measures to remove and contain stormwater flow from the design storm. The design of these measures will be based on:

- Design storm information for the site;
- Peak discharge calculations using the Rational Method and/or USDA-NRCS (SCS) Methods; and
- Stormwater routing using USDA-NRCS (SCS) or other methods.

References

Debo, T.N., and Reese, A.J. (1995), Municipal Storm Water Management, Lewis Publishers, Boca Raton, FL.

Federal Highway Administration (2001), Urban Drainage Design Manual, Hydraulic Engineering Circular No. 22, FHWA NHI-01-021, Second Ed., U.S. Dept. of Transportation, Washington, D.C.

Georgia Soil and Water Conservation Commission (2000), Manual for Erosion and Sediment Control in Georgia, Fifth Edition, Athens, GA.

HydroCAD Software Solutions, LLC (2006), HydroCAD Stormwater Modeling System Owner's Manual - Version 8, Chocorua, NH.

Malcom, H. Rooney (1989 & 2003 Supplement), Elements of Urban Stormwater Design, NC State Univ., Raleigh, NC.

North Carolina Division of Land Resources (2006), North Carolina Erosion & Sediment Control Planning & Design Manual, Raleigh, NC.

North Carolina Division of Water Quality (July 2005) Updated Draft Manual of Stormwater Best Management Practices, (Public Comment Version), Raleigh, NC.

Pennsylvania DEP Bureau of Watershed Protection (2000), Erosion and Sediment Pollution Control Program Manual.

USDA-NRCS (1992), Computer Program for Project Formulation Hydrology (TR-20).

USDA-NRCS (1986 & 1999 Update), Urban Hydrology for Small Watersheds (TR-55).

Virginia Department of Conservation and Recreation (1992), Virginia Erosion & Sediment Control Handbook, Third Edition, Richmond, VA.

D&E&SC CALCS OVERVIEW.WPD

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577

Analysis The main design criteria will be to ensure that all stormwater conveyance and detention measures will be able to accommodate the runoff from the design storm. Drainage channels, culverts, etc. were designed based on the peak discharge to each measure. Detention measures were designed based on stormwater routing methods and/or State/local criteria.

Calculations

- Peak Discharge Calculations:

- USDA-NRCS (SCS) Methods:

Use HydroCAD program to determine the peak discharge to each device or structure. HydroCAD is based on the SCS unit hydrograph procedure, which is a principal component of NRCS TR-20. Alternatively spreadsheets can be used to determine flow rates using the procedures detailed in NRCS TR-55.

- Rational Method:

$$Q = CIA \qquad \text{(Malcom Eq. I -1)}$$

where:
Q = peak discharge (cfs)
C = rational runoff coefficient
I = applicable rainfall intensity (in/hr) of storm event (based on time of concentration)
A = drainage area (acres)

- Time of Concentration:

The time of concentration for use in determining the peak discharge in the NRCS and/or Rational methods can be determined by the methods detailed in NRCS TR-55 or other methods. HydroCAD uses the NRCS methods.

- Stormwater Routing:

Stormwater routing was accomplished using the HydroCAD program, which is based on USDA-NRCS (SCS) methods. Unless otherwise specified, the unit hydrograph method was used. The storm type (i.e. Type I 24-hr., Type II 24-hr., etc.) was selected as appropriate for the project location.

Objective To compile the expected design storm depths and intensities over various return periods. These design storm values will be used in various calculations.

References Rainfall data was obtained from the following references:

Frederick, R.H., V.A. Myers, and E.P. Anciello (1977), "Five to 60-Minute Precipitation Frequency for the Eastern and Central United States," NOAA Technical Memo. NWS HYDRO-35, National Weather Service, NOAA, U.S. Dept. Of Commerce, Silver Spring, MD.

U.S. Weather Bureau (1961), "Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years," U.S. Weather Bureau Technical Paper 40.

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SHEET: 2 / 2
JOB #: WASH-09-1
DATE: 11/20/09
BY: PKS
CHKD BY:

Washington County Landfill
Analysis of Design Storms

LOCATION: **Roper, NC**

DURATION	RETURN PERIOD 2-YR P (in)	100-YR P (in)	SOURCE
5 min	0.48	0.80	NOAA HYDRO-35
15 min	1.05	1.80	NOAA HYDRO-35
60 min	1.85	3.85	NOAA HYDRO-35
2 hr to 24 hr Rainfall Events =	**USER INPUT**		USWB TP-40

DEPTH-DURATION-FREQUENCY TABLE

DURATION	RETURN PERIOD 2-YR (in)	5-YR (in)	10-YR (in)	25-YR (in)	50-YR (in)	100-YR (in)
5 min	0.48	0.55	0.60	0.68	0.74	0.80
10 min	0.82	0.94	1.03	1.17	1.28	1.39
15 min	1.05	1.21	1.33	1.51	1.66	1.80
30 min	1.44	1.75	1.97	2.30	2.55	2.80
60 min	1.85	2.32	2.65	3.12	3.48	3.85
2 hr	2.30	3.00	3.50	4.00	4.50	5.00
3 hr	2.50	3.30	3.80	4.40	5.00	5.60
6 hr	3.10	3.90	4.50	5.50	6.00	6.80
12 hr	3.60	4.70	5.50	6.50	7.10	8.10
24 hr	4.00	5.50	6.30	7.30	8.30	9.20

INTENSITY-DURATION-FREQUENCY TABLE

DURATION	RETURN PERIOD 2-YR (in/hr)	5-YR (in/hr)	10-YR (in/hr)	25-YR (in/hr)	50-YR (in/hr)	100-YR (in/hr)
5 min	5.76	6.55	7.17	8.11	8.86	9.60
10 min	4.90	5.62	6.17	7.01	7.68	8.34
15 min	4.20	4.83	5.32	6.05	6.63	7.20
30 min	2.88	3.50	3.95	4.60	5.10	5.61
60 min	1.85	2.32	2.65	3.12	3.48	3.85
2 hr	1.15	1.50	1.75	2.00	2.25	2.50
3 hr	0.83	1.10	1.27	1.47	1.67	1.87
6 hr	0.52	0.65	0.75	0.92	1.00	1.13
12 hr	0.30	0.39	0.46	0.54	0.59	0.68
24 hr	0.17	0.23	0.26	0.30	0.35	0.38

PROJECT Washington County C&D Landfill	SHEET 1 OF 2
	JOB NO. WASH-09-1
	DATE 11/23/09
SUBJECT Drainage Areas & Curve Numbers	COMPUTED BY PKS
	CHECKED BY

Objective To breakout drainage areas and associated runoff curve numbers for the drainage and erosion control plan(s). Drainage areas and runoff curve numbers will be used to determine the design flow to each stormwater conveyance and/or detention measure. Areas were measured by planimeter or AutoCAD on the attached plan drawings. Curve numbers (or runoff coefficients) are noted in each calculation.

DRAIN AREAS & CURVE NUMBERS.WPD

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577

APPROXIMATE PROPERTY LINE

6/D2 SILT FENCE

INFILTRATION BASIN (EL=3.0)

SIDE SLOPE SWALE (TYP.) 1/D2

DRAINAGE CHANNEL 4/D2

PHASE 1 C&D LANDFILL AREA

200' BUFFER

EXISTING WASTE LIMITS (APPROXIMATE)

3/D1 LANDFILL GAS WELL/VENT (TYP.)

2/D1 CAP DIVERSION BERM

CLEARING LIMITS (14.3 AC.)

GRADE TO DRAIN

PROPOSED LANDFILL AREA

DC-1

DP-2

DP-1

3

2

1

INFILTRATION BASIN (EL=3.0)

4H:1V FINAL COVER SLOPE

PHASE 1 TIRE MONOFILL AREA

3H:1V EXTERIOR BERM SLOPE

MOBILE HOME DECONSTRUCTION AREA

GRADE TO DRAIN

2/D2 DOWN PIPE (TYP.)

5/D2 PRECAST ENERGY DISSIPATOR (TYP.)

WETLANDS BOUNDARY AREA (TYP.)

INFILTRATION BASIN (EL=3.0)

DP-1 → 0.41 Ac
DP-2 → 0.79 Ac
DC-1 → 0.59 Ac
1 → 3.01 Ac
2 → 4.03 Ac
3 → 2.99 Ac

2/2

LEGEND

150	EXISTING 10' CONTOUR (SEE REFERENCE 1)
	EXISTING 2' CONTOUR
10	PROPOSED 10' CONTOUR
6	PROPOSED 2' CONTOUR
3	PROPOSED 1' CONTOUR
	APPROXIMATE PROPERTY LINE
	APPROXIMATE EXISTING WASTE LIMITS
	PROPOSED LANDFILL AREA
	200' PROPERTY OFFSET BUFFER
	SIDE SLOPE SWALE
CDB	CAP DIVERSION BERM
DP-1	DOWN PIPE
	WETLANDS BOUNDARY AREA (SEE REFERENCE 1)
DC-1	DRAINAGE CHANNEL
X	SILT FENCE
CD-1	MONITORING WELL
CM	EXISTING CONCRETE MONUMENT
B-6	SOIL BORING (SAME, 1994)
B-1	EXISTING PIEZOMETER (SAME 1994)
	PROPOSED LANDFILL GAS WELL OR VENT

NOTES

1. THE TIRE MONOFILL IS NO LONGER USED BY THE COUNTY. THIS AREA WAS PREVIOUSLY INCORPORATED INTO THE C&D LANDFILL FOOTPRINT.
2. 100-YEAR FLOODPLAIN IS AT ELEVATION 7.0.

REFERENCES

1. OVERALL SITE BASE TOPOGRAPHY WETLAND, STREAM, AND DITCH BOUNDARIES PROVIDED BY SANBORN, BASED ON MARCH 28, 2006 AERIAL SURVEY.
2. COORDINATE SYSTEM IS STATE PLANE GRID.
3. SITE PROPERTY LINE OBTAINED FROM DRAWING "PROPOSED GULF CAP SECTION" BY THE WOOTEN COMPANY, DATED DECEMBER 2004.
4. WELL LOCATIONS OBTAINED FROM FROM THE WASHINGTON COUNTY LANDFILL MONITOR WELL SURVEY REPORT DATED APRIL 24, 2009.
5. FLOODPLAIN INFORMATION FROM NC FIRM MAP NO. 3720078400L

0 50' 100' 150'

WASHINGTON COUNTY

PROJECT TITLE:

DRAWING TITLE:

DESIGNED BY: PKB

CHECKED BY:

SCALE: AS SHOWN

FILE NAME:

SHEET NO. 4

SEAL

DATE

NO.

REVISION

PROJECT Washington County C&D Landfill

SUBJECT Drainage Channel Analysis

JOB NO. WASH-09-1
DATE 11/20/09
COMPUTED BY PKS
CHECKED BY

Objective

To design drainage channels, ditches, etc. to handle stormwater flow from the design storm(s). The main design criteria will be to ensure that all drainage channels, ditches, etc. will be able to accommodate the peak discharge from the design storm without overtopping and without exceeding the allowable shear stress and/or velocity of the selected channel lining.

References

Federal Highway Administration (2001), Urban Drainage Design Manual, Hydraulic Engineering Circular No. 22, FHWA NHI-01-021, Second Ed., U.S. Dept. of Transportation, Washington, D.C.

North Carolina Division of Land Resources (2006), North Carolina Erosion & Sediment Control Planning & Design Manual, Raleigh, NC.

Malcom, H. Rooney (1989 & 2003 Supplement), Elements of Urban Stormwater Design, NC State Univ., Raleigh, NC.

Pennsylvania DEP Bureau of Watershed Protection (2000), Erosion and Sediment Pollution Control Program Manual.

Analysis

The following approach is used in the design of drainage channels:

1. Determine the peak discharge from the design storm(s) (from HydroCAD or spreadsheet methods). For permanent linings (Grass, TRM, rip rap, gabions, etc.) use the peak discharge from the 25-Yr 24-Hr storm unless otherwise specified. For grass lined channels, a smaller design storm (2-Yr 24-Hr - unless otherwise specified) is used to evaluate temporary linings.
2. Input other design parameters (bottom width; side slopes; minimum freeboard, min./max. slopes; and channel lining).
3. Based on the design parameters calculate normal depth of flow, velocity, Froude number, and maximum shear stress for both max./min. slopes. Also determine the critical slope and corresponding normal depth.
4. Compare the velocity and/or shear stress to allowable values (the maximum slope values will control). If values are exceeded, revise design parameters as required.
5. Based on normal depth values and required freeboard (generally use the greater of 6 inches or 25% of the flow depth), determine the minimum channel depth and top width for both max./min. slopes (the minimum slope values will control).
6. If the channel has a significant curved reach, evaluate the shear stress and superelevation of the water surface in the bend.

DRAINAGE CHANNEL.WPD

Calculations

- Manning's Equation:

$$Q = \frac{1.49\,AR^{2/3}S^{1/2}}{n} = AV \qquad \text{(HEC-22 Eq. 5-5)}$$

where:
- Q = discharge (cfs)
- n = Manning's roughness coefficient (See Below)
- A = cross sectional area of flow (ft^2)
- R = hydraulic radius (ft) = A/P
- P = wetted perimeter
- S = slope of channel (ft/ft)
- V = average channel velocity (ft/sec)

- Maximum Shear Stress (Tractive Force Method):

$$\tau_d = \gamma d S \qquad \text{(HEC-22 Eq. 5-13)}$$

where:
- τ_d = maximum shear stress on channel lining (lb/ft^2)
- γ = unit weight of water (62.4 lb/ft^3)
- d = maximum depth of flow (ft)
- S = channel slope (ft/ft)

- Froude Number:

$$Fr = \frac{v}{\sqrt{\frac{gA}{T}}}$$

where:
- Fr = Froude number (dimensionless)
- v = flow velocity (ft/sec)
- g = acceleration of gravity (32.2 ft/sec^2)
- A = cross-sectional area of flow (ft^2)
- T = top width of flow (ft)

Note that A/T = the hydraulic depth (D). For $Fr > 1.0$, flow is supercritical; $Fr < 1.0$, flow is subcritical; $Fr = 1.0$, flow is critical.

Critical Slope:

The critical slope (S_c) is the slope at which $Fr = 1.0$. When the slope is between $0.7S_c$ and $1.3S_c$, unstable flow may occur as small flow disturbances can initiate a change in the flow state. If slopes are within this range, consider additional freeboard.

- Manning's Roughness Coefficient (n):

Grass:

$$n = \frac{R^{1/6}}{\left[K + 19.97\log\left(R^{1.4}S^{0.4}\right)\right]}$$ (HEC-22 Eq. 5-6 - 5-10)

where:
R = hydraulic radius (ft)
K = vegetative coefficient (depending on retardance class)
= 15.8 (Class A)
= 23.0 (Class B)
= 30.2 (Class C)
= 34.6 (Class D)
= 37.7 (Class E)
S = slope of channel (ft/ft)

Rip Rap:

$$n = \frac{y^{1/6}}{21.6\log\left(\frac{y}{d_{50}}\right) + 14}$$ (PA DEP Manual Fig. 3)

where:
y = depth of flow (ft)
d_{50} = median size of rip rap (ft)

- Curved Channels (Where Applicable):

Shear Stress in Bend:

$$\tau_b = K_b \tau_d \qquad \text{(HEC-22 Eq. 5-15)}$$

where:
τ_d = bend shear stress (lb/ft^2)
K_b = function of R_c/B (use HEC-22 Chart 21)
τ_d = maximum shear stress on channel lining (lb/ft^2)
R_c = radius to the centerline of the channel (ft)
B = bottom width of channel (ft)

Superelevation at Outside of Bend:

$$\Delta d = 0.5\frac{V^2 T}{gR_c} \qquad \text{(HEC-22 Eq. 5-11 modified)}$$

where:
Δd = superelevation of water surface between the outer channel bank and the centerline of the channel (avg. water surface before bend) (ft)
V = average channel velocity (ft/sec)
T = top width of flow (ft)
g = acceleration of gravity (32.2 ft/sec^2)
R_c = radius to the centerline of the channel (ft)

- Allowable Shear Stress/Velocity:

Grass-Lined Channels:

For grass-lined channels, an allowable velocity approach is applicable for slopes flatter than 10%. For slopes of 10% and steeper appropriate permanent linings should be used. For use in the evaluation of curved channels, the following allowable shear stress values (lb/ft^2) can be assumed based on retardance class:

Class A: 3.70
Class B: 2.10
Class C: 1.00
Class D: 0.60
Class E: 0.35

Rip Rap-Lined Channels:

For rip rap-lined channels, an allowable velocity approach is applicable for slopes flatter than 10% (see attached table). For slopes of 10% or steeper, use the following equation:

$$\tau_{allow} = 4 \times d_{50} \qquad \text{(HEC-22 Eq. 5-17)}$$

where: τ_{allow} = allowable shear stress (lb/ft^2)
d_{50} = median size of rip rap (ft)

Reno Mattress or Gabion-Lined Channels:

For Reno mattress or gabion-lined channels, use allowable velocity for slopes flatter than 10% and allowable shear stress for slopes of 10% or steeper (see attached table).

Riprap Gradation, Filter Blanket Requirements, Maximum Velocities

	Graded Rock Size (in)			Filter Blanket Requirements**		
NSA No.	Max.	d_{50}*	Min.	Size NSA No.	Placement Thickness	V_{max} (ft/sec)
R-1	1.5	75	No. 8	FS-1	N/A	2.5
R-2	3	1.5	1	FS-1	N/A	4.5
R-3	6	3	2	FS-1	3	6.5
R-4	12	6	3	FS-2	4	9.0
R-5	18	9	5	FS-2	6	11.5
R-6	24	12	7	FS-3	8	13.0
R-7	30	15	12	FS-3	10	14.5

* The d_{50} stone size is the size exceeded by 50% of the total weight of the tonnage shipped (i.e. 50% by weight shall consist of pieces larger than the d_{50} stone size")

** This is a general standard. Soil conditions at each site should be analyzed to determine actual filter size. A suitable woven or non-woven geotextile underlayment, used according to manufacturer's recommendations, may be substituted for the filter stone

Ref: PA DEP Manual Table 9

Maximum Permissible Velocities for Reno Mattress & Gabions

Type	n	Thickness Inches	Rock Fill Gradation (in)	Permissible* Velocity (fps)	Permissible** Shear Stress (lb/ft^2)
Reno Mattress	.025 - .030	6	3 - 6	6.0	8.35
	.025 - .030	6 - 10	3 - 6	12.0	8.35
	.025 - .030	10 - 12	3 - 6	15.0	8.35
	.025 - .030	12 - 18	4 - 6	18.0	8.35
Gabion	.027	>18	5 - 9	22.0	8.35

* Permissible velocities may be increased by the introduction of sand mastic grout. Refer to manufacturer's recommendations/specifications for permissible velocities and for recommendations regarding filters or geotextile fabric underlayment when using Reno mattresses or gabions for channel linings

**Based on vegetation completely grown

Ref: PA DEP Manual Table 13

RICHARDSON SMITH GARDNER & ASSOCIATES
[redacted]
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Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 68
JOB #: WASH-09-1
DATE: 11/23/09
BY: PKS
CHKD BY:

Washington County C&D Landfill
Drainage Channel Analysis (Grass Lined)

Channel No. DC-1

Design Parameters:

PEAK DISCHARGE, Q2 = 2.0 ft^3/s Source: Estimated
PEAK DISCHARGE, Q25 = 4.0 ft^3/s Source: Q = CIA = 0.35 x 8.11 x 1.4 Ac. (25 Yr. - 5 Min. Storm)

Bottom Width, B = 8.0 ft
Left Side Slope, z_1 = 3.0 horizontal :1 vertical
Right Side Slope, z_2 = 3.0 horizontal :1 vertical
Minimum Freeboard = 0.5 ft

Maximum Channel Slope, S_{max} = 0.020 ft/ft
Minimum Channel Slope, S_{min} = 0.005 ft/ft

Permanent Grass Lining:
Grass Retardance = D
K = 34.6
V_{allow} = 4.0 ft/sec
τ_{allow} = 0.60 lb/ft^2

Bare Ground (If Temporary Liner Not Used):
Manning's Coefficient, n = 0.020
V_{allow} = 2.0 ft/sec

Temporary Lining:
Temporary Lining Used (Y/N) = Y
RECP Product Name = NA Green - Curlex I, or equal
Manning's Coefficient, n = 0.035
τ_{allow} = 1.55 lb/ft^2

Normal Depth

Depth of Flow (Norm. Depth) Y_n ft	Manning's Roughness Coefficient n	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius $R=A/P$ ft	Top Width T ft	Hydraulic Depth $D=A/T$ ft	Average Velocity V_n ft/s	Flow Rate Q ft^3/s	Froude Number F_r (Normal) #	Maximum Shear Stress τ_d lb/ft^2	Allowable Velocity (V) or Sh. Stress (S) Used?	Factor of Safety V_{allow}/V_n or τ_{allow}/τ_d	Comment
Q2													
Maximum Slope:													
0.15	0.035	1.27	8.95	0.14	8.90	0.14	1.63	2.1	0.76	**0.2**	S	8.3	**O.K.**
Minimum Slope:													
0.22	0.035	1.91	9.39	0.20	9.32	0.20	1.04	2.0	0.40	**0.1**	S	22.6	**O.K.**
Q25													
Maximum Slope:													
0.41	0.100	3.78	10.59	0.36	10.46	0.36	1.06	4.0	0.31	**0.5**	V	3.8	**O.K.**
Minimum Slope:													
0.64	0.107	6.35	12.05	0.53	11.84	0.54	0.64	4.1	0.15	**0.2**	V	6.3	**O.K.**

Critical Depth

Depth of Flow (Crit. Depth) Y_c ft	Manning's Roughness Coefficient n	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius $R=A/P$ ft	Top Width T ft	Hydraulic Depth $D=A/T$ ft	Section Factor $Z=AD^{1/2}$ $ft^{2.5}$	Flow Rate Q ft^3/s	Average Velocity V_c ft/s	Froude Number F_r (Critical) #	Uniform-Flow Critical Slope S_c ft/ft	Comment
Q2												
0.12	0.035	1.00	8.76	0.11	8.72	0.12	0.34	1.9	1.92	1.00	0.037	**Flow is Stable.**
Q25												
0.19	0.083	1.63	9.20	0.18	9.14	0.18	0.69	3.9	2.40	1.00	0.179	**Flow is Stable.**

Determination of Minimum Channel Depth & Top Width (Based on Q25)

Maximum Slope		Minimum Slope	
Minimum Channel Depth ft	Minimum Top Width T ft	Minimum Channel Depth ft	Minimum Top Width T ft
0.91	13.46	**1.14**	**14.84**

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Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 78
JOB #: WASH-09-1
DATE: 11/23/09
BY: PKS
CHKD BY:

Washington County C&D Landfill
Drainage Channel Analysis (Grass Lined)

Channel No. Cap Diversion Berms

Design Parameters:

PEAK DISCHARGE, Q2 = 1.0 ft^3/s Source: Estimated
PEAK DISCHARGE, Q25 = 1.4 ft^3/s Source: Q = CIA = 0.35 x 8.11 x 0.5 Ac. (25 Yr. - 5 Min. Storm)

Bottom Width, B = 0.0 ft
Left Side Slope, z_1 = 10.0 horizontal :1 vertical
Right Side Slope, z_2 = 3.0 horizontal :1 vertical
Minimum Freeboard = 0.5 ft

Maximum Channel Slope, S_{max} = 0.020 ft/ft
Minimum Channel Slope, S_{min} = 0.005 ft/ft

Permanent Grass Lining:
Grass Retardance = D
K = 34.6
V_{allow} = 4.0 ft/sec
τ_{allow} = 0.60 lb/ft^2

Bare Ground (If Temporary Liner Not Used):
Manning's Coefficient, n = 0.020
V_{allow} = 2.0 ft/sec

Temporary Lining:
Temporary Lining Used (Y/N) = N
RECP Product Name = NA Green - Curlex I, or equal
Manning's Coefficient, n = 0.035
τ_{allow} = 1.55 lb/ft^2

Normal Depth

Depth of Flow (Norm. Depth) Y_n ft	Manning's Roughness Coefficient n	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius $R=A/P$ ft	Top Width T ft	Hydraulic Depth $D=A/T$ ft	Average Velocity V_n ft/s	Flow Rate Q ft^3/s	Froude Number F_r (Normal) #	Maximum Shear Stress τ_d lb/ft^2	Allowable Velocity (V) or Sh. Stress (S) Used?	Factor of Safety V_{allow}/V_n or τ_{allow}/τ_d	Comment
Q2													
Maximum Slope:													
0.30	0.035	0.59	3.96	0.15	3.90	0.15	1.68	1.0	0.76	**0.4**	V	1.2	**O.K.**
Minimum Slope:													
0.39	0.035	0.99	5.15	0.19	5.07	0.20	1.00	1.0	0.40	**0.1**	V	2.0	**O.K.**
Q25													
Maximum Slope:													
0.58	0.142	2.19	7.66	0.29	7.54	0.29	0.64	1.4	0.21	**0.7**	V	6.2	**O.K.**
Minimum Slope:													
0.80	0.172	4.16	10.57	0.39	10.40	0.40	0.33	1.4	0.09	**0.2**	V	12.2	**O.K.**

Critical Depth

Depth of Flow (Crit. Depth) Y_c ft	Manning's Roughness Coefficient n	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius $R=A/P$ ft	Top Width T ft	Hydraulic Depth $D=A/T$ ft	Section Factor $Z=AD^{1/2}$ $ft^{2.5}$	Flow Rate Q ft^3/s	Average Velocity V_c ft/s	Froude Number F_r (Critical) #	Uniform-Flow Critical Slope S_c ft/ft	Comment
Q2												
0.27	0.035	0.47	3.57	0.13	3.51	0.14	0.17	1.0	2.08	1.00	0.035	**Flow is Stable.**
Q25												
0.31	0.082	0.62	4.10	0.15	4.03	0.16	0.25	1.4	2.23	1.00	0.187	**Flow is Stable.**

Determination of Minimum Channel Depth & Top Width (Based on Q25)

Maximum Slope		Minimum Slope	
Minimum Channel Depth ft	Minimum Top Width T ft	Minimum Channel Depth ft	Minimum Top Width T ft
1.08	14.04	**1.30**	**16.90**

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SHEET: 8/8
JOB #: WASH-09-1
DATE: 11/23/09
BY: PKS
CHKD BY:

Washington County C&D Landfill
Drainage Channel Analysis (TRM Lined)

Channel No. Side Slope Swales

Design Parameters:

PEAK DISCHARGE, $Q25$ = 1.4 ft^3/s Source: Q = CIA = 0.35 x 8.11 x 0.5 Ac. (25 Yr. - 5 Min. Storm)

Bottom Width, B = 0.0 ft
Left Side Slope, z_1 = 1.5 horizontal :1 vertical
Right Side Slope, z_2 = 4.0 horizontal :1 vertical

Minimum Freeboard = 0.5 ft

Maximum Channel Slope, S_{max} = 0.050 ft/ft
Minimum Channel Slope, S_{min} = 0.010 ft/ft

Turf Reinforcement Matting (TRM) Lining:
Grass Retardance = D
K = 34.6
TRM Product Name = Propex - Landlok TRM 435, or equal
τ_{allow} = 5.0 lb/ft^2

Normal Depth

Depth of Flow (Norm. Depth) Y_n ft	Manning's Roughness Coefficient n	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius $R=A/P$ ft	Top Width T ft	Hydraulic Depth $D=A/T$ ft	Average Velocity V_n ft/s	Flow Rate Q ft^3/s	Froude Number F_r (Normal) #	Maximum Shear Stress τ_d lb/ft^2	Factor of Safety τ_{allow}/τ_d	Comment
Maximum Slope:												
0.59	0.094	0.96	3.50	0.27	3.25	0.30	1.49	1.4	0.48	**1.8**	2.7	**O.K.**
Minimum Slope:												
0.85	0.116	1.99	5.04	0.39	4.68	0.43	0.69	1.4	0.19	**0.5**	9.4	**O.K.**

Critical Depth

Depth of Flow (Crit. Depth) Y_c ft	Manning's Roughness Coefficient n	Area of Flow A ft^2	Wetted Perimeter P ft	Hydraulic Radius $R=A/P$ ft	Top Width T ft	Hydraulic Depth $D=A/T$ ft	Section Factor $Z=AD^{1/2}$ $ft^{2.5}$	Flow Rate Q ft^3/s	Average Velocity V_c ft/s	Froude Number F_r (Critical) #	Uniform-Flow Critical Slope S_c ft/ft	Comment
0.44	0.084	0.53	2.61	0.20	2.42	0.22	0.25	1.4	2.66	1.00	0.189	**Flow is Stable.**

Determination of Minimum Channel Depth & Top Width

Maximum Slope		Minimum Slope	
Minimum Channel Depth ft	Minimum Top Width T ft	Minimum Channel Depth ft	Minimum Top Width T ft
1.09	6.00	**1.35**	**7.43**

PROJECT Washington County C&D Landfill

SUBJECT Down Pipe Analysis

JOB NO. WASH-09-1
DATE 11/20/09
COMPUTED BY PKS
CHECKED BY

Objective To design down pipes to handle the peak discharge from the design storm.

Reference Debo, T.N., and Reese, A.J. (1995), Municipal Storm Water Management, Lewis Publishers, Boca Raton, FL.

Malcom, H. Rooney (1989 & 2003 Supplement), Elements of Urban Stormwater Design, NC State Univ., Raleigh, NC.

Analysis The following approach is used in the design of down pipes:

1. Determine the peak discharge from the design storm(s). Use the Rational Method.

2. For each pipe size, determine the maximum area (A), to handle the predicted peak discharge (Q) with an added factor of safety. Analyze down pipes based on partial flow to determine flow depth and velocity then compare the full flow capacity of each pipe size with the calculated peak flow rate to verify the desired factor of safety. Analyze down pipe inlets as a culverts under inlet control.

Calculations

- Down Pipe Inlets (Inlet Control):

Determine Q_{max}:

For $Z \leq D$:

$$Q_{\max} = 0.372 C_d D (Z)^{3/2}$$ (Malcom Equation III-13)

For $Z > D$:

$$Q_{\max} = 0.0437 C_d D^2 \left(Z - \frac{D}{24} \right)^{1/2}$$ (Malcom Equation III-13)

where:

Q_{max} = flow capacity of inlet (cfs)
Z = height of water above pipe invert (ft)
= allowable headwater depth (HW)
C_d = coefficient of discharge
D = inside diameter of pipe (in)

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Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577

Determine Factor of Safety (FS):

$$FS = \frac{Q_{\max}}{Q}$$

Iterate the drainage area (A) to each inlet such that $Q_{max}/Q \geq$ the desired factor of safety.

- Down Pipes:

Determine Flow Capacity of Pipe:

$$Q_{\max} = \frac{0.463 D^{8/3} S^{1/2}}{n} \qquad \text{(D\&R Equation 8.24)}$$

where:
Q_{max} = flow capacity of pipe (cfs)
D = inside diameter of pipe (ft)
S = pipe slope (ft/ft)
n = Manning's roughness coefficient

Determine Factor of Safety (FS):

$$FS = \frac{Q_{\max}}{Q}$$

Iterate the drainage area (A) to each drainage structure such that $Q_{max}/Q \geq$ the desired factor of safety.

Determine Flow Depth:

$$h = \frac{1}{2}\left(1 - \cos\left(\frac{\theta}{2}\right)\right) D \qquad \text{(D\&R Equation 8.29)}$$

where:
h = flow depth (inches)
θ = central angle

$$\theta = \frac{3\pi}{2}\left[1 - \left(1 - (\pi K)^{1/2}\right)^{1/2}\right]^{1/2} \qquad \text{(D\&R Equation 8.28)}$$

K = constant

$$K = 0.673QnD^{-8/3}S^{-1/2}$$ (D&R Equation 8.27)

Determine Flow Velocity:

$$V = \frac{Q}{A} = \frac{Q}{D^2 \frac{(\theta - \sin\theta)}{8}}$$ (D&R Equation 8.30 for "A")

where: V = flow velocity (ft/sec)
A = cross-sectional area of flow (ft^3)

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue Tel: 919-828-0577
Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 4 / 4
JOB #: WASH-09-1
DATE: 11/23/09
BY: PKS
CHKD BY:

Washington County C&D Landfill
Down Pipe Analysis (CPE Pipe)

Input Parameters:

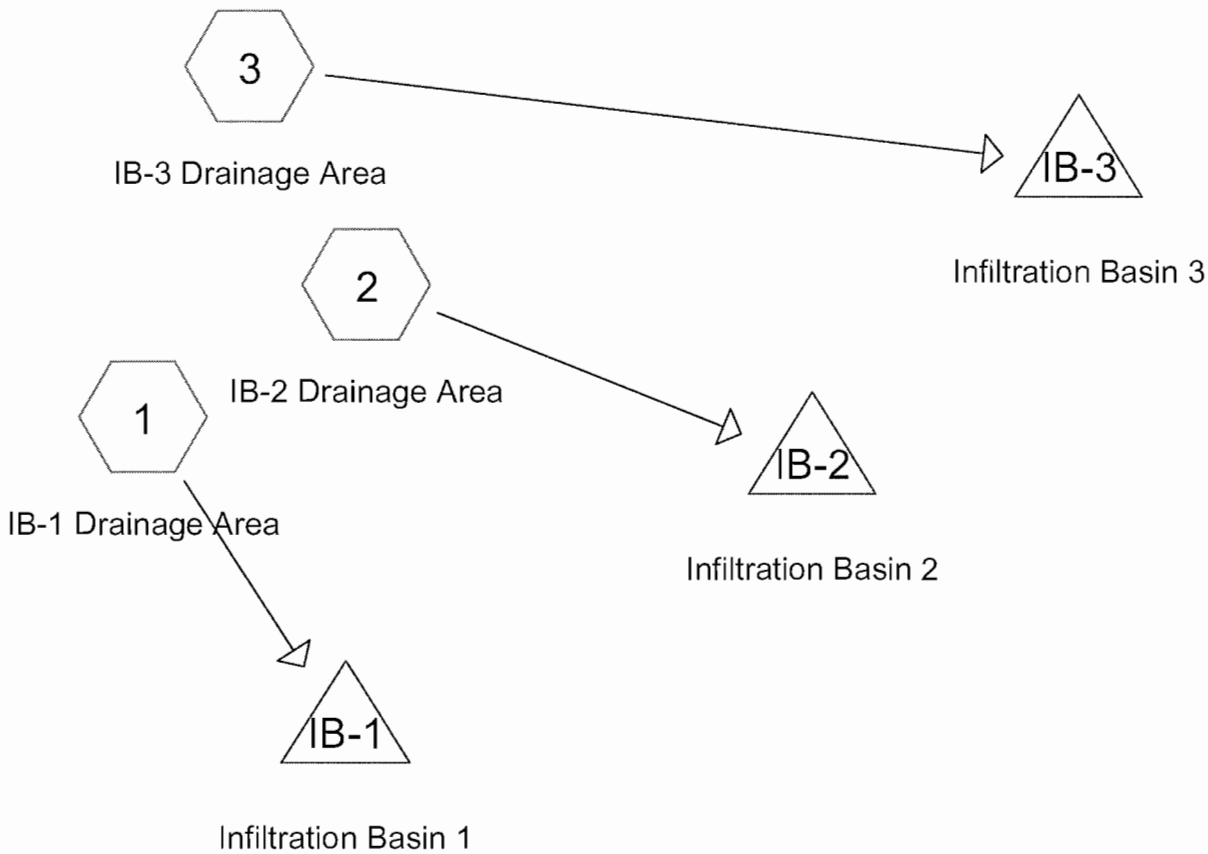
Manning's Rougness Coefficient =	**0.020**	--> CPE Pipe (Type S - Use 0.012; Type C - Use 0.02)
Runoff Coefficient =	**0.35**	
Rainfall Intensity =	**8.86**	IN/HR ---> 50 YR - 5 MIN STORM
Allowable Headwater Depth (Above Pipe Invert) (Down Pipe Inlets) =	**2.0**	FEET
Orifice Coef. Of Discharge (Down Pipe Inlets) =	**0.6**	TYPICAL

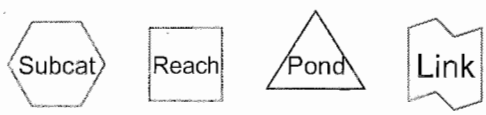
Down Pipe Inlets

ID	Drainage Area (AC)	Runoff Volume (Q) (CFS)	Pipe I.D. (IN)	X-Sectional Area (SF)	Flow Capacity (Q_{max}) (CFS)	Factor of Safety (>/= 1.10)	
Max. Area - 18"	**0.80**	2.48	**18.0**	1.77	9.50	3.83	Max Area for Down Pipes 1 and 2

Down Pipes

ID	Drainage Area (AC)	Runoff Volume (Q) (CFS)	Pipe I.D. (IN)	Pipe Slope (%)	Flow Capacity (Q_{max}) (CFS)	Factor of Safety (>/= 1.10)	K (CONSTANT)	θ (< 265°)	Flow Depth (IN)	Flow Area (SF)	Flow Velocity (FPS)
Max. Area - 18"	**0.80**	2.48	**18.0**	7	18.06	7.28	0.043	122	4.64	0.36	6.88





Drainage Diagram for WC Infiltration Basins
Prepared by Richardson Smith Gardner & Assocs., Inc. 11/23/2009
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Area Listing (all nodes)

Area (acres)	CN	Description (subcats)
3.010	39	Area 1 (Mostly Flat & Sandy) (1)
4.030	39	Area 2 (Mostly Flat & Sandy) (2)
2.990	39	Area 3 (Mostly Flat & Sandy) (3)
0.410	68	Areas DP-1 (1)
1.380	68	Areas DP-2 & DC-1 (3)
11.820		

Time span=1.00-24.00 hrs, dt=0.05 hrs, 461 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1: IB-1 Drainage Area Runoff Area=3.420 ac Runoff Depth>1.11"
Flow Length=510' Tc=23.8 min CN=42 Runoff=2.00 cfs 0.317 af

Subcatchment 2: IB-2 Drainage Area Runoff Area=4.030 ac Runoff Depth>0.87"
Flow Length=350' Tc=24.5 min CN=39 Runoff=1.57 cfs 0.292 af

Subcatchment 3: IB-3 Drainage Area Runoff Area=4.370 ac Runoff Depth>1.64"
Flow Length=780' Tc=25.2 min CN=48 Runoff=4.40 cfs 0.596 af

Pond IB-1: Infiltration Basin 1 Peak Elev=3.47' Storage=4,447 cf Inflow=2.00 cfs 0.317 af
Outflow=0.39 cfs 0.316 af

Pond IB-2: Infiltration Basin 2 Peak Elev=3.18' Storage=2,469 cf Inflow=1.57 cfs 0.292 af
Outflow=0.52 cfs 0.291 af

Pond IB-3: Infiltration Basin 3 Peak Elev=3.58' Storage=9,351 cf Inflow=4.40 cfs 0.596 af
Outflow=0.81 cfs 0.587 af

Total Runoff Area = 11.820 ac Runoff Volume = 1.206 af Average Runoff Depth = 1.22"
100.00% Pervious Area = 11.820 ac 0.00% Impervious Area = 0.000 ac

Subcatchment 1: IB-1 Drainage Area

Runoff = 2.00 cfs @ 12.45 hrs, Volume= 0.317 af, Depth> 1.11"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Yr 24-Hr Rainfall=7.30"

Area (ac)	CN	Description
0.410	68	Areas DP-1
3.010	39	Area 1 (Mostly Flat & Sandy)
3.420	42	Weighted Average
3.420		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.1	60	0.1000	0.33		**Sheet Flow, Top of Final Cover** Grass: Short n= 0.150 P2= 4.00"
0.5	120	0.0200	3.80	15.21	**Channel Flow, Cap Diversion Berm** Area= 4.0 sf Perim= 10.0' r= 0.40' n= 0.030 Earth, grassed & winding
0.1	130	0.2500	19.32	34.14	**Circular Channel (pipe), Down Pipe** Diam= 18.0" Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.020
20.1	200	0.0100	0.17		**Sheet Flow, Sheet Flow Across Borrow Area** Grass: Short n= 0.150 P2= 4.00"
23.8	510	Total			

Subcatchment 2: IB-2 Drainage Area

Runoff = 1.57 cfs @ 12.51 hrs, Volume= 0.292 af, Depth> 0.87"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Yr 24-Hr Rainfall=7.30"

Area (ac)	CN	Description
4.030	39	Area 2 (Mostly Flat & Sandy)
4.030		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.4	150	0.2500	0.57		**Sheet Flow, Landfill Side Slope** Grass: Short n= 0.150 P2= 4.00"
20.1	200	0.0100	0.17		**Sheet Flow, Sheet Flow Across Borrow Area** Grass: Short n= 0.150 P2= 4.00"
24.5	350	Total			

Subcatchment 3: IB-3 Drainage Area

Runoff = 4.40 cfs @ 12.41 hrs, Volume= 0.596 af, Depth> 1.64"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Yr 24-Hr Rainfall=7.30"

Area (ac)	CN	Description
1.380	68	Areas DP-2 & DC-1
2.990	39	Area 3 (Mostly Flat & Sandy)
4.370	48	Weighted Average
4.370		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.1	60	0.1000	0.33		**Sheet Flow, Top of Final Cover** Grass: Short n= 0.150 P2= 4.00"
0.5	120	0.0200	3.80	15.21	**Channel Flow, Cap Diversion Berm** Area= 4.0 sf Perim= 10.0' r= 0.40' n= 0.030 Earth, grassed & winding
0.1	90	0.2500	19.32	34.14	**Circular Channel (pipe), Down Pipe** Diam= 18.0" Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.020
1.4	310	0.0150	3.82	22.93	**Channel Flow, DC-1** Area= 6.0 sf Perim= 12.0' r= 0.50' n= 0.030 Earth, grassed & winding
20.1	200	0.0100	0.17		**Sheet Flow, Sheet Flow Across Borrow Area** Grass: Short n= 0.150 P2= 4.00"
25.2	780	Total			

Pond IB-1: Infiltration Basin 1

Inflow Area = 3.420 ac, Inflow Depth > 1.11" for 25-Yr 24-Hr event
Inflow = 2.00 cfs @ 12.45 hrs, Volume= 0.317 af
Outflow = 0.39 cfs @ 14.72 hrs, Volume= 0.316 af, Atten= 80%, Lag= 136.5 min
Discarded = 0.39 cfs @ 14.72 hrs, Volume= 0.316 af

Routing by Stor-Ind method, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 3.47' @ 14.72 hrs Surf.Area= 12,117 sf Storage= 4,447 cf
Flood Elev= 5.00' Surf.Area= 60,000 sf Storage= 51,500 cf

Plug-Flow detention time= 132.4 min calculated for 0.315 af (99% of inflow)
Center-of-Mass det. time= 129.9 min (1,049.9 - 920.0)

Volume	Invert	Avail.Storage	Storage Description
#1	3.00'	51,500 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
3.00	7,000	0	0
4.00	18,000	12,500	12,500
5.00	60,000	39,000	51,500

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**1.400 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.39 cfs @ 14.72 hrs HW=3.47' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 0.39 cfs)

Pond IB-2: Infiltration Basin 2

Inflow Area =	4.030 ac,	Inflow Depth >	0.87"	for	25-Yr 24-Hr event
Inflow =	1.57 cfs @	12.51 hrs,	Volume=	0.292 af	
Outflow =	0.52 cfs @	13.58 hrs,	Volume=	0.291 af,	Atten= 67%, Lag= 64.1 min
Discarded =	0.52 cfs @	13.58 hrs,	Volume=	0.291 af	

Routing by Stor-Ind method, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 3.18' @ 13.58 hrs Surf.Area= 16,049 sf Storage= 2,469 cf
Flood Elev= 5.00' Surf.Area= 80,000 sf Storage= 81,000 cf

Plug-Flow detention time= 44.8 min calculated for 0.291 af (100% of inflow)
Center-of-Mass det. time= 42.4 min (978.9 - 936.5)

Volume	Invert	Avail.Storage	Storage Description
#1	3.00'	81,000 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
3.00	12,000	0	0
4.00	35,000	23,500	23,500
5.00	80,000	57,500	81,000

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**1.400 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.52 cfs @ 13.58 hrs HW=3.18' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 0.52 cfs)

Pond IB-3: Infiltration Basin 3

Inflow Area =	4.370 ac,	Inflow Depth >	1.64"	for	25-Yr 24-Hr event
Inflow =	4.40 cfs @	12.41 hrs,	Volume=	0.596 af	
Outflow =	0.81 cfs @	14.05 hrs,	Volume=	0.587 af,	Atten= 82%, Lag= 98.0 min
Discarded =	0.81 cfs @	14.05 hrs,	Volume=	0.587 af	

Routing by Stor-Ind method, Time Span= 1.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 3.58' @ 14.05 hrs Surf.Area= 24,870 sf Storage= 9,351 cf
Flood Elev= 5.00' Surf.Area= 80,000 sf Storage= 81,100 cf

Plug-Flow detention time= 143.2 min calculated for 0.586 af (98% of inflow)
Center-of-Mass det. time= 135.0 min (1,032.5 - 897.5)

Volume	Invert	Avail.Storage	Storage Description
#1	3.00'	81,100 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
3.00	7,200	0	0
4.00	37,500	22,350	22,350
5.00	80,000	58,750	81,100

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**1.400 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.81 cfs @ 14.05 hrs HW=3.58' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.81 cfs)

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ATTACHMENT G

PERMIT AMENDMENT DRAWINGS

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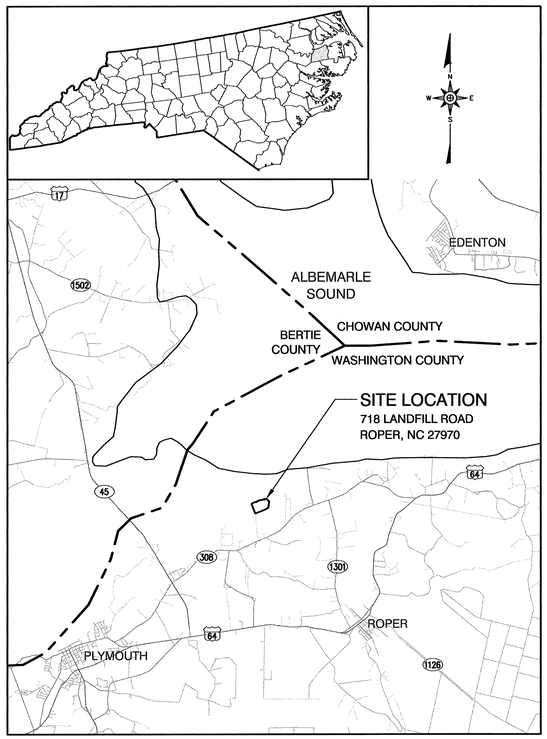
WASHINGTON COUNTY DEPARTMENT OF PUBLIC UTILITIES
PLYMOUTH, NORTH CAROLINA

CONSTRUCTION & DEMOLITION DEBRIS (C&D) LANDFILL PHASE 2 PERMIT AMENDMENT DRAWINGS

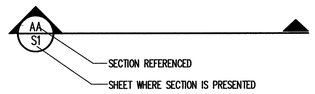
JANUARY 2009



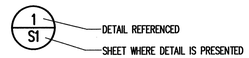
SITE LOCATION MAP
NOT TO SCALE

SHEET NO.	DRAWING NO.	TITLE
1	–	TITLE – COVER SHEET
2	S1	EXISTING SITE CONDITIONS
3	S2	SITE DEVELOPMENT PLAN – SUBGRADE GRADING AND DRAINAGE
4	S3	SITE DEVELOPMENT PLAN – FINAL COVER GRADING AND DRAINAGE
5	D1	DETAILS (SHEET 1 OF 2)
6	D2	DETAILS (SHEET 2 OF 2)
7	X1	ENGINEERING CROSS SECTIONS
8	P1	PHASING PLAN

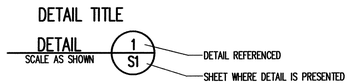
STANDARD SECTION LOCATION CALLOUT (SHEET AND DETAIL)



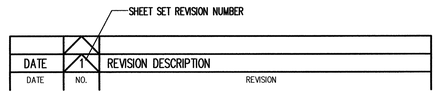
STANDARD DETAIL CALLOUT



STANDARD DETAIL LABEL AND CALLOUT



STANDARD REVISION CALLOUT (SHEET AND DETAIL)



RICHARDSON SMITH GARDNER & ASSOCIATES
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NORTH CAROLINA PROFESSIONAL SEAL 021666 ENGINEER PETER K. SCHEER
1/8/10

FILE NAME
WASH-D0007

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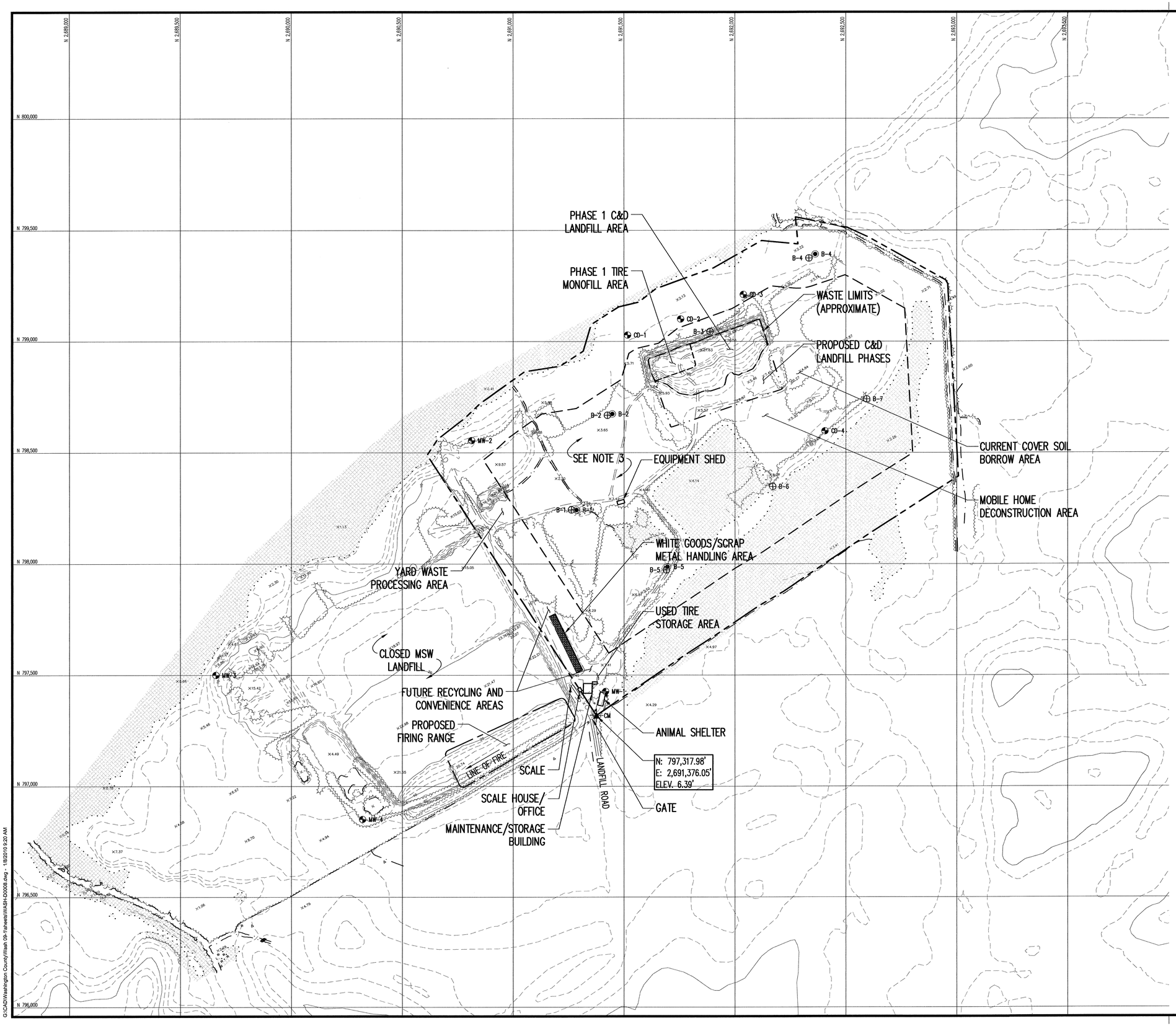

LEGEND

150	EXISTING 10' CONTOUR (SEE REFERENCE 1)
	EXISTING 2' CONTOUR
	APPROXIMATE PROPERTY LINE
	APPROXIMATE EXISTING WASTE LIMITS
	STREAM/POND/DITCH BOUNDARY
	PROPOSED LANDFILL AREA
	WETLANDS (APPROXIMATE)
MW-1	MONITORING WELL (CLOSED MSWLF)
CD-1	MONITORING WELL (C&DLF)
CM	EXISTING CONCRETE MONUMENT
B-6	SOIL BORING (S&ME, 1994)
B-1	EXISTING PIEZOMETER (S&ME 1994)

NOTES

1. THE TIRE MONOFILL IS NO LONGER USED BY THE COUNTY. THIS AREA WAS PREVIOUSLY INCORPORATED INTO THE C&D LANDFILL FOOTPRINT.
2. 100-YEAR FLOODPLAIN IS AT ELEVATION 7.0.
3. THIS AREA IS DESIGNATED AS A DISASTER DEBRIS HANDLING AREA.

REFERENCES

1. OVERALL SITE BASE TOPOGRAPHY WETLAND, STREAM, AND DITCH BOUNDARIES PROVIDED BY SANBORN, BASED ON MARCH 28, 2009 AERIAL SURVEY. ADDITIONAL WETLAND AREAS OBTAINED FROM DRAWING "PROPOSED CDLF CAP SECTION" BY THE WOOTEN COMPANY, DATED DECEMBER 2004.
2. COORDINATE SYSTEM IS STATE PLANE GRID.
3. SITE PROPERTY LINE (NORTHEASTERN HALF) OBTAINED FROM DRAWING "PROPOSED CDLF CAP SECTION" BY THE WOOTEN COMPANY, DATED DECEMBER 2004. SITE PROPERTY LINE (SOUTHEASTERN HALF) FROM DRAWING "MAP OF WASHINGTON COUNTY SANITARY LAND" SURVEYED AND PREPARED BY DOWNEAST LAND SURVEYS.
4. WELL LOCATIONS OBTAINED FROM FROM THE WASHINGTON COUNTY LANDFILL MONITOR WELL SURVEY REPORT DATED APRIL 24, 2009.
5. FLOODPLAIN INFORMATION FROM NC FIRM MAP NO. 3720678800J.

0 200' 400' 600'

REVISION	DATE	NO.

RICHARDSON SMITH GARDNER & ASSOCIATES
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14 N. Boylan Ave. Raleigh, N.C. 27603
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SEAL

PROJECT TITLE: WASHINGTON COUNTY C&D LANDFILL PHASE 2 PERMIT AMENDMENT DRAWINGS

DRAWING TITLE: EXISTING SITE CONDITIONS

DESIGNED BY: P.K.S	DRAWN BY: W.R.B.
CHECKED BY: PKS	PROJECT NO.: WASH 09-1
SCALE: AS SHOWN	DATE: JAN. 2009
FILE NAME WASH-D0008	
SHEET NO. 2	DRAWING NO. S1

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APPROXIMATE PROPERTY LINE

6/D2 SILT FENCE

DRAINAGE CHANNEL 4/D2

PHASE 1 C&D LANDFILL AREA

200' BUFFER

EXISTING WASTE LIMITS (APPROXIMATE)

INFILTRATION BASIN (EL=3.0)

CLEARING LIMITS (14.3 AC.)

GRADE TO DRAIN

PROPOSED LANDFILL AREA

PHASE 1 TIRE MONOFILL AREA

PHASE 2

PHASE 3

2H:1V INTERIOR BERM SLOPE (TYP.)

3H:1V EXTERIOR BERM SLOPE (TYP.)

PROPOSED PHASE 3 WASTE LIMITS

MOBILE HOME DECONSTRUCTION AREA

WETLANDS BOUNDARY AREA (TYP.)

B-1 B-2 B-3 B-4 B-6 B-7 CD-1 CD-2 CD-3 CD-4

LEGEND

150	EXISTING 10' CONTOUR (SEE REFERENCE 1)
	EXISTING 2' CONTOUR
10	PROPOSED 10' CONTOUR
6	PROPOSED 2' CONTOUR
3	PROPOSED 1' CONTOUR
	APPROXIMATE PROPERTY LINE
	APPROXIMATE EXISTING WASTE LIMITS
	PROPOSED LANDFILL AREA
	200' PROPERTY OFFSET BUFFER
	WETLANDS BOUNDARY AREA (SEE REFERENCE 1)
DC-1	DRAINAGE CHANNEL
	SILT FENCE
CD-1	MONITORING WELL
CM	EXISTING CONCRETE MONUMENT
B-6	SOIL BORING (S&ME, 1994)
B-1	EXISTING PIEZOMETER (S&ME 1994)

NOTES

1. THE TIRE MONOFILL IS NO LONGER USED BY THE COUNTY. THIS AREA WAS PREVIOUSLY INCORPORATED INTO THE C&D LANDFILL FOOTPRINT.
2. 100-YEAR FLOODPLAIN IS AT ELEVATION 7.0.

REFERENCES

1. OVERALL SITE BASE TOPOGRAPHY WETLAND, STREAM, AND DITCH BOUNDARIES PROVIDED BY SANBORN, BASED ON MARCH 28, 2009 AERIAL SURVEY.
2. COORDINATE SYSTEM IS STATE PLANE GRID.
3. SITE PROPERTY LINE OBTAINED FROM DRAWING "PROPOSED CDLF CAP SECTION" BY THE WOOTEN COMPANY, DATED DECEMBER 2004.
4. WELL LOCATIONS OBTAINED FROM FROM THE WASHINGTON COUNTY LANDFILL MONITOR WELL SURVEY REPORT DATED APRIL 24, 2009.
5. FLOODPLAIN INFORMATION FROM NC FIRM MAP NO. 3720678800J.

0 50' 100' 150'

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www.rsgengineers.com

REVISION | NO. | DATE

SEAL

PROJECT TITLE: WASHINGTON COUNTY C&D LANDFILL PHASE 2 PERMIT AMENDMENT DRAWINGS

DRAWING TITLE: SITE DEVELOPMENT PLAN SUBGRADE GRADING AND DRAINAGE

DESIGNED BY: P.K.S.	DRAWN BY: W.R.B.
CHECKED BY: PKS	PROJECT NO.: WASH 09-1
SCALE: AS SHOWN	DATE: JAN. 2009
FILE NAME: WASH-D0009	
SHEET NO. 3	DRAWING NO. S2

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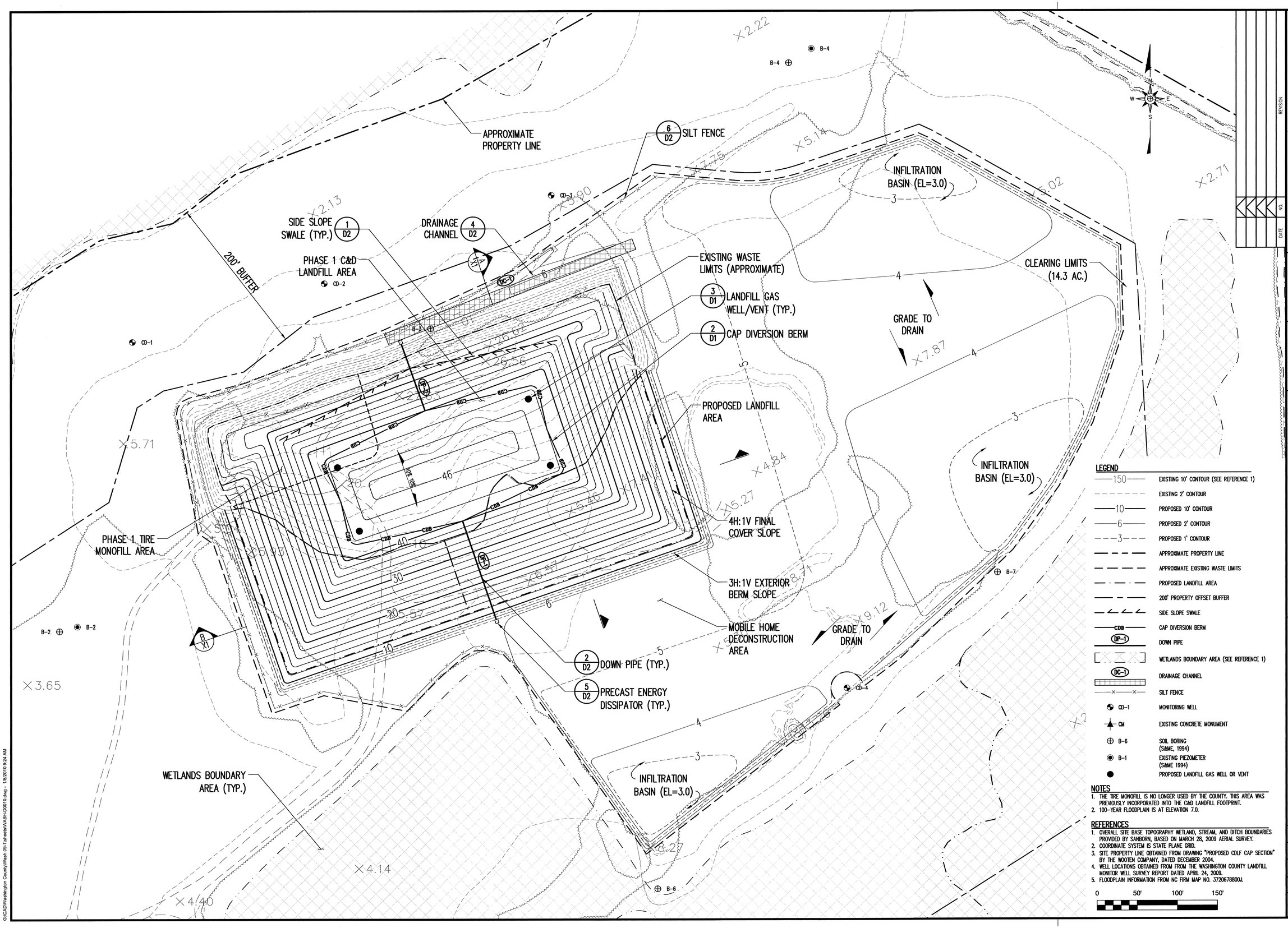

LEGEND

150	EXISTING 10' CONTOUR (SEE REFERENCE 1)
	EXISTING 2' CONTOUR
10	PROPOSED 10' CONTOUR
6	PROPOSED 2' CONTOUR
3	PROPOSED 1' CONTOUR
	APPROXIMATE PROPERTY LINE
	APPROXIMATE EXISTING WASTE LIMITS
	PROPOSED LANDFILL AREA
	200' PROPERTY OFFSET BUFFER
	SIDE SLOPE SWALE
CDB	CAP DIVERSION BERM
DP-1	DOWN PIPE
	WETLANDS BOUNDARY AREA (SEE REFERENCE 1)
DC-1	DRAINAGE CHANNEL
	SILT FENCE
CD-1	MONITORING WELL
CM	EXISTING CONCRETE MONUMENT
B-6	SOIL BORING (S&ME, 1994)
B-1	EXISTING PIEZOMETER (S&ME 1994)
	PROPOSED LANDFILL GAS WELL OR VENT

NOTES

1. THE TIRE MONOFILL IS NO LONGER USED BY THE COUNTY. THIS AREA WAS PREVIOUSLY INCORPORATED INTO THE C&D LANDFILL FOOTPRINT.
2. 100-YEAR FLOODPLAIN IS AT ELEVATION 7.0.

REFERENCES

1. OVERALL SITE BASE TOPOGRAPHY WETLAND, STREAM, AND DITCH BOUNDARIES PROVIDED BY SANBORN, BASED ON MARCH 28, 2009 AERIAL SURVEY.
2. COORDINATE SYSTEM IS STATE PLANE GRID.
3. SITE PROPERTY LINE OBTAINED FROM DRAWING "PROPOSED CDLF CAP SECTION" BY THE WOOTEN COMPANY, DATED DECEMBER 2004.
4. WELL LOCATIONS OBTAINED FROM FROM THE WASHINGTON COUNTY LANDFILL MONITOR WELL SURVEY REPORT DATED APRIL 24, 2009.
5. FLOODPLAIN INFORMATION FROM NC FIRM MAP NO. 3720678800J.

0 50' 100' 150'

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REVISION | NO. | DATE

SEAL

PROJECT TITLE: WASHINGTON COUNTY C&D LANDFILL PHASE 2 PERMIT AMENDMENT DRAWINGS

DRAWING TITLE: SITE DEVELOPMENT PLAN FINAL COVER GRADING AND DRAINAGE

DESIGNED BY: P.K.S.	DRAWN BY: W.R.B.
CHECKED BY: PKS	PROJECT NO.: WASH 09-1
SCALE: AS SHOWN	DATE: JAN. 2009
FILE NAME: WASH-D0010	
SHEET NO. 4	DRAWING NO. S3

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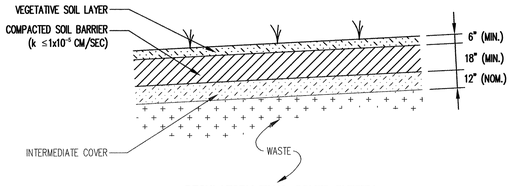
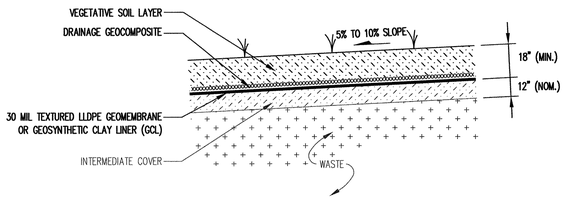
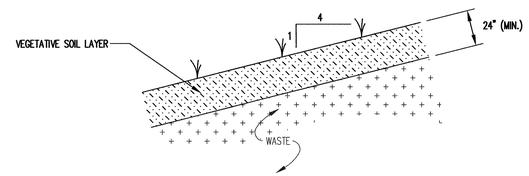


REGULATORY FINAL COVER SYSTEM



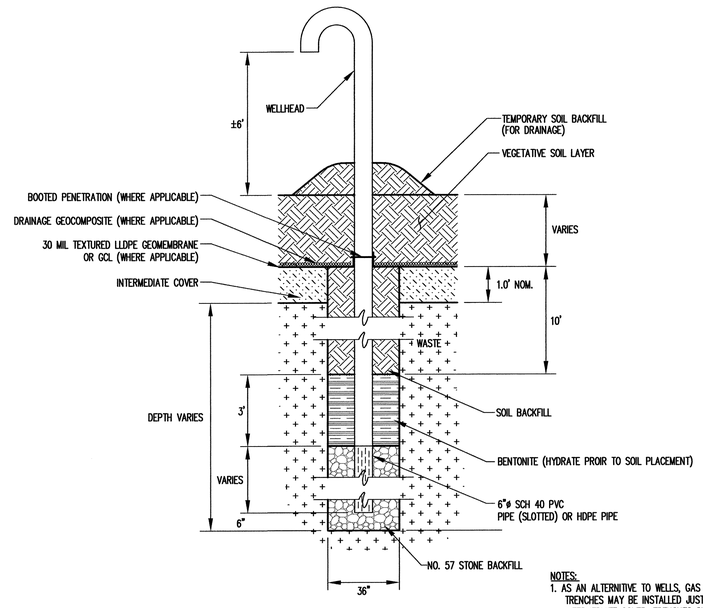
ALTERNATIVE FINAL COVER SYSTEM – TOP SLOPES



ALTERNATIVE FINAL COVER SYSTEM – SIDE SLOPES

FINAL COVER SYSTEM CROSS SECTIONS

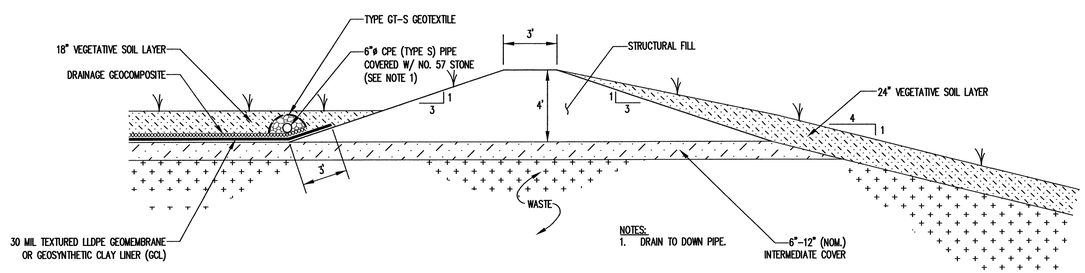
DETAIL 1/D1
NOT TO SCALE



NOTES:
1. AS AN ALTERNITIVE TO WELLS, GAS COLLECTION TRENCHES MAY BE INSTALLED JUST BELOW THE INTERMEDIATE COVER. TRENCHES SHALL CONSIST OF PERFORATED PIPE BEDDED IN NO. 57 STONE AND WRAPPED IN A TYPE GT-S GEOTEXTILE. TRENCHES SHALL HAVE NOMINAL SIZE OF 6' WIDE x 20' LONG x 2' DEEP.

TYPICAL LANDFILL GAS WELL

DETAIL 3/D1
NOT TO SCALE



NOTES:
1. DRAIN TO DOWN PIPE.

CAP DIVERSION BERM

DETAIL 2/D1
NOT TO SCALE

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PROJECT TITLE:
WASHINGTON COUNTY
C&D LANDFILL PHASE 2
PERMIT AMENDMENT DRAWINGS

DRAWING TITLE:
DETAILS
(SHEET 1 OF 2)

DESIGNED BY: P.K.S.	DRAWN BY: W.R.B.
CHECKED BY: PKS	PROJECT NO.: WASH 09-1
SCALE: AS SHOWN	DATE: JAN. 2009
FILE NAME: WASH-D0011	
SHEET NO. 5	DRAWING NO. D1

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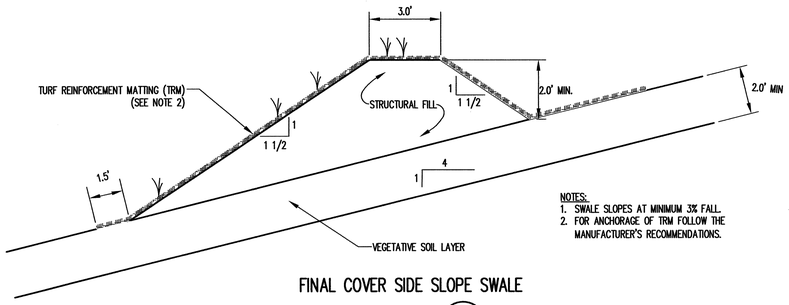
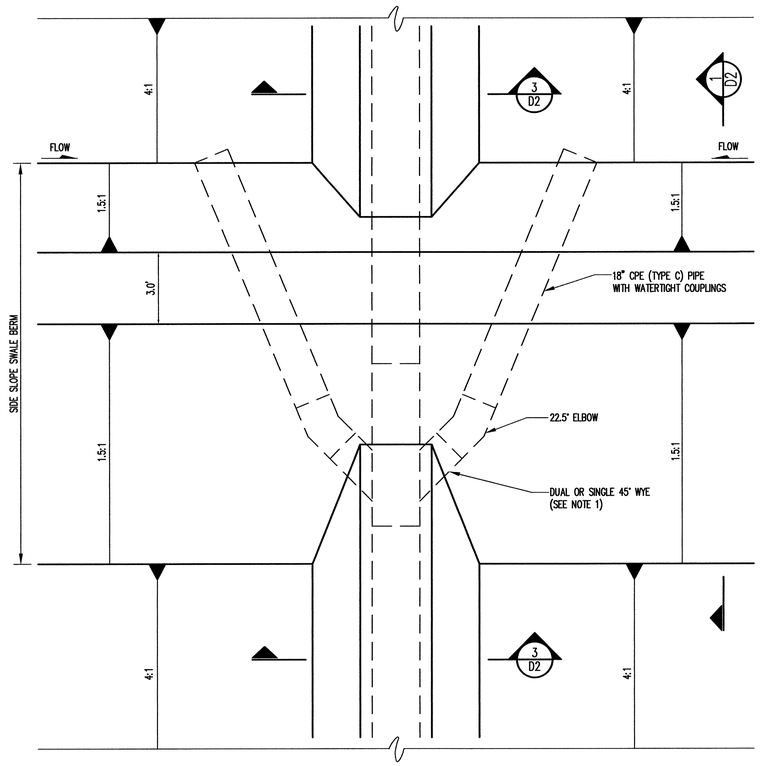


NOTES:
1. SWALE SLOPES AT MINIMUM 3% FALL.
2. FOR ANCHORAGE OF TRM FOLLOW THE MANUFACTURER'S RECOMMENDATIONS.

FINAL COVER SIDE SLOPE SWALE

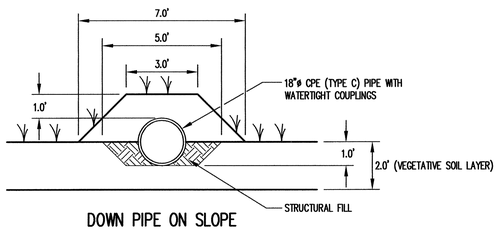
DETAIL 1/D2
NOT TO SCALE



NOTES:
1. DEPENDING ON LOCATION AND SIZE OF DOWN PIPE, WYE FITTING MAY BE SINGLE OR DUAL AND MAY BE A REDUCING WYE.

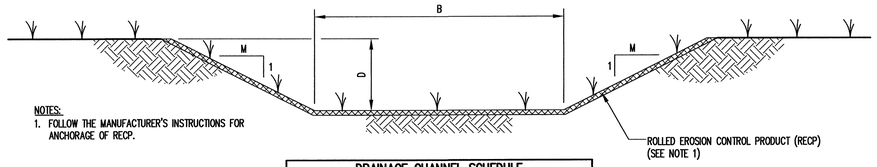
DOWN PIPE

DETAIL 2/D2
NOT TO SCALE



DOWN PIPE ON SLOPE

DETAIL 3/D2
NOT TO SCALE



NOTES:
1. FOLLOW THE MANUFACTURER'S INSTRUCTIONS FOR ANCHORAGE OF RECP.

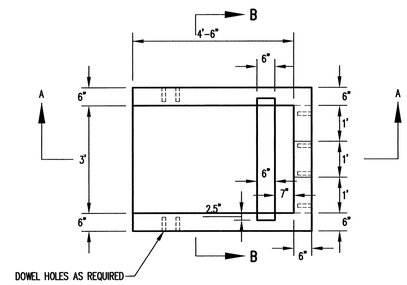
DRAINAGE CHANNEL SCHEDULE

DRAINAGE CHANNEL NO.	LINING	B (FEET)	D (FEET)	M
DC-1	ECB*	8	1	3

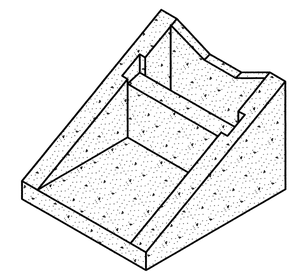
*ECB = EROSION CONTROL BLANKET

DRAINAGE CHANNEL DETAIL

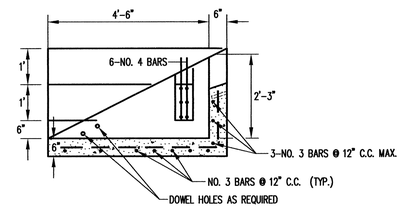
DETAIL 4/D2
NOT TO SCALE



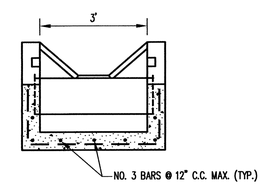
PLAN VIEW



ISOMETRIC VIEW



SECTION A-A

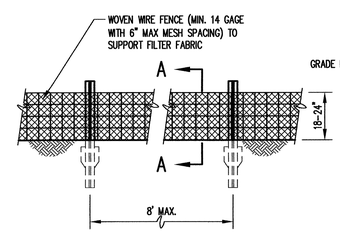


SECTION B-B

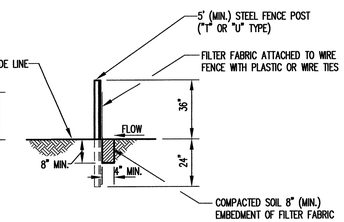
NOTES:
1. CONCRETE STRENGTH 4000 PSI MINIMUM.
2. REINFORCING STEEL SHALL CONFORM TO ASTM A-615, GRADE 40.
3. DIMENSIONS SHOWN FOR CONCRETE THICKNESS ARE MINIMUMS. ACTUAL MEASUREMENTS MAY VARY WITH MANUFACTURER'S TOLERANCES.

PRECAST ENERGY DISSIPATOR

DETAIL 5/D2
NOT TO SCALE



ELEVATION



SECTION A-A

SILT FENCE

DETAIL 6/D2
NOT TO SCALE

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PROJECT TITLE:
WASHINGTON COUNTY
C&D LANDFILL PHASE 2
PERMIT AMENDMENT DRAWINGS

DRAWING TITLE:
DETAILS
(SHEET 2 OF 2)

DESIGNED BY: PKS	DRAWN BY: WRB
CHECKED BY: PKS	PROJECT NO.: WASH 09-1
SCALE: AS SHOWN	DATE: JAN. 2009
FILE NAME: WASH-D0012	
SHEET NO. 6	DRAWING NO. D2

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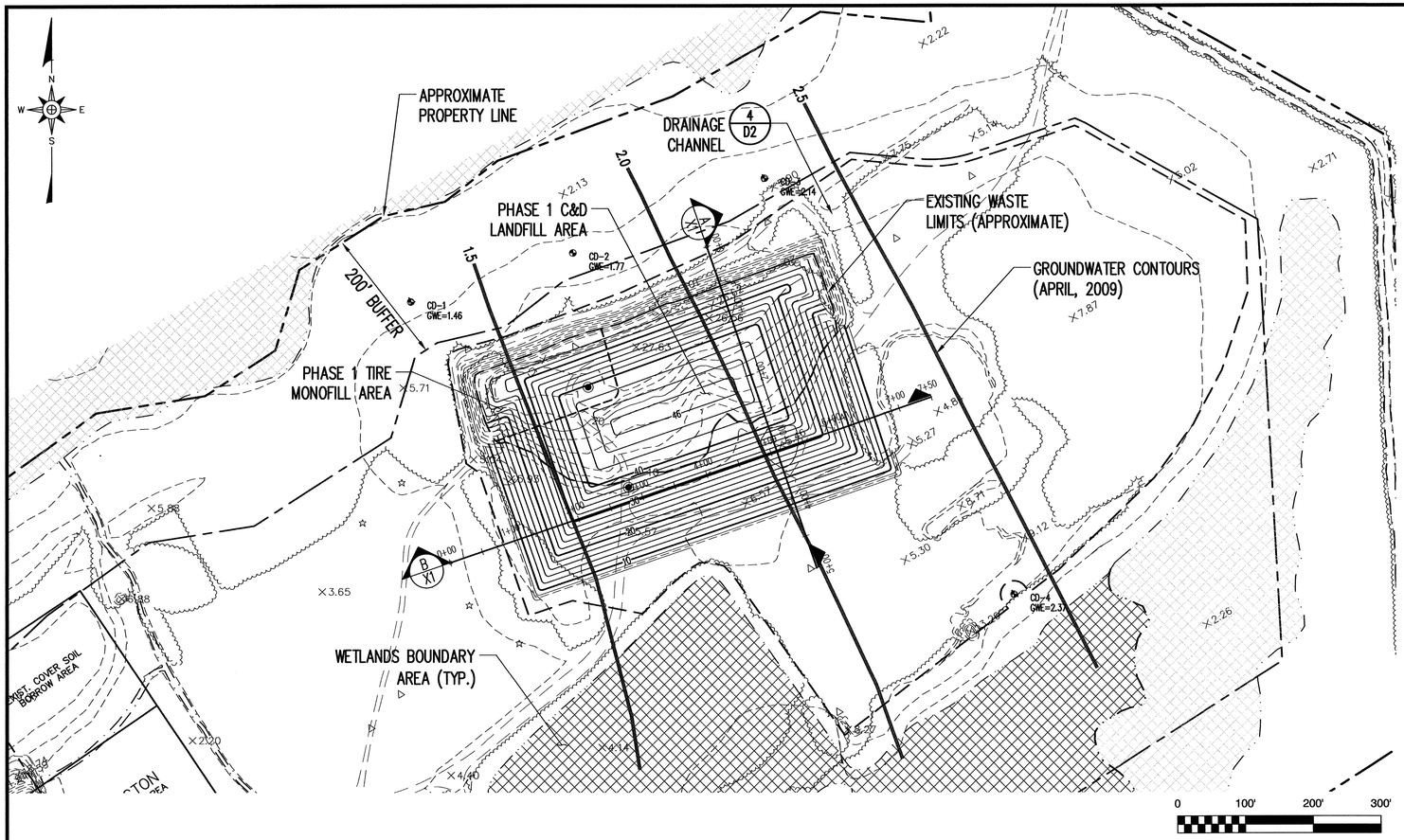


LEGEND

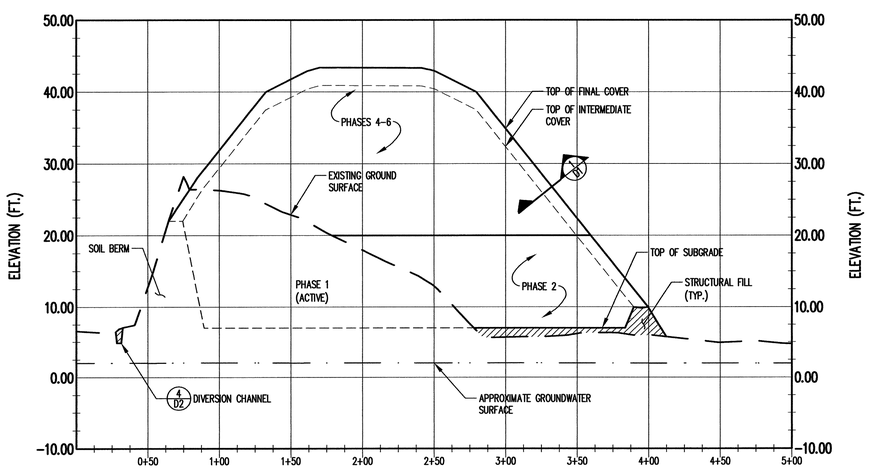
150	EXISTING 10' CONTOUR (SEE REFERENCE 1)
	EXISTING 2' CONTOUR
10	PROPOSED 10' CONTOUR
	PROPOSED 2' CONTOUR
	PROPOSED 1' CONTOUR
	APPROXIMATE PROPERTY LINE
	APPROXIMATE EXISTING WASTE LIMITS
	PROPOSED WASTE LIMITS
	200' PROPERTY OFFSET BUFFER
2.0	GROUNDWATER CONTOUR
	WETLANDS BOUNDARY AREA (SEE REFERENCE 1)
CD-1	MONITORING WELL (C&DLF)
CM	EXISTING CONCRETE MONUMENT
B-6	SOIL BORING (S&ME, 1994)
B-1	EXISTING PIEZOMETER (S&ME 1994)

NOTES

1. THE TIRE MONOFILL IS NO LONGER USED BY THE COUNTY. THIS AREA WAS PREVIOUSLY INCORPORATED INTO THE C&D LANDFILL FOOTPRINT.
2. 100-YEAR FLOODPLAIN IS AT ELEVATION 7.0.

REFERENCES

1. OVERALL SITE BASE TOPOGRAPHY WETLAND, STREAM, AND DITCH BOUNDARIES PROVIDED BY SANBORN, BASED ON MARCH 28, 2009 AERIAL SURVEY.
2. COORDINATE SYSTEM IS STATE PLANE GRID.
3. SITE PROPERTY LINE OBTAINED FROM DRAWING "PROPOSED COLF CAP SECTION" BY THE WOOTEN COMPANY, DATED DECEMBER 2004.
4. WELL LOCATIONS OBTAINED FROM FROM THE WASHINGTON COUNTY LANDFILL MONITOR WELL SURVEY REPORT DATED APRIL 24, 2009.
5. FLOODPLAIN INFORMATION FROM NC FIRM MAP NO. 3720678800J.



CROSS-SECTION A

SECTION A X1
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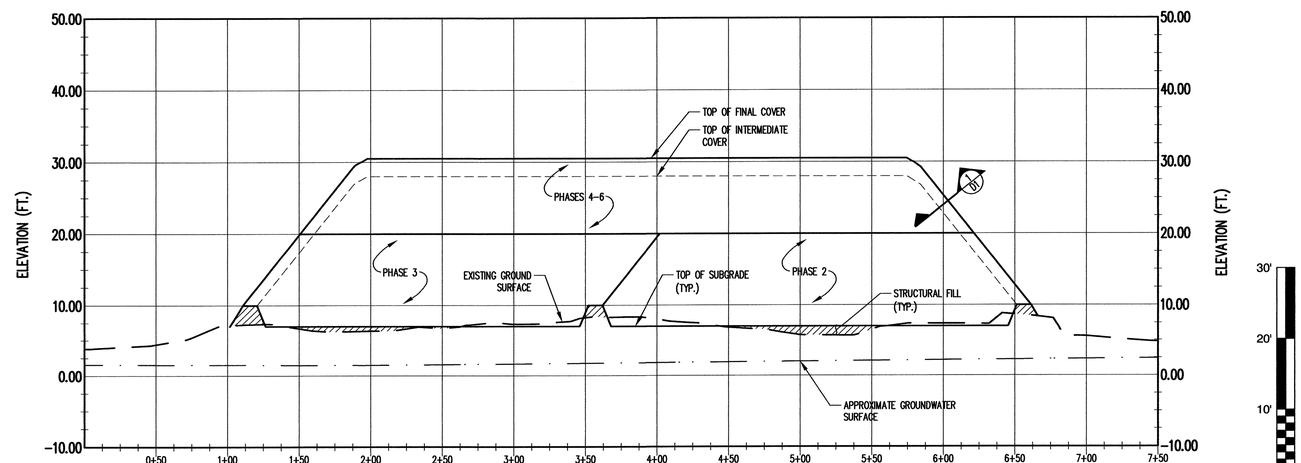

CROSS-SECTION B

SECTION B X1
SCALE: AS NOTED

0 50' 100' 150'

30' 20' 10' 0

REVISION | NO. | DATE

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NORTH CAROLINA PROFESSIONAL SEAL 021660 ENGINEER PIETER K. SMITH 10/8/10

PROJECT TITLE:
WASHINGTON COUNTY
C&D LANDFILL PHASE 2
PERMIT AMENDMENT DRAWINGS

DRAWING TITLE:
ENGINEERING CROSS SECTIONS

DESIGNED BY: P.K.S.	DRAWN BY: W.R.B.
CHECKED BY: PKS	PROJECT NO.: WASH 09-1
SCALE: AS SHOWN	DATE: JAN. 2009
FILE NAME: WASH-D0013	
SHEET NO. 7	DRAWING NO. X1

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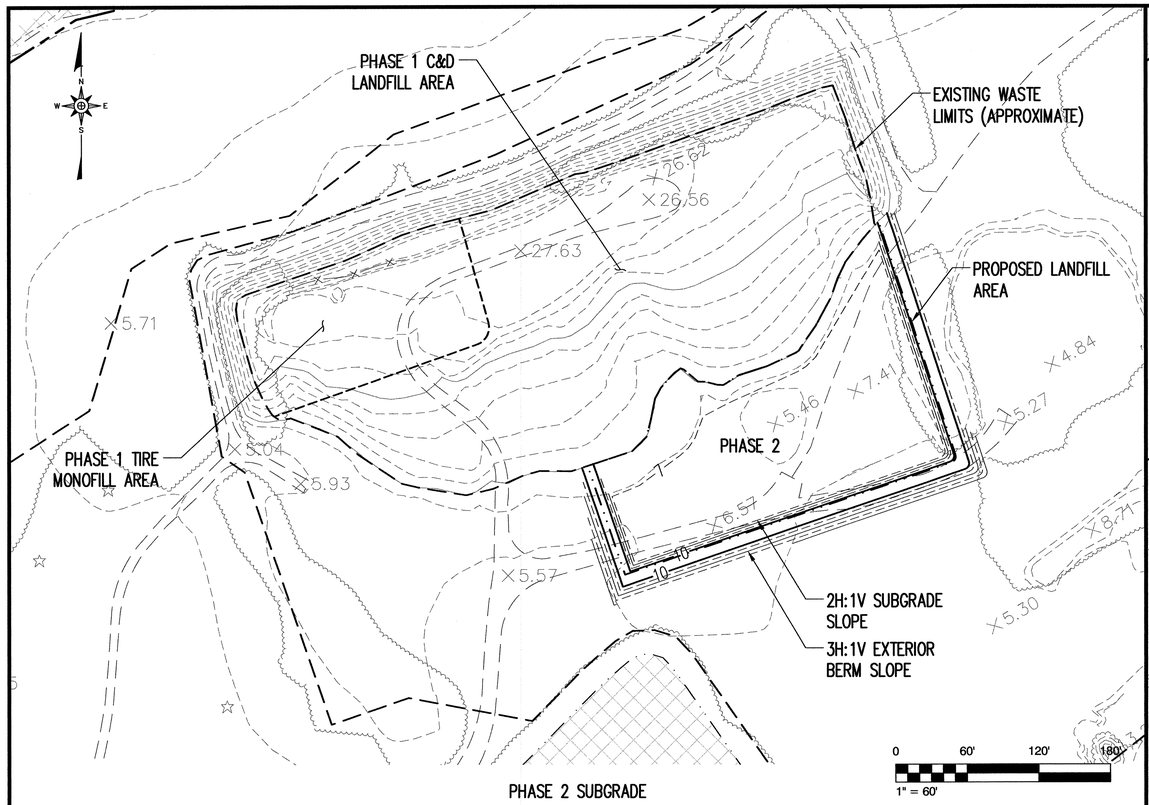
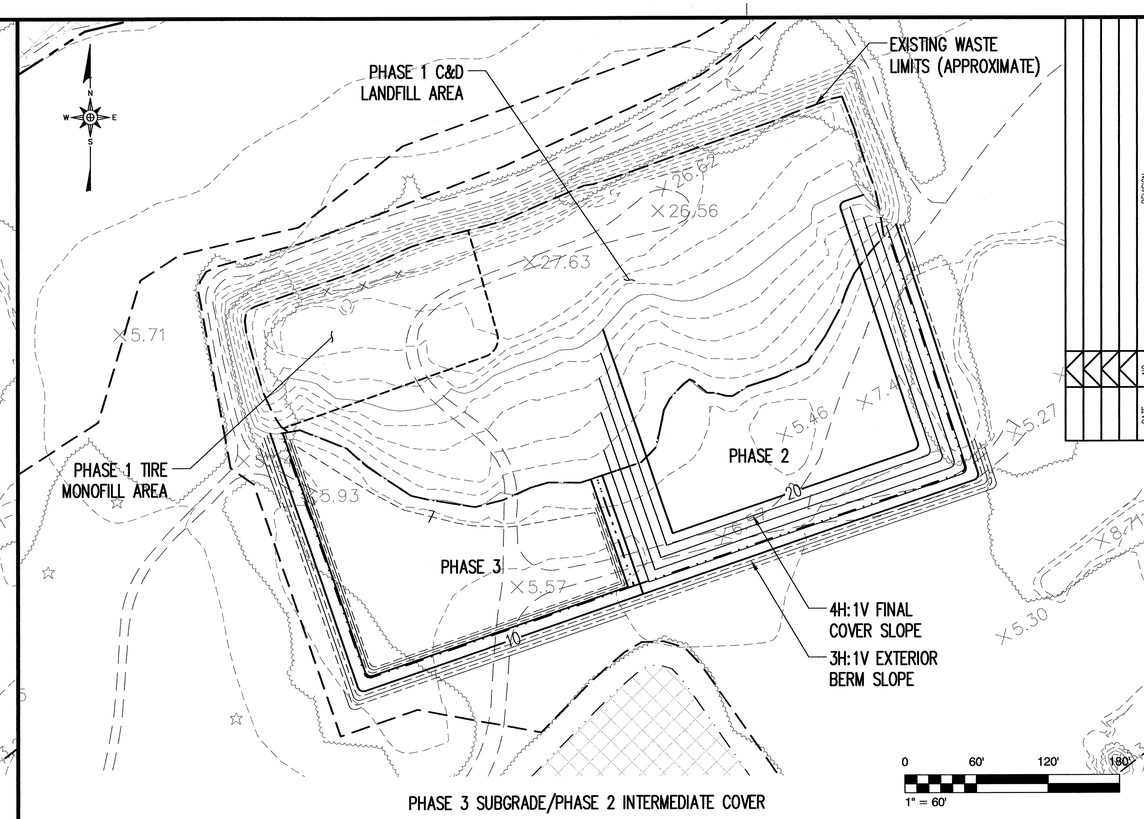
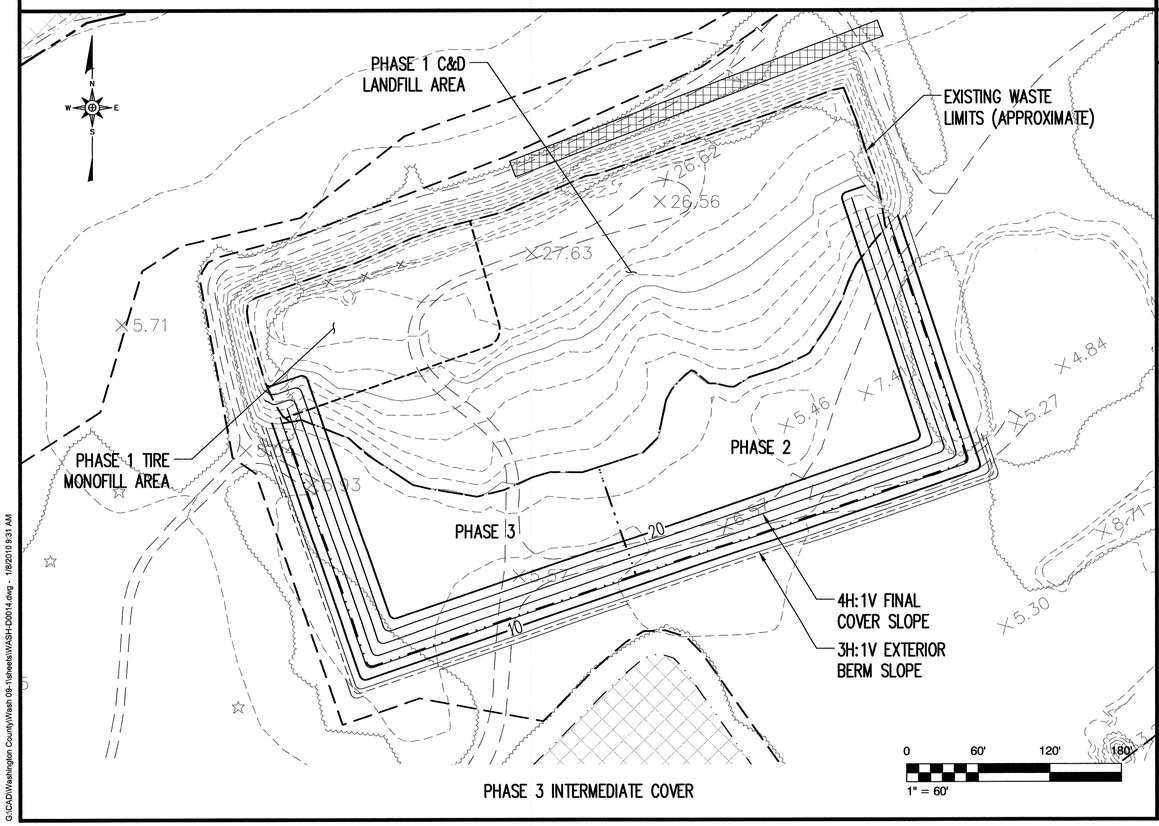


PHASE 2 SUBGRADE



PHASE 3 SUBGRADE/PHASE 2 INTERMEDIATE COVER



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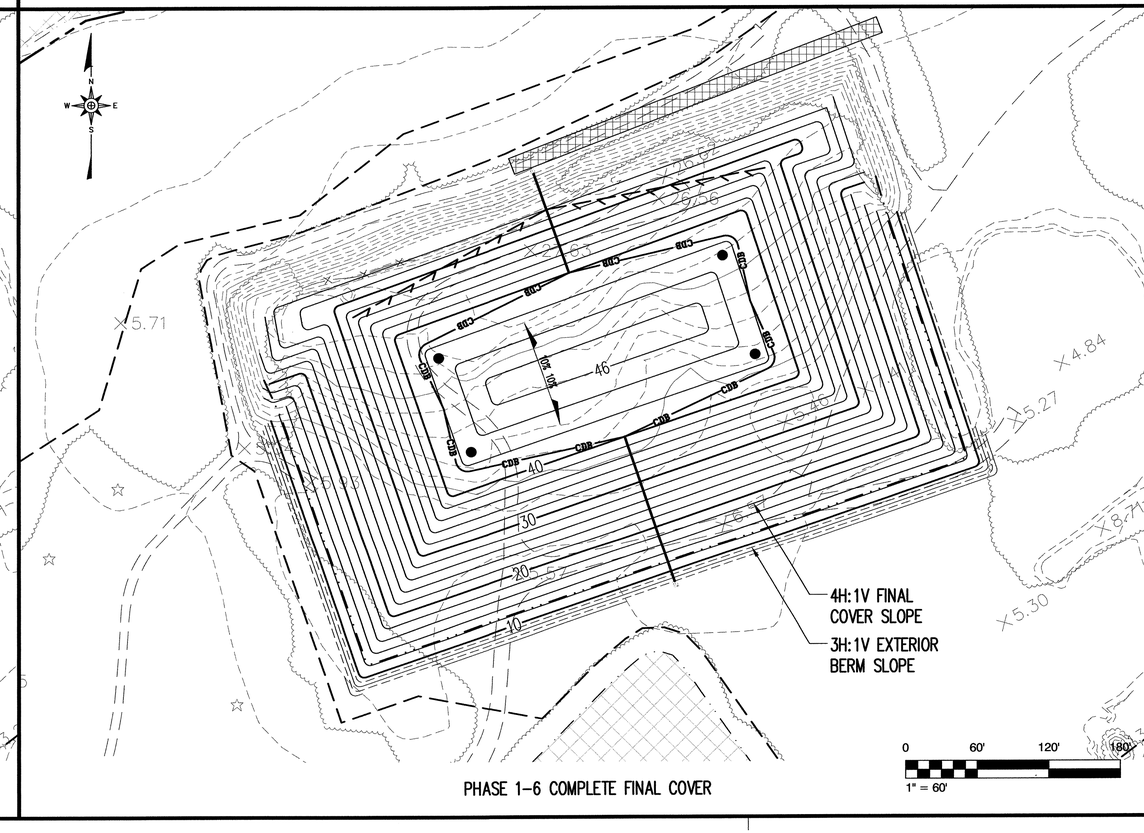

PHASE 1-6 COMPLETE FINAL COVER

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SEAL

SEAL

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 021666 PIETER K. SCHEER 1/8/10

PROJECT TITLE:
WASHINGTON COUNTY
C&D LANDFILL PHASE 2
PERMIT AMENDMENT DRAWINGS

DRAWING TITLE:
PHASING PLAN

DESIGNED BY: P.K.S.	DRAWN BY: W.R.B.
CHECKED BY: PKS	PROJECT NO.: WASH 09-1
SCALE: AS SHOWN	DATE: JAN. 2009
FILE NAME: WASH-D0014	
SHEET NO. 8	DRAWING NO. P1

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Water Quality Monitoring Plan

Washington County C&D Landfill (Permit 94-04)

Roper, North Carolina

Prepared For:

Washington County Public Utilities
396 Millpond Road
Roper, North Carolina 27970

Prepared By:

RICHARDSON SMITH GARDNER
& ASSOCIATES
ENGINEERING & GEOLOGICAL
SERVICES
14 N. BOYLAN AVENUE
RALEIGH, NORTH CAROLINA 27603
NC LIC. NO. C-0828 (ENGINEERING)

November 2009

WATER QUALITY MONITORING PLAN

Washington County C&D Landfill

Roper, North Carolina

Prepared for:
Washington County Public Utilities
Roper, North Carolina

RSG Project No. WASH-09-1

Joan A. Smyth, P.G.
Principal, Senior Hydrogeologist

November 2009

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WASHINGTON COUNTY C&D LANDFILL

WATER QUALITY MONITORING PLAN

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Table 2 - Analytical Methods

FIGURES
Figure 1 - Site Map with Monitoring Network

ATTACHMENTS
Attachment 1 - Solid Waste Environmental Monitoring Reporting Form

SECTION 1.0
INTRODUCTION

1.1 PLAN BACKGROUND

This Water Quality Monitoring Plan (WQMP) specifies the procedures and requirements to satisfy North Carolina Solid Waste Management Rule 15A NCAC 13B.0544 (b). Surface water is not addressed in this WQMP due to a lack of surface water near the landfill. Although the landfill is surrounded by wetlands, no consistently flowing surface water is located within approximately 1/4 mile. Based upon the lack of surface water in the immediate vicinity of the landfill, no surface water sampling is proposed in this document. The WQMP addresses monitoring/sampling of the groundwater monitoring system.

The WQMP is designed to comply with the following requirements:

- *Represent the quality of the background groundwater that has not been affected by leakage from the unit (.0544 (b)(1)(A)).*
- *Represent the quality of the groundwater passing the relevant point of compliance as approved by the Division (.0544 (b)(1)(B)).*
- *The groundwater monitoring programs must include consistent sampling and analysis procedures that are designed to ensure monitoring results that provide an accurate representation of groundwater quality at the background and down-gradient wells (.0544 (b)(1)(C)).*
- *Detection Groundwater monitoring program (.0544 (b)(1)(D)).*
- *The sampling procedures and frequency must be protective of human health and the environment (.0544 (b)(1)(E)).*
- *Responsibility of sample collection and analysis must be defined as a part of the monitoring plan (.0544 (c)(2)).*

This WQMP also addresses the following subjects:

- Sample preservation and shipment;
- Laboratory analytical procedures;
- Sample chain-of-custody control; and
- Quality assurance/quality control programs;

The methods and procedures described in the WQMP are intended to facilitate the collection of true and representative samples and test data. Field procedures are presented in **Section 2.0** in their general order of implementation. Equipment requirements for each field task are presented

within the applicable section. Laboratory procedures, quality assurance methods, and record keeping requirements are presented in **Sections 3.0 through 7.0.**

Strict adherence to the procedures stipulated in this plan is required. Any variations from these procedures should be thoroughly documented.

1.2 SITE CONTACT INFORMATION

In case of emergencies, or if questions arise during the implementation of this program, please contact the following:

Owner:	
Mr. Carl Critcher	Ms. Joan Smyth, P.G.
Washington County	RSG
Office (252) 793-5615	Office (919) 828-0577 x122
	Cell (919) 815-1494

1.3 SITE BACKGROUND

Washington County owns and operates a construction and demolition debris (C&D) landfill under NC Solid Waste Permit No. 94-04, located at 718 Landfill Road Roper, North Carolina. The nearest water body is an unnamed tributary of the Roanoke River that drains into Swan Bay located approximately 1/4 mile to the northeast of the site. The site and monitoring network are shown in **Figure 1**. Information for existing monitoring wells can be found in **Table 1**. The County's closed MSW landfill (NC Solid Waste Permit 94-02) is located on the property to the southwest of the C&D landfill.

1.3.1 Geology

The site is located in the Coastal Plain physiographic province of North Carolina. The site is located east of the Suffolk Scarp and is underlain by undifferentiated Quaternary sediments. These sediments consist of sand, clay, gravel, and peat that were deposited in marine, fluvial, eolian, and lacustrine environments. Ground water at the site flows in the unconsolidated sediments toward discharge features.

1.3.2 Hydrogeology

The uppermost aquifer at the site flows within the unconsolidated sediments described above with discharge to the unnamed tributary of the Roanoke River. Hydraulic conductivities[1] for this aquifer range from 1×10^{-2} to 3.6×10^{-2}.

[1]Site Application Report for Proposed Construction and Demolition Waste Landfill and Tire Monofill for Washington County, Diehl & Phillips, P.A. Consulting Engineers, October 1994.

SECTION 2.0
MONITORING PROGRAM

2.1 MONITORING NETWORK AND ANALYTICAL PARAMETERS

The monitoring network for the C&D landfill currently includes four (4) compliance groundwater monitoring wells (CD-1, CD-2, CD-3, & CD-4). These wells are monitored for constituents referenced in 15A NCAC 13B 0.544(b)(1)(D) on a semi-annual basis. The monitoring network is shown on **Figure 1**. Analytical parameters for each well are outlined in **Table 2**.

Additionally, applicable local, state, and federal health and safety requirements will be followed. Requirements for the disposal of any investigation derived wastes will also be followed.

2.2 GROUNDWATER SAMPLE COLLECTION

2.2.1 Introduction

This section presents details of the procedures and equipment required to perform groundwater field measurements and sampling from monitoring wells during each monitoring event. **Where possible, phases of work will proceed from the upgradient (background) wells to downgradient (compliance) wells.**

2.2.1.1 Guidance Documents

Sampling, analysis, and submittals shall be performed in accordance with this plan and the following guidance documents:

1. Groundwater, Surface Water and Soil Sampling for Landfills - NCDENR Guidance updated April 2008.

2. October 26, 2006 Memo from NCDENR entitled: "New Guidelines for Electronic Submittal of Environmental Monitoring Data".

3. February 23, 2007 Memo from NCDENR entitled Addendum to October 27, 2006 North Carolina Solid Waste Section Memorandum Regarding New Guidelines for Electronic Submittal of Environmental Data.

4. October 16, 2007 Memo from NCDENR entitled Environmental Monitoring Data for North Carolina Solid Waste Management Facilities.

2.2.1.2 Fuel Powered Equipment

Fuel-powered equipment, such as generators for pumps, must be situated away and downwind from all site activities (ie. purging and sampling). If field conditions prevent such placement, then the fuel source must be placed as far away as possible from the

sampling activities. The conditions of sampling must be described in detail in the field notes.

If fuel must be handled, it should be done the day before sampling. Effort should be made to avoid handling fuels on the day of sampling. If fuels must be dispensed during sampling activities, dispense fuel downwind and well away from any sampling locations. Wear gloves while working with fuel and dispose of the gloves away from sampling activities. Wash hands thoroughly after handling any fuels.

2.2.1.3 Equipment Decontamination

All non-dedicated equipment that will come in contact with the well casing and water will be decontaminated between wells. The procedure for decontaminating non-dedicated equipment is as follows:

1. Don new powder-free Nitrile gloves.
2. Clean item with tap water and phosphate-free laboratory detergent (Liquinox or equivalent), using a brush if necessary to remove particulate matter and surface films.
3. Rinse thoroughly with pesticide grade isopropanol and allow to air dry.
4. Rinse with organic-free water (Milli-Q water or other ultra-pure water) and allow to air dry.
5. Wrap with commercial-grade aluminum foil, if necessary, to prevent contamination of equipment during storage or transport.

It should be noted that Liqui-Nox detergent solutions will be stored in a clearly marked HDPE or PP container. Containers for pesticide-grade isopropanol will be made of inert materials such as Teflon, stainless steel, or glass.

Sampling will be planned and conducted in such a way as to minimize the need for decontamination in the field through the use of dedicated sampling equipment, or a new disposable Teflon bailer at each well. Unclean equipment will be segregated from clean equipment during all field activities. All clean equipment will remain in the manufacturer's packaging until use, or will be wrapped in commercial-grade aluminum foil or untreated butcher paper.

2.2.2 Water Level Measurements

2.2.2.1 Static Levels

Static water level and depth to the well bottom will be measured in each well prior to any purging or sampling activities. Static water level and well depth measurements are necessary to calculate the volume of stagnant water in the well prior to purging. Additionally, these measurements provide a field check on well integrity, degree of siltation, and are used to prepare potentiometric maps, calculate aquifer flow velocities

and monitor changes in site hydrogeologic conditions.

Groundwater depths will be measured to a vertical accuracy of 0.01 feet relative to established wellhead elevations, provided in **Table 1**. Each well will have a permanent, easily identified reference point on the lip of the well riser from which all water level measurements will be taken. The elevation of the reference point will be established by a Registered Land Surveyor.

2.2.2.2 Contamination Prevention

Upon opening each well, new latex or nitrile surgical gloves will be donned. Appropriate measures will be taken during all measurement activities to prevent soils, decontamination supplies, precipitation, and other potential contaminants from entering the well or contacting clean equipment.

2.2.2.3 Equipment

An electronic water level indicator will be used to accurately measure depth to groundwater in each well and/or piezometer. The electronic water level indicator will be constructed of inert materials such as stainless steel and Teflon (example). **Between each well, the device will be thoroughly decontaminated by washing with non-phosphate (Liqui-Nox) soap and rinsing with organic-free water to prevent cross contamination from one well to another.**

The following measurements will be recorded in a dedicated field book prior to sample collection (see **Section 5.0** for detailed description of field notes to be collected):

- Depth to static water level and well bottom (to the nearest 0.01 foot)
- Height of water column in the riser (based upon measured depth of well)
- Condition of wellhead protective casing, base pad, and riser
- Changes in condition of well and surroundings.

2.2.3 Well Evacuation

2.2.3.1 Description

Water accumulated in each well may be stagnant and unrepresentative of surrounding aquifer conditions, and therefore must be removed to insure that fresh formation water is sampled. Each well will be purged of standing water in the well casing following the measurement of the static water level. Monitoring well evacuation should be performed in upgradient wells first, then moving to downgradient wells.

2.2.3.2 Contamination Prevention

New latex or nitrile surgical gloves will be donned for all well purging and sampling activities and whenever handling decontaminated field equipment. Appropriate measures will be taken during all measurement, purging, and sampling activities to prevent surface soils, decontamination supplies, precipitation, and other potential contaminants from entering the well or contacting cleaned equipment.

2.2.3.3. Calculation

The volume of standing water in the well riser and screen will be calculated immediately before well evacuation during each monitoring event. A standing water volume will be calculated for each well using the measured static water level, well depth, and well casing diameter according to the following equation:

$$\mathbf{V = (TD - SWL) \times C}$$

Where:

V = One well volume
TD = Total depth of the well (in feet)
SWL = Static water level (in feet)
C = Volume constant for given well diameter (gallons/foot)
C = 0.163 gal/ft for two-inch wells.
C = 0.653 gal/ft for four-inch wells.

2.2.3.4 Well Purging

After the volume of standing water within the casing is established, a minimum of three and a maximum of five well volumes of water will be evacuated from each well. New, disposable bailers with either double or bottom check-valves will be used to purge each well. Disposable bailers will be constructed of fluorocarbon resin (Teflon) or inert plastic suitable for the well conditions. Each bailer will be factory-clean and remain sealed in a plastic sleeve until use. A new Teflon-coated stainless steel, inert mono-filament line, or nylon cord will be used for each well to retrieve the bailers. Alternately, well pumps which are cleaned between uses or are dedicated to each well may be used.

2.2.3.5 Purge Rate

Wells will be purged at a rate that will not cause recharge water to be excessively agitated or cascade through the screen. Care will also be taken to minimize disturbance to the well sidewalls and bottom which could result in the suspension of silt and fine particulate matter. The volume of water purged from each well and the relative rate of recharge will be documented in sampling field notes. Wells which are of very low recharge rates will be purged once until dry. Damaged, dry or low yielding, and high turbidity wells will noted for reconsideration before the next sampling event.

2.2.3.6 Purge Water Disposal

Purge water will be managed to prevent possible soil and surface water contamination. Well site management options may include temporary containment and disposal as leachate or portable activated carbon filtration.

2.2.3.7 Non-Dedicated Equipment

Durable, non-dedicated equipment to be lowered into the well or which may contact the water samples will be thoroughly decontaminated before each use. Equipment shall be disassembled to the degree practical, washed with (non-phosphate) soapy potable tap water, and triple rinsed using de-ionized water. Detailed equipment decontamination procedures are detailed in **Section 2.2.1.3**.

2.2.4 Sample Collection

After purging activities are complete, groundwater samples will be collected for laboratory analysis. Samples should be collected from least contaminated location(s) first, followed by locations of increasing contamination across the site. Prior to sample collection, all sample labels should be properly filled-out with permanent ink, such as Sharpie pen. At a minimum, the label should identify the sample with the following information:

- Sample Location or Well Number;
- Sample Identification Number;
- Date and Time of Collection;
- Analysis Required;
- Sampler's Initials;
- Preservative Used (if any); and
- Other Pertinent Information As Necessary.

Upon completion of the sample label, the label should be affixed to the sample bottle prior to sampling.

Sampling will occur within 24 hours of the purging of each well and as soon after well recovery as possible. Wells which fail to recharge or produce an adequate sample volume within 24 hours of purging will not be sampled.

2.2.4.1 Field Parameters

Field measurements of temperature, pH, and specific conductivity will be made immediately prior to sampling each monitoring point. The field test specimens will be collected with the sampling bailer and placed in a clean, non-conductive glass or plastic container for observation. The calibration of the pH, temperature, conductivity, and turbidity meters will be completed according to the manufacturers' specifications and consistent with Test Methods for Evaluating Solid Waste -Physical/Chemical Methods (SW-846). A pocket thermometer and litmus paper will be available in case of meter malfunction.

2.2.4.2 Sample Equipment

Each well will be sampled using a new, factory-cleaned, disposable Teflon bailer with bottom check-valve and sample discharge mechanism. A new segment of Teflon-coated stainless steel wire, inert mono-filament line or nylon cord will be used to lower and retrieve each bailer. The bailer will be lowered into each well to the point of groundwater contact, then allowed to fill as it sinks below the water table. Bottom contact will be avoided in order to avoid suspending sediment in the samples. The bailer will be retrieved and emptied in a manner which minimizes sample agitation.

2.2.4.3 Sample Transference

Samples will be transferred directly from the Teflon bailer into a sample container that has been specifically prepared for the preservation and storage of compatible parameters. A bottom emptying device provided will be used to transfer samples from bailer to sample container. The generation of air bubbles and sample agitation will be minimized during bailer discharge. Groundwater samples will be collected and contained in the order of volatilization sensitivity.

2.2.4.4 Order of Sample Collection

Initially, only purgeable organics and total metals samples will be collected for laboratory analysis. Subsequently, other analytical methods may be required. When collected, the following order of sampling will be observed:

- Volatile Organics and Volatile Inorganics;
- Extractable Organics, Petroleum Hydrocarbons, Aggregate Organics and Oil and Grease;
- Total Metals;
- Inorganic Nonmetallics, Physical and Aggregate Properties and Biologicals;
- Microbiologicals; and
- Measurements of pH, temperature, DO, ORP, conductivity and turbidity.

Note: Where applicable, if the pump used to collect groundwater samples is not suitable to collect volatile or extractable organics then collect all other parameters and withdraw the pump and tubing. Then collect the volatile and extractable organics.

All samples will be collected and analyzed in an **unfiltered** state during sampling events. Samples for dissolved metal analysis, if subsequently required, will be prepared by field filtration using a decontaminated peristaltic pump and a disposable 0.45 micron filter cartridge specifically manufactured for this purpose.

2.2.4.5 Decontamination

All reusable sampling equipment including water level probes, pH/conductivity meters, interface probes, and filtering pumps which might contact aquifer water or samples will be thoroughly decontaminated between wells by washing with non-phosphate soapy, de-ionized water and rinsing with isopropanol and organic-free water. Detailed equipment decontamination procedures are detailed in **Section 2.2.1.3**.

2.2.4.6 Sample Preservation

Upon completion of sampling at each location, the sample bottles will be placed in a cooler with ice, that is sealed in plastic zip bags, for preservation.

2.2.4.7 Field Quality Assurance

Field and trip blanks will be prepared, handled, and analyzed as groundwater samples to ensure cross-contamination has not occurred. One set of trip blanks, as described later in this document, will be prepared before leaving the laboratory to ensure that the sample containers or handling processes have not affected the quality of the samples. One set of field (equipment) blanks will be created in the field at the time of sampling to ensure that the field conditions, equipment, and handling during sampling collection have not affected the quality of the samples. A duplicate groundwater sample may be

collected from a single well as a check of laboratory accuracy. Where applicable, blanks and duplicate containers, preservatives, handling, and transport procedures for surface water samples will be the same as those noted for groundwater samples.

2.2.4.8 Sample Containers

Sample containers will be provided by the laboratory for each sampling event. Containers must be either new and factory-certified analytically clean by the manufacturer, or cleaned by the laboratory prior to shipment for sampling. Laboratory cleaning methods will be based on the bottle type and analyte of interest. Metal containers are thoroughly washed with non-phosphate detergent and tap water, and rinsed with (1:1) nitric acid, tap water, (1:1) hydrochloric acid, tap water, and deionized water, in that order. Organic sample containers are thoroughly washed with non-phosphate detergent in hot water and rinsed with tap water, distilled water, acetone, and pesticide quality hexane, in that order. Other sample containers are thoroughly washed with non-phosphate detergent and tap water, rinsed with tap water, and rinsed with deionized water. The laboratory shall provide proper preservatives in the sample containers prior to shipment (see **Section 6.0**).

SECTION 3.0
FIELD QA/QC PROGRAM

Field Quality Assurance/Quality Control (QA/QC) requires the routine collection and analysis of trip blanks to verify that the handling process has not affected the quality of the samples. Any contaminants found in the trip blanks could be attributed to:

1. Interaction between the sample and the container;
2. Contaminated source water; or
3. A handling procedure that alters the sample.

3.1 TRIP BLANK

The laboratory will prepare a trip blank by filling each type of sample bottle with laboratory grade distilled or deionized water. Trip blanks will be placed in bottles of the specific type required for the analyzed parameters and taken from a bottle pack specifically assembled by the laboratory for each groundwater sampling event. Trip blanks will be taken prior to the sampling event and transported with the empty bottle packs. The blanks will be analyzed for volatile and purgeable organics only.

3.2 TRIP BLANK CONCENTRATIONS

The concentration levels of any contaminants found in the trip blank will be reported but will not be used to correct the groundwater data. In the event that elevated parameter concentrations are found in a blank, the analysis will be flagged for future evaluation and possible re-sampling.

3.3 FIELD INSTRUMENTS

All field instruments utilized to measure groundwater characteristics will be calibrated prior to entering the field, and recalibrated in the field as required, to insure accurate measurement for each sample. The specific conductivity and pH meter shall be recalibrated utilizing two prepared solutions of known concentration in the range of anticipated values (between 4 and 10). A laboratory grade thermometer, calibrated against a National Bureau of Standards Certified thermometer, will be used for temperature meter calibration.

SECTION 4.0
SAMPLE PRESERVATION AND SHIPMENT

Methods of sample preservation, shipment, and chain-of-custody procedures to be observed between sampling and laboratory analysis are presented in the following sections.

4.1 SAMPLE PRESERVATION

Pre-measured chemical preservatives will be provided by the analytical laboratory. Hydrochloric acid will be used as a chemical stabilizer and preservative for volatile and purgeable organic specimens. Nitric acid will be used as the preservative for samples for metals analysis.

4.2 STORAGE/TRANSPORT CONDITIONS

Proper storage and transport conditions must be maintained in order to preserve the integrity of samples between collection and analysis. Ice and chemical cold packs will be used to cool and preserve samples, as directed by the analytical laboratory. Samples will be maintained at a temperature of 4° C. **Dry ice is not to be used**. Samples will be packed and/or wrapped in plastic bubble wrap to inhibit breakage or accidental spills.

Chain-of-custody control documents will be placed in a waterproof pouch and sealed inside the cooler with the samples for shipping. Tape and/or custody seals shall be placed on the outside of the shipping coolers, in a manner to prevent and detect tampering with the samples.

4.3 SAMPLE DELIVERY

Samples shall be delivered to the analytical laboratory within a 24-hour period in person or using an overnight delivery service to insure holding times are not exceeded. Shipment and receipt of samples will be coordinated with the laboratory. Do NOT store or ship highly contaminated samples (concentrated wastes, free product, etc.) or samples suspected of containing high concentrations of contaminants in the same cooler or shipping container with other environmental samples.

4.4 CHAIN-OF-CUSTODY

Chain-of-custody control will be maintained from sampling through analysis to prevent tampering with analytical specimens. Chain-of-custody control procedures for all samples will consist of the following:

1. Chain-of-custody will originate at the laboratory with the shipment of prepared sample bottles and a sealed trip blank. Identical container kits will be shipped by express carrier to the sampler or site or picked up at the laboratory in sealed coolers.

2. Upon receipt of the sample kit, the sampler will inventory the container kit and

check its consistency with number and types of containers indicated in the Chain-of-custody forms and required for the sampling event.

3. Labels for individual sample containers will be completed in the field, indicating the site, time of sampling, date of sampling, sample location/well number, and preservation methods used for the sample.

4. Collected specimens will be placed in the iced coolers and will remain in the continuous possession of the field technician until shipment or transferral as provided by the Chain-of-custody form has occurred. If continuous possession can not be maintained by the field technician, the coolers will be temporarily sealed and placed in a secured area.

5. Upon delivery to the laboratory, samples will be given laboratory sample numbers and recorded into a logbook indicating client, well number, and date and time of delivery. The laboratory director or his designee will sign the Chain-of-custody control forms and formally receive the samples. The field technician, project manager and the laboratory director will work together to insure that proper refrigeration of the samples is maintained.

6. Copies of the complete Chain-of-custody forms will be placed in the laboratory's analytical project file and attached to the laboratory analysis report upon completion.

Chain-of-custody forms will be used to transfer direct deliveries from the sampler to the laboratory. A coded, express delivery shipping bill shall constitute the Chain-of custody between the sampler and laboratory for overnight courier deliveries.

SECTION 5.0
FIELD LOGBOOK

The field technician will keep an up-to-date logbook documenting important information pertaining to the technician's field activities. The field logbook will document the following:

- Site Name and Location;
- Date and Time of Sampling ;
- Climatic Conditions During Sampling Event;
- Sampling Point/Well Identification Number;
- Well Static Water Level;
- Height of Water Column in Well**;**
- Purged Water Volume and Well Yield (High or Low);
- Presence of Immiscible Layers and Detection Method;
- Observations on Purging and Sampling Event;
- Time of Sample Collection;
- Temperature, pH, Temperature, DO, ORP, Turbidity, and Conductivity Readings;and
- Signature of Field Technician.

SECTION 6.0
LABORATORY ANALYSIS

The ground and surface water parameters will be analyzed for field indicators of water quality (pH, conductivity, temperature, and turbidity) and those constituents listed in **Table 2**. All analytical methods are taken from Test Methods For Evaluating Solid Waste - Physical/Chemical Methods (SW-846) or Methods For the Chemical Analysis of Water and Wastes and will be consistent with the Division of Waste Management's policies regarding analytical methods and reporting limits. Analysis will be performed by a laboratory certified by the North Carolina DENR for the analyzed parameters.

6.1 LABORATORY QUALITY ASSURANCE/QUALITY CONTROL

Formal environmental laboratory Quality Assurance/Quality Control (QA/QC) procedures are to be utilized at all times. The owner/operator of the landfill is responsible for selecting a laboratory contractor and insuring that the laboratory is utilizing proper QA/QC procedures. The laboratory must have a QA/QC program based upon specific routine procedures outlined in a written laboratory Quality Assurance/Quality Control Manual. The QA/QC procedures listed in the manual shall provide the lab with the necessary assurances and documentation that accuracy and precision goals are achieved in all analytical determinations. Internal quality control checks shall be undertaken regularly by the lab to assess the precision and accuracy of analytical procedures.

6.2 LABORATORY QUALITY CONTROL CHECKS

The internal quality control checks include the use of calibration standards, standard references, duplicate samples, and spiked or fortified samples. Calibration standards shall be verified against a standard reference obtained from an outside source. Calibration curves shall be developed using at least one blank and three standards. Samples shall be diluted if necessary to insure that analytical measurements fall on the linear portion of the calibration curve. Duplicate samples shall be processed at an average frequency of 10 percent to assess the precision of testing methods, and standard references shall be processed monthly to assess accuracy of analytical procedures. Spiked or fortified samples shall be carried through all stages of sample preparation and measurement to validate the accuracy of the analysis.

6.3 DATA REVIEW

During the course of the analyses, quality control data and sample data shall be reviewed by the laboratory manager to identify questionable data and determine if the necessary QA/QC requirements are being followed. If a portion of the lab work is subcontracted, it is the responsibility of the contracted laboratory to verify that all subcontracted work is completed by certified laboratories, using identical QA/QC procedures.

SECTION 7.0
RECORD KEEPING AND REPORTING

After each monitoring event, the potentiometric surface will be evaluated to determine whether the monitoring system remains adequate and to determine the rate and direction of groundwater flow at the site.

7.1 GROUNDWATER SYSTEM EVALUATIONS

The direction of groundwater flow will be determined by a comparison of groundwater surface elevations across the site through the construction of a potentiometric surface map. Groundwater flow rate will be determined using the following equation:

$$V=KI/n$$

Where: V = Velocity (feet/day)
K = Hydraulic Conductivity (feet/day)
I = Hydraulic Gradient (foot/foot)
n = Effective Porosity of aquifer soils (unitless)

If these evaluations indicate the groundwater monitoring system is insufficient in meeting the requirements of the Rules, the monitoring system will be modified accordingly and a work plan will be submitted to NCDENR for review prior to modifications to enhance the monitoring system.

7.2 RESULT REPORTING

Copies of all laboratory analytical data will be forwarded to the SWS within 60 calendar days of the receipt of laboratory data. The analytical data submitted will specify the date of sample collection, the sampling point identification, and include a map of sampling locations. Should a significant concentration of contaminants be detected in groundwater, as defined in North Carolina Solid Waste Rules, Groundwater Quality Standards, the owner/operator of the landfill shall notify the SWS and will place a notice in the landfill records as to which constituents were detected.

All monitoring reports will be submitted with the following:

- An evaluation of potentiometric surface;
- Analytical laboratory reports and summary tables;
- A Solid Waste Environmental Monitoring Reporting Form (**Attachment 1**); and
- Laboratory Data submitted in accordance with the Electronic Data Deliverable Template.

Monitoring reports may be submitted electronically by e-mail or in paper copy form. Copies of all laboratory results and water quality reports for the Washington County Landfill will be kept at the Landfill office. Reports summarizing all groundwater quality results and data evaluation will be submitted to the Division of Waste Management for each sampling event. Depending upon the analytical results received, graphical analyses may be performed to evaluate plume movement and contaminant trends over time.

SECTION 8.0
MONITORING PROGRAM MODIFICATIONS

8.1 WELL ABANDONMENT/REHABILITATION

After each groundwater monitoring event, the potentiometric surface will be evaluated to determine whether the monitoring system remains adequate and to determine the rate and direction of groundwater flow at the site.

Should wells become irreversibly damaged or require rehabilitation, the SWS shall be notified. If monitoring wells and/or piezometers are damaged irreversibly they shall be abandoned under the direction of the SWS. The abandonment procedure in unconsolidated materials will consist of over-drilling and/or pulling the well casing and plugging the well with an impermeable, chemically-inert sealant such as neat cement grout and/or bentonite clay. For bedrock well completions the abandonment will consist of plugging the interior well riser and screen with an impermeable neat cement grout and/or bentonite clay sealant.

8.2 ADDITIONAL WELL INSTALLATIONS

Any additional well installations will be carried out in accordance with SWS directives. If the potentiometric maps reveal that the depths, location, or number of wells is insufficient to monitor potential releases of solid waste constituents from the solid waste management area, new well locations and depths will be submitted to the SWS for approval.

All monitoring wells shall be installed under the supervision of a geologist or engineer who is registered in North Carolina and who will certify to the SWS that the installation complies with the North Carolina Regulations. Upon installation of future wells, the documentation for the construction of each well will be submitted by the registered geologist or engineer within 30 days after well construction.

8.3 IMPLEMENTATION SCHEDULE

This monitoring program will be implemented upon approval of this Water Quality Monitoring Plan.

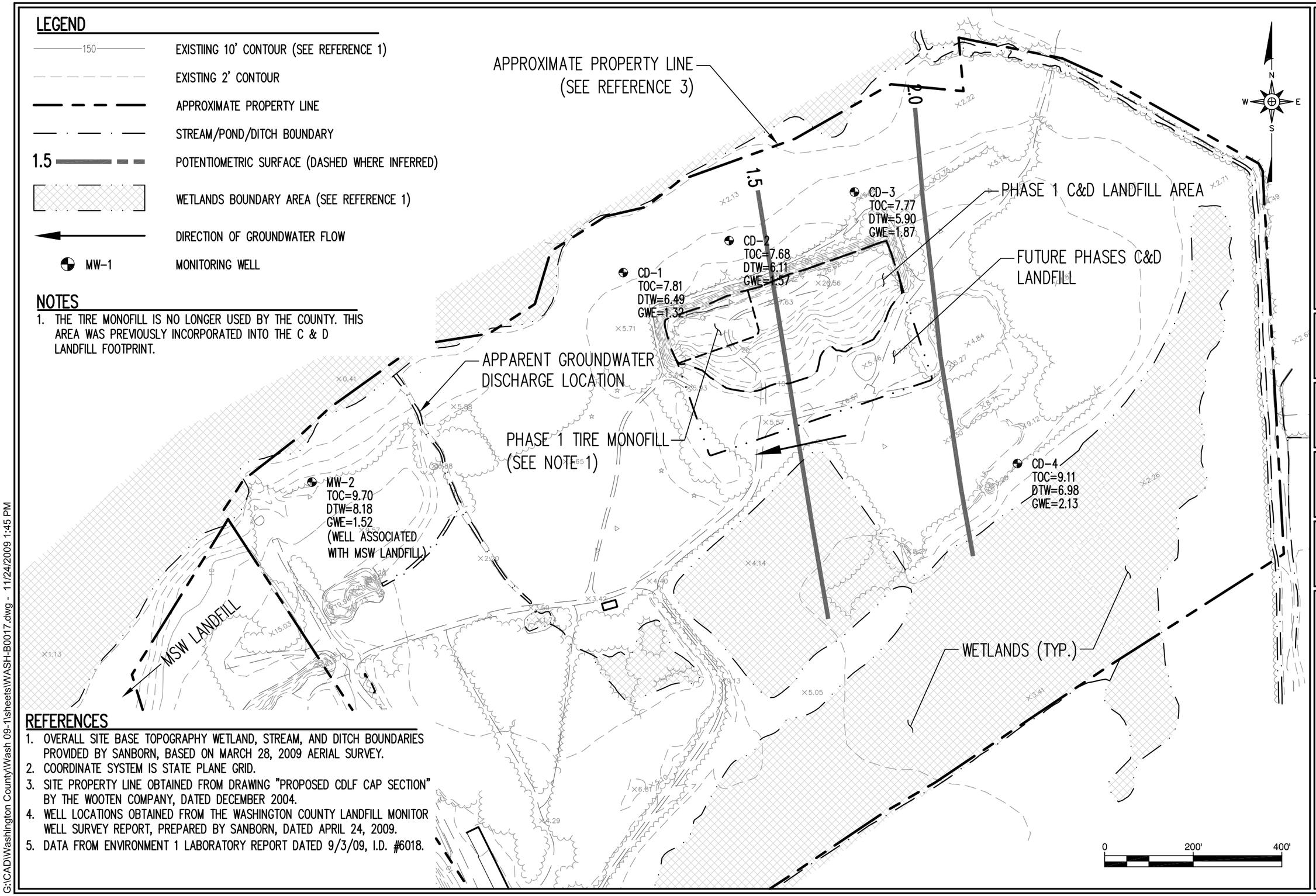
Figures

LEGEND

- 150 — EXISTIING 10' CONTOUR (SEE REFERENCE 1)
- EXISTING 2' CONTOUR
- APPROXIMATE PROPERTY LINE
- STREAM/POND/DITCH BOUNDARY
- 1.5 — POTENTIOMETRIC SURFACE (DASHED WHERE INFERRED)
- WETLANDS BOUNDARY AREA (SEE REFERENCE 1)
- DIRECTION OF GROUNDWATER FLOW
- MW-1 — MONITORING WELL

NOTES

1. THE TIRE MONOFILL IS NO LONGER USED BY THE COUNTY. THIS AREA WAS PREVIOUSLY INCORPORATED INTO THE C & D LANDFILL FOOTPRINT.



REFERENCES

1. OVERALL SITE BASE TOPOGRAPHY WETLAND, STREAM, AND DITCH BOUNDARIES PROVIDED BY SANBORN, BASED ON MARCH 28, 2009 AERIAL SURVEY.
2. COORDINATE SYSTEM IS STATE PLANE GRID.
3. SITE PROPERTY LINE OBTAINED FROM DRAWING "PROPOSED CDLF CAP SECTION" BY THE WOOTEN COMPANY, DATED DECEMBER 2004.
4. WELL LOCATIONS OBTAINED FROM THE WASHINGTON COUNTY LANDFILL MONITOR WELL SURVEY REPORT, PREPARED BY SANBORN, DATED APRIL 24, 2009.
5. DATA FROM ENVIRONMENT 1 LABORATORY REPORT DATED 9/3/09, I.D. #6018.

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FIGURE NO.	1
FILE NAME	WASH-B0017
SCALE:	AS SHOWN
PROJECT NO.	WASH 09-1
CHECKED BY:	J.A.S.
DRAWN BY:	C.T.J.
DATE:	Nov. 2009

TITLE: WASHINGTON COUNTY C&D LANDFILL SITE MAP WITH MONITORING NETWORK

G:\CAD\Washington County\Wash 09-1\sheets\WASH-B0017.dwg - 11/24/2009 1:45 PM

Tables

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RALEIGH, NORTH CAROLINA 27603
NC. LIC. NO. C0828 (ENGINEERING)

By: JAS
Date: 11/18/09

Table 1

Monitoring Well Completion Information
Washington County C&D Landfill
Roper, North Carolina

Monitoring Well	Northing	Easting	Top of Casing Elevation	Depth to Well Bottom	Depth to Water 9/09	Upgradient/ downgradient
CD-1	799028.14	2691515.73	7.81	22.90	6.49	Down
CD-2	799100.9	2691755.17	7.68	19.90	6.11	Down
CD-3	799210.55	2692038.09	7.77	21.45	5.90	Cross
CD-4	798597.78	2692406.42	9.11	20.67	6.98	Up

Notes: 1. Survey data from Sanborn Survey Report dated 4/24/09
2. Depth to Well Bottom measured from Top of Casing by Environment 1 personnel.

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By: JAS
Date: 10/15/09

Table 2

Appendix I Analyte List with C&D Landfill Indicator Analytes

Appendix I Constituents	EPA Method	Synonyms	2L or GWP Standard
Antimony	7041		1.4
Arsenic	7060/7061		50
Barium	7080/6010		2000
Beryllium	7091		4
Cadmium	7131		1.75
Chloride	SM4500 CLB		250000
Chromium	7191		50
Cobalt	7201		70
Copper	7210/6010		1000
Iron	7300		300
Lead	7421		15
Manganese	200.7		50
Mercury	245.1		1.05
Nickel	7520/6010		100
Selenium	7740/7741		50
Silver	7761		17.5
Sulfate	SM4500		250000
Thallium	7841		0.28
Vanadium	7911		3.5
Zinc	7950/6010		1050
Temperature	Field		na
pH	Field		6 - 8
Specific Conductance	Field		na
Alkalinity	SM2320B		na
Total Dissolved Solids	SM2540C		na
Acetone	8260	2-Propanone	700
Acrylonitrile	8260	2-Propenenitrile	na
Benzene	8260		1
Bromochloromethane	8260	Chlorobromomethane	0.6
Bromodichloromethane	8260	Dibromochloromethane	0.56
Bromoform	8260	Tribromomethane	4.43
Carbon Disulfide	8260		700
Carbon Tetrachloride	8260	Tetrachloromethane	0.269
Chlorobenzene	8260		50
Chloroethane	8260	Ethyl chloride	2800
Chloroform	8260	Trichloromethane	70
Dibromochloromethane	8260	Chlorodibromomethane	0.41
1,2-Dibromo-3-chloropropane	8260	DBCP	0.025
1,2-Dibromoethane	8260	Ethylene dibromide, EDB	0.0004
1,2-Dichlorobenzene	8260	o-Dichlorobenzene	24
1,4-Dichlorobenzene	8260	p-Dichlorobenzene	1.4
trans-1,4-Dichloro-2-butene	8260		na
1,1-Dichloroethane	8260	Ethyldidene chloride	70
1,2-Dichloroethane	8260	Ethylene dichloride	0.38
1,1-Dichloroethylene	8260	Vinylidene chloride	7
cis-1,2-Dichloroethylene	8260		70
trans-1,2-Dichloroethylene	8260		100
1,2-Dichloropropane	8260	Propylene dichloride	0.51
cis-1,3-Dichloropropene	8260		0.19
trans-1,3-Dichloropropene	8260		0.19
Ethylbenzene	8260		550
2-Hexanone	8260	Methyl butyl ketone	280
Methyl bromide	8260	Bromomethane	na
Methyl chloride	8260	Chloromethane	2.6
Methyl ethyl ketone	8260	2-Butanone	4200
Methyl iodide	8260	Iodomethane	na
4-Methyl-2-pentanone	8260	Methyl isobutyl ketone	560
Methylene bromide	8260	Dibromomethane	na
Methylene chloride	8260	Dichloromethane	4.6
Styrene	8260	Ethenylbenzene	100
1,1,1,2-Tetrachloroethane	8260		1.3
1,1,2,2-Tetrachloroethane	8260		0.18
Tetrachloroethylene	8260	Perchloroethylene	0.7
Toluene	8260	Methyl benzene	1000
1,1,1-Trichloroethane	8260	Methyl chloroform	200
1,1,2-Trichloroethane	8260		0.6
Trichloroethylene	8260		2.8
Trichloroflouromethane	8260	CFC-11	2100
1,2,3-Trichloropropane	8260		0.005
Vinyl acetate	8260	Acetic acid, ethenyl ester	7000
Vinyl chloride	8260	Choroethene	0.015
Xylenes	8260	Dimethyl benzene	530

All concentrations in ug/l
NC 2L is the ground water standard for each constituent.GWP is Groundwater Protection Standard.
Detections abovve these concentrations are considered to require source determination, and possible assessment and remediation.
na = no standard available

Attachment 1

DENR USE ONLY: ☐ Paper Report ☐ Electronic Data - Email CD (data loaded: Yes / No) Doc/Event #:

NC DENR
Division of Waste Management - Solid Waste

Environmental Monitoring Reporting Form

Notice: This form and any information attached to it are "Public Records" as defined in NC General Statute 132-1. As such, these documents are available for inspection and examination by any person upon request (NC General Statute 132-6).

Instructions:

- **Prepare one form for each individually monitored unit.**
- **Please type or print legibly.**
- Attach a notification table with values that attain or exceed NC 2L groundwater standards or NC 2B surface water standards. The notification must include a preliminary analysis of the cause and significance of each value. (e.g. naturally occurring, off-site source, pre-existing condition, etc.).
- Attach a notification table of any groundwater or surface water values that equal or exceed the reporting limits.
- Attach a notification table of any methane gas values that attain or exceed explosive gas levels. This includes any structures on or nearby the facility (NCAC 13B .1629 (4)(a)(i).
- Send the original signed and sealed form, any tables, and Electronic Data Deliverable to: Compliance Unit, NCDENR-DWM, Solid Waste Section, 1646 Mail Service Center, Raleigh, NC 27699-1646.

Solid Waste Monitoring Data Submittal Information

Name of entity submitting data (laboratory, consultant, facility owner):

Contact for questions about data formatting. Include data preparer's name, telephone number and E-mail address:

Name: _____ Phone: _____

E-mail: _____

Facility name:	Facility Address:	Facility Permit #	NC Landfill Rule: (.0500 or .1600)	Actual sampling dates (e.g., October 20-24, 2006)

Environmental Status: (Check all that apply)

☐ Initial/Background Monitoring ☐ Detection Monitoring ☐ Assessment Monitoring ☐ Corrective Action

Type of data submitted: (Check all that apply)

☐ Groundwater monitoring data from monitoring wells
☐ Groundwater monitoring data from private water supply wells
☐ Leachate monitoring data
☐ Surface water monitoring data
☐ Methane gas monitoring data
☐ Corrective action data (specify) _____
☐ Other(specify) _____

Notification attached?

☐ No. No groundwater or surface water standards were exceeded.
☐ Yes, a notification of values exceeding a groundwater or surface water standard is attached. It includes a list of groundwater and surface water monitoring points, dates, analytical values, NC 2L groundwater standard, NC 2B surface water standard or NC Solid Waste GWPS and preliminary analysis of the cause and significance of any concentration.
☐ Yes, a notification of values exceeding an explosive methane gas limit is attached. It includes the methane monitoring points, dates, sample values and explosive methane gas limits.

Certification

To the best of **my knowledge, the information reported** and statements made **on this data submittal and attachments are true and correct. Furthermore, I have attached complete notification of any sampling values meeting or exceeding groundwater standards or explosive gas levels, and a preliminary analysis of the cause and significance of concentrations exceeding groundwater standards. I am aware that there are significant penalties for making any false statement, representation, or certification including the possibility of a fine and imprisonment.**

Facility Representative Name (Print) Title (Area Code) Telephone Number

Affix NC Licensed/ Professional Geologist Seal

Signature Date

Facility Representative Address

NC PE Firm License Number (if applicable effective May 1, 2009)

Revised 6/2009

ATTACHMENT G

PERMIT AMENDMENT DRAWINGS

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ATTACHMENT I

LOCAL GOVERNMENT APPROVAL DOCUMENTATION

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WASHINGTON COUNTY C&D LANDFILL
PHASE 2

LOCAL GOVERNMENT APPROVAL DOCUMENTATION

TABLE OF CONTENTS

1.0 Legal Notice of Public Meeting*

2.0 Information for Adjacent Property Owners*
- List of Recipients
- Example Letter
- Certified Mail Receipts

3.0 Information from _____, 2010 Commissioner's Meeting*
- Agenda
- Copy of RSG PowerPoint Presentation
- Approved Resolution
- Meeting Minutes

4.0 Letter Demonstrating Consistency with Zoning Ordinances*

*To be provided when obtained/approved.

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