# FINAL CLOSURE AND POST CLOSURE PLAN
# COAL ASH LANDFILL COVER SYSTEM
# ASH LANDFILL PERMIT SW-09/01

**INVISTA SITE**
**SEAFORD, DELAWARE**

**Prepared For:**
**INVISTA S.à.r.l**


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TABLE OF CONTENTS


Page

1.0 INTRODUCTION ..... 1
1.1 SCOPE OF REMEDY ..... 1
1.2 PLAN ORGANIZATION ..... 2

2.0 SITE BACKGROUND ..... 4
2.1 SITE LOCATION AND DESCRIPTION ..... 4
2.2 SITE HISTORY AND OPERATIONS ..... 4
2.3 REGIONAL AND SITE GEOLOGY ..... 5
2.4 REGIONAL AND SITE HYDROGEOLOGY ..... 6

3.0 LANDFILL BACKGROUND ..... 7
3.1 ASH PRODUCTION ..... 7
3.2 COAL ASH SETTLING PONDS ..... 8
3.3 LANDFILL OPERATIONS ..... 9
3.3.1 TRANSPORTATION TO LANDFILL ..... 9
3.3.2 PLACEMENT AND COMPACTION OF ASH ..... 9
3.3.3 STORMWATER, EROSION, AND SEDIMENT CONTROL ..... 9

4.0 FINAL DESIGN APPROACH ..... 10
4.1 DESIGN OBJECTIVES ..... 10
4.2 SITE-SPECIFIC DESIGN CONSIDERATIONS ..... 10
4.3 REVISED CONTOUR DESIGN ..... 11
4.4 COVER SYSTEM COMPONENTS ..... 12
4.4.1 FINAL ASH/SOIL GRADING LAYER (SELECT FILL) ..... 12
4.4.2 BARRIER LAYER (GEOMEMBRANE) ..... 14
4.4.3 BARRIER PROTECTION LAYER (SUBSURFACE SAND DRAINAGE LAYER) ..... 14
4.4.4 BARRIER PROTECTION LAYER (GENERAL FILL) ..... 15
4.4.5 TOPSOIL AND VEGETATIVE LAYER ..... 15
4.5 COVER SYSTEM PERFORMANCE ..... 15
4.5.1 LANDFILL COVER MODELING ..... 15
4.5.2 SLOPE STABILITY ANALYSIS ..... 18
4.5.3 SOIL LOSS/EROSION CONTROL ..... 19
4.6 STORMWATER MANAGEMENT ..... 20
4.7 POST-CLOSURE PLAN ..... 21

5.0 COVER SYSTEM CONSTRUCTION ..... 22
5.1 CONSTRUCTION PROCEDURES ..... 22
5.2 SURVEY CONTROL ..... 24
5.3 DUST CONTROL ..... 24
5.4 STORMWATER CONTROL ..... 25
5.5 HEALTH AND SAFETY ..... 26
5.6 CONSTRUCTION QUALITY CONTROL ..... 26

TABLE OF CONTENTS

Page

6.0 CONSTRUCTION SCHEDULE ..... 27

7.0 FINANCIAL ASSURANCE ..... 28
7.1 CLOSURE COSTS ..... 28
7.2 POST-CLOSURE COSTS ..... 28
7.3 INSURANCE POLICY ..... 29

## LIST OF FIGURES
(Following Text)


FIGURE 1 SITE LOCATION MAP

FIGURE 2 SITE PLAN

FIGURE 3 TENTATIVE CLOSURE SCHEDULE


## LIST OF TABLES
(Following Text)


TABLE 1 HELP MODEL SUMMARY

TABLE 2 COVER STABILITY ANALYSES

TABLE 3 COAL ASH LANDFILL CLOSURE AND POST-CLOSURE CARE COST ESTIMATES

# LIST OF APPENDICES


| | |
|---|---|
| APPENDIX A | DESIGN DRAWINGS |
| APPENDIX B | TECHNICAL SPECIFICATIONS |
| APPENDIX C | COVER SOIL STABILITY CALCULATIONS |
| APPENDIX D | HELP MODELING CALCULATIONS |
| APPENDIX E | SOIL LOSS/EROSION CALCULATIONS |
| APPENDIX F | POST-CLOSURE PLAN |
| APPENDIX G | CONSTRUCTION QUALITY ASSURANCE PLAN (CQAP) |
| APPENDIX H | FINANCIAL ASSURANCE INFORMATION |

## 1.0 INTRODUCTION

This Final Closure Plan (FCP) presents a remedial design work plan for closure of the Coal Ash Landfill and construction of the Coal Ash Landfill Final Cover System at the INVISTA S.à.r.l (INVISTA) Nylon Site in Seaford, Delaware (Site), in compliance with the Ash Landfill Permit SW-09/01. Conestoga-Rovers & Associates, Inc. (CRA) has prepared this FCP for submittal to the Delaware Department of Natural Resources and Environmental Control's (DNREC's) Solid and Hazardous Waste Management Branch (SHWMB). Figure 1 presents the location of the INVISTA Site within the Seaford area, while Figure 2 presents the location of the Coal Ash Landfill within the INVISTA Site.

### 1.1 SCOPE OF REMEDY

This FCP is intended to provide for a long-term, environmentally sound closure of the existing Coal Ash Landfill at the INVISTA Site, subsequent to placement of final coal ash in the landfill. The process of closing the Coal Ash Landfill will consist of construction of the final cover system, as presented in subsequent sections of this FCP. This FCP replaces the previous Conceptual Closure Plan originally submitted to DNREC in September 2003 and revised on July 25, 2007 as part of the re-submittal of the Solid Waste Permit renewal application. The final cover system will not be placed until the remaining ash is removed from the Coal Ash Settling Ponds (located elsewhere on the INVISTA Site) and relocated to the Coal Ash Landfill for appropriate placement. The design for the closure of the Coal Ash Settling Ponds was presented to DNREC in a separate plan, which was approved on July 13, 2010.

The aforementioned Conceptual Closure Plan and a jointly prepared Engineering Report for the INVISTA Seaford Powerhouse Ash Landfill, dated September 2003, presented the previously planned landfill operations and closure of the Coal Ash Landfill. These two documents assumed filling of the landfill until 2027 based on the continued use of the Coal Ash Settling Ponds. However, as the INVISTA Site discontinued the burning of coal in its power plant in April 2009, the Coal Ash Landfill is anticipated to be closed in 2012/2013 (in conjunction with closure of the Coal Ash Settling Ponds). These two previous reports are not directly connected to this Coal Ash Landfill FCP (i.e., do not form any part of this report); however, pertinent information from these two historical documents is incorporated into this FCP, where appropriate.

The previously submitted cover system design for the Coal Ash Landfill, as identified in the historical Conceptual Closure Plan consisted of a 40-mil high density polyethylene (HDPE) geomembrane, 12 inches of protective soil cover, and 6 inches of topsoil capable

of sustaining vegetative growth. This FCP presents an updated cover system design whereby the protective soil cover depth is increased from 12 inches to 18 inches by adding a 12-inch sand drainage layer directly above the geomembrane (while reducing the common fill layer to 6 inches in depth), the geomembrane material is changed from HDPE to a linear low density polyethylene (LLDPE), and, if necessary, up to 6 inches of grading fill is placed over the landfilled coal ash material for protection of the overlying geomembrane and/or stabilization of the coal ash. The details of the final cover system are presented on the attached design drawings in Appendix A. Detailed descriptions of each of the cover system components are presented in subsequent sections of this FCP, including the rationale for additional and amended cover system components.

The final cover system is designed to meet the following remedial action objectives:

- Minimize need for further maintenance
- Prevent the post-closure escape/release of solid waste constituents, leachate, and landfill gases to the surface water, groundwater, or atmosphere
- Prevent direct contact with ash materials
- Minimize infiltration to groundwater
- Mitigate soil erosion and runoff
- Provide stormwater management to protect water quality
- Promote establishment of vegetative cover.

## 1.2 PLAN ORGANIZATION

Subsequent to this introductory section, the remainder of this Coal Ash Landfill FCP is organized as follows:

Section 2.0 Site Background – provides Site background information relative to this plan

Section 3.0 Landfill Background – Includes specific information about the past use of the coal ash landfill

Section 4.0 Final Design Approach – Provides an overview of the approach to close the coal ash landfill as previously discussed with DNREC

Section 5.0 Cover System Construction – Provides specific construction details and expectations in conjunction with supporting attached appendices, which define the closure requirements

Section 6.0 Construction Schedule – Includes the currently anticipated construction schedule

Section 7.0 Financial Assurance – Includes updated financial assurance information considering the planned design

The selected contractor will be required to prepare the following documents:

- A Work Plan for executing the final cover system construction activities, which meets all of the requirements of this Coal Ash Landfill FCP and facility-specific requirements
- A comprehensive Health and Safety Plan (HASP) for use during the Coal Ash Landfill closure implementation
- A Storm Water Management Plan (SWMP) for use during construction of final cover system as well as upon completion of construction
- An Erosion and Sedimentation (E&S) Plan for all earth work to be conducted during the closure implementation and for final cover system maintenance until vegetation has been firmly established (1 - 2 years)

## 2.0 SITE BACKGROUND

### 2.1 SITE LOCATION AND DESCRIPTION

The INVISTA Site is located at 25876 DuPont Road, southeast of the town of Seaford, Delaware. Seaford is located in the southwest portion of the state, in Sussex County, Delaware and is situated along U.S. Route 13, the main north-south artery running from Wilmington, Delaware to Norfolk, Virginia.

INVISTA operates a nylon textiles manufacturing Site on a 650-acre property, which included a coal-burning power plant for the generation of steam and electricity to operate the Site. Historically, three steam boilers burned bituminous coal for steam and power generation; however, the Seaford operations were re-structured and, as a result, the Site discontinued the burning of coal in its power plant in April 2009. Current and future steam needs will be provided by natural gas fired boilers.

### 2.2 SITE HISTORY AND OPERATIONS

INVISTA purchased the assets and operations of the Site from E.I. Du Pont de Nemours & Company (DuPont) in April 2004. The Coal Ash Landfill permit (Solid Waste Permit SW-98/01) was transferred from DuPont to INVISTA in June 2005.

The Site has been the subject of a RCRA Corrective Action (CA) under DNREC and US EPA. Nineteen (19) Solid Waste Management Units (SWMUs) were identified and investigated. Remedial action was proposed at three of these SWMUs, of which one is the combined SWMU 7/12/13 (which includes the Coal Ash Settling Ponds, Process Settling Impoundments, and Coal Ash Landfill, respectively). This SWMU is co-located with the units that INVISTA proposes to close with the remedial designs developed in this Coal Ash Landfill FCP.

The Coal Ash Landfill received the ash generated from the on-Site power plant. When burning coal, the power plant generated two by-products, fly ash and bottom ash. The fly ash and bottom ash were sluiced to one of two Coal Ash Settling Ponds located to the south of the power plant. When the settling pond receiving ash was full, the flow was diverted to the other (empty) settling pond, while the ash in the first (full) settling pond was allowed to dry out. The full settling pond was then sampled to verify that the ash was non-hazardous.

Operation of the Coal Ash Landfill has remained consistent since the RCRA assessment activities were initiated in the 1980s at the INVISTA Site. The Coal Ash Landfill is located within SWMU 7/12/13. This area was thoroughly assessed and evaluated by DNREC and U.S. EPA during the RFI/CMS process and a Record of Decision (ROD) was issued for the Site, which included SWMU 7/12/13.

The coal ash generated at the INVISTA Site has never exceeded Resource Conservation and Recovery Act (RCRA) Toxic Characteristic Leaching Procedure (TCLP) levels.

After the ash was verified to be non-hazardous, the ash material was excavated from the full settling pond and placed in the permitted Coal Ash Landfill in accordance with the DNREC Solid Waste Permit SW-09/01. The Coal Ash Landfill has accepted ash under a DNREC permit since 1979. As previously mentioned, the landfill anticipated receipt of the coal ash until 2027; however, with the re-structuring of the Site operations and the discontinued use of coal in the facility's power plant, INVISTA has decided to close the Coal Ash Settling Ponds and the Coal Ash Landfill after the material that is currently stored in the Coal Ash Settling Ponds is excavated and placed in the Coal Ash Landfill.

## 2.3 REGIONAL AND SITE GEOLOGY

Delaware lies within two geologic provinces, the Piedmont and the Atlantic Coastal Plain, separated by the fall line in New Castle County. The Atlantic Coastal Plan of New Castle, Kent, and Sussex counties, south of the fall line, is composed of a thickening wedge of unconsolidated sedimentary beds, dipping to the southeast. These sediments are generally comprised of sand, clay, and gravel. In western Sussex County, where the INVISTA Site is located, the thickness of these sediments ranges from 4,200 feet in the northwest to 5,500 feet in the southeast.

The INVISTA Site and the Coal Ash Landfill are situated within the Atlantic Coastal Plain physiographic province and are underlain by unconsolidated sediments of the Beaverdam Formation. Although not entirely certain, it is thought that the Beaverdam Formation is of the Pliocene age, and is unconformably overlaid by the Columbia Formation.

The Columbia Formation is widespread throughout northern Delaware and the majority of the State's aquifers are composed of its sands and gravels. However, it appears that the Beaverdam Formation is the geologic unit occurring at land surface over much of the Seaford area (and the younger Columbia Formation is absent in this part of the state).

Additional information regarding the regional geology and geologic deposits in the immediate vicinity of the INVISTA Site is provided in the ARCADIS report entitled "Ash Landfill Hydrogeologic Assessment" dated August 31, 2003 and revised on May 30, 2006, which was previously submitted to DNREC's Solid Waste Group.

## 2.4 REGIONAL AND SITE HYDROGEOLOGY

Groundwater occurs in the Beaverdam Formation in the Seaford area. The Beaverdam Formation is divided into the upper zone (silty to fine sand and clayey silt) and the lower zone (medium to coarse sand and gravel). The lower zone can be as much as 70 feet thick and the upper zone can be as much as 35 feet thick. Total thickness of the Beaverdam Formation ranges from 55 to 100 feet. Groundwater withdrawals from the Seaford area are taken primarily from the upper 100 feet of sediment. The Beaverdam Formation is underlain by the Chesapeake Group, which consists primarily of silt.

Previous investigative work at the INVISTA Site has included the monitoring of both a shallow (upper) and a deep (lower) groundwater aquifer beneath the Site. A downward hydraulic gradient has historically been observed, with the head difference indicating that a confining layer is present between the two aquifers. The Nanticoke River experiences daily tidal fluctuations and these cycles affect groundwater elevations in the shallow aquifer.

Specific information regarding the groundwater flows and the water quality within the shallow and deep aquifer zones beneath the Coal Ash Landfill and the INVISTA Site is provided in the previously referenced "Ash Landfill Hydrogeologic Assessment" report.

## 3.0 LANDFILL BACKGROUND

The Coal Ash Landfill at the INVISTA Site has accepted ash under a DNREC permit since 1979. The original Solid Waste Permit (SW-91/02) was renewed by DNREC and issued as Permit SW-98/01 in January 1998 pursuant to Section 4.1.1.1 of the Delaware Regulations Governing Solid Waste (DRGSW), with a number of modifications being made over the next several years for various reasons.

INVISTA submitted a permit renewal application on May 31, 2006 to Mr. Bryan Ashby of the SHWMB, since the previous Solid Waste Permit was set to expire on January 15, 2007. The renewal application included several accompanying documents including the aforementioned September 2003 Engineering Report, plus a May 2006 addendum, and the corresponding September 2003 Conceptual Closure Plan, which was subsequently revised on July 25, 2007. Following comments received from SHWMB on May 25, 2007 and responses provided by INVISTA on July 27, 2007 (as part of the re-submittal of the Coal Ash Landfill Permit Renewal Application), the new Solid Waste Permit SW-09/01 was issued and became effective on May 15, 2009.

The Engineering Report for the INVISTA Coal Ash Landfill included engineering design drawings for placement of ash until 2027 and the eventual closure of the Coal Ash Landfill thereafter. Additional details regarding the closure of the Coal Ash Landfill were presented in the accompanying Conceptual Closure Plan. All pertinent information previously presented in these two historical documents has been incorporated into this Coal Ash Landfill FCP (such that this report is comprehensive and the previous reports are not required to fully understand the proposed design concepts presented in this FCP). The subsequent sections of this FCP summarize the ash handling procedures at the INVISTA Site from production through storage in the Coal Ash Settling Ponds and eventual disposal at the Coal Ash Landfill, as previously described in detail in the two aforementioned documents.

### 3.1 ASH PRODUCTION

Three steam boilers burned bituminous coal for steam and power generation at the Seaford powerhouse and this burning of coal produced two by-products, bottom ash and fly ash. The bottom ash was collected in a large, refractory hopper at the bottom of each boiler and in the base of the main powerhouse stack. All other ash was considered fly ash and was collected at several different locations along the gas release system, with each location having one or more hoppers.

Of the ash produced from the combustion of coal, approximately 85 percent (by volume) was fly ash and the other 15 percent was bottom ash. Physically, there was not much difference between the generated bottom ash and fly ash, other than particle size. The bottom ash passed through a grinder as it was sluiced to the Settling Ponds such that its particle size distribution became similar to that of fly ash. The amount of ash generated per year was approximately 25,000 tons (dry weight) based on a material balance.

## 3.2 COAL ASH SETTLING PONDS

Separate procedures were used for transferring the bottom ash and fly ash to the Coal Ash Settling Ponds. The fly ash from the various hoppers was conveyed pneumatically by vacuum through a water jet exhauster system where it was mixed with water and discharged into a sluice pit. The smaller amounts of bottom ash were periodically removed from the refractory-lined hoppers by a water spray system, and then allowed to flow into a trench through a clinker grinder and into the same sluice pit as the fly ash. The combined ash material was then transferred via piping to the settling ponds using sluice pumps with the capability of 1,000 to 1,200 gallons per minute (gpm).

There are two Coal Ash Settling Ponds and an associated finishing pond located south of the powerhouse. The north pond is approximately 480 feet long, while the south pond is approximately 650 feet long, and both ponds are between 300 and 320 feet wide (so the south pond is about 35 percent larger than the north pond). The north and south ponds are approximately 3.4 and 4.6 acres in size, respectively. In between the two settling ponds is a secondary (finishing) pond approximately 1.3 acres in size. The total overall depth of the three ponds is approximately 14.5 feet, with the bottom elevations being approximately 4.0 feet above mean sea level (amsl) and the top of the perimeter berm being approximately 18.5 feet amsl.

During past operations, the Coal Ash Settling Ponds were filled to the 17.0-foot overflow elevation, which resulted in approximately 55,000 cubic yards (c.y.) of settled ash in the north pond and approximately 80,000 c.y. in the south pond, when full. At present, the north pond is full and the south pond is approximately at 80 to 90 percent of capacity.

As the solid-liquid separation occurred and the ash settled to the bottom of the ponds, the accumulating water on top was allowed to overflow to the secondary finishing pond located between the north and south ponds. The finishing pond has an overflow at an approximate elevation of 12.0 feet amsl, with a fixed boom located around the overflow. The overflowing water discharged through a weir box into an adjacent effluent ditch which discharged to the Nanticoke River. This overflow discharge is regulated as Outfall 007 under the Site's NPDES permit.

## 3.3 LANDFILL OPERATIONS

### 3.3.1 TRANSPORTATION TO LANDFILL

After the solid-liquid separation occurred and the ash settled to the bottom of the ponds, the ponds were typically left to dewater through natural drainage, evaporation, and via a dewatering trench with a sump and transfer pump. The settled ash in the two ponds was excavated, as each individual settling pond reached capacity, and was transported to the nearby landfill using standard earth moving equipment (i.e., front end loaders, dragline cranes, dump trucks, etc.). Existing on-Site haul roads were used to transport the ash from the Coal Ash Settling Ponds to the Coal Ash Landfill. Additional details regarding the past practices for ash transportation to the Coal Ash Landfill are provided in the Engineering Report for the INVISTA Seaford Powerhouse Ash Landfill.

### 3.3.2 PLACEMENT AND COMPACTION OF ASH

Prior to placement of the excavated ash from the Coal Ash Settling Ponds at the Coal Ash Landfill, the existing topsoil over previously placed ash material was stripped and stockpiled for future use in the cover system. The excavated ash from the Coal Ash Settling Ponds was hauled by dump truck to the Coal Ash Landfill and deposited over previously placed ash. The ash was placed within designated cells to be constructed over the life span of the Coal Ash Landfill (until 2027).

The ash was spread in lifts not exceeding 12 inches in thickness and compacted to at least 92 percent of the maximum dry density prior to placement of the next 12-inch lift. If the ash material was too wet to meet the compaction requirement, the ash material was allowed to air dry. A maximum of two density tests per acre per 12-inch lift were performed, with no less than 1 test per 15,000 c.y. of placed coal ash. Documentation of certified testing was provided during and after completion of the landfilling operations.

### 3.3.3 STORMWATER, EROSION, AND SEDIMENT CONTROL

The stormwater management system for the Coal Ash Landfill at the INVISTA Site was managed during ash placement to:

- Prevent erosion of the ash and final cover
- Prevent the collection of standing water
- Minimize surface water run-off onto and into the ash

# 4.0 FINAL DESIGN APPROACH

## 4.1 DESIGN OBJECTIVES

The design objectives of the final cover system for the Coal Ash Landfill at the INVISTA Site are:

- Minimize need for further maintenance
- Prevent post-closure escape/release of solid waste constituents, leachate, and landfill gases to the surface water, groundwater, or atmosphere
- Prevent direct contact with ash materials
- Minimize infiltration to groundwater
- Mitigate soil erosion and runoff
- Provide stormwater management to protect water quality
- Promote establishment of vegetative cover

The following sections provide an overview of the approach to closing the coal ash landfill.

## 4.2 SITE-SPECIFIC DESIGN CONSIDERATIONS

The Coal Ash Landfill is an active landfill on the INVISTA Site and coal ash materials have been placed within the unit since 1979. As such, there is already a base layer of ash materials present, including the establishment of 3:1 side slopes around the perimeter of the landfill site to a height of approximately 10 feet (in preparation for the previously planned filling through 2027 to a final height of 92 feet amsl). These side slopes have already been stabilized and there is a vegetative growth present, so these external areas of the Coal Ash Landfill will not be used for any future placement of coal ash materials. However, these side slopes will need to be disturbed to place the cover system, as the existing 3:1 slopes will be flattened to a maximum of 5:1 slopes.

The operating procedures defined in the 2003 Engineering Report require the construction of starter berms around any landfilling area for the containment of all surface water. In addition, a new perimeter containment berm will be constructed around the entire landfill beyond the toe of the existing 3:1 side slopes before regrading the existing slopes. The perimeter containment berm will remain in place when the landfill cover system is completed to provide overall stormwater control.

Subsequent to final coal ash placement but prior to completion of the final cover system, the retained contractor will perform a full topographic as-built survey to clearly define the final waste footprint. As well, final as-built surveys of the final cover system barrier and protective cover soil layers will be performed to precisely define the limits of the final cover system. Upon completion, the outer limits of the final cover system (i.e., beyond the geomembrane anchor trench and toe of slope) will be delineated in the field with permanent signs indicating restrictions on digging and other detrimental activities (see Appendix A, Drawing C-04, Detail 6 and Appendix F, Post-Closure Plan, Section 6.2).

## 4.3 REVISED CONTOUR DESIGN

With the re-structuring of the Site operations and the discontinuation of the use of coal in the on-Site power plant, the Coal Ash Landfill will no longer need to accommodate the estimated 600,000 c.y. of ash that would have been generated through the year 2027 (as previously planned in the Engineering Report). Based on the current understanding of the Site conditions, it now is estimated that the Coal Ash Landfill will have a final volume of ash that is the sum of the amount currently in the landfill and approximately 120,000 c.y. of ash to be removed from the Coal Ash Settling Ponds.

Although the current 3:1 side slopes are stable, some of the existing coal ash materials previously placed on these steep side slopes will be relocated (pushed up on the landfill) to flatten the side slopes to a maximum 5:1 angle. This provides a more reasonable final overall shape for cover system maintenance, reducing the velocity of surface water runoff and the potential for cover soil erosion. Any further placement of coal ash on top of the existing landfill will be constructed with substantially reduced slopes (between 3 and 10 percent), eliminating the need for the back sloping benches that were part of the previous grading plan.

The new 5:1 side slopes will extend to an estimated elevation of approximately 35 feet amsl, which is 10 to 15 feet beyond the current height of the existing 3:1 slopes. At this point, the upper portion of the landfill will be constructed at 10:1 slopes to an estimated elevation of approximately 40 feet amsl, reduced to 15:1 slopes to an estimated elevation of approximately 45 feet amsl, and further reduced to 33:1 (3 percent) over the remaining central portion of the landfill cover system. After adding the 2.0 to 2.5-foot thick final cover system to the landfilled ash, the estimated final peak elevation will be approximately 48 feet amsl. The final height of the landfill will be dependent upon the actual volume of ash placed.

Appendix A presents the design drawings, including drawings showing the proposed subgrade and final contours.

## 4.4 COVER SYSTEM COMPONENTS

The Coal Ash Landfill final cover system will consist of (from bottom to top):

- Landfilled ash materials, including existing topsoil (trees/brush to be removed but not placed in landfill)
- Final ash and/or soil grading layer (6 inches) with no particles greater than 3/8 inches, if required
- Barrier layer consisting of geomembrane material (40-mil LLDPE)
- Sand layer (12 inches) for subsurface drainage and additional cover depth to protect the geomembrane
- Barrier protection layer (and rooting zone) consisting of general fill (6 inches)
- Topsoil layer (6 inches) and vegetative cover (seeding)

In order to ensure that only clean imported soils are placed within the landfill cover system, all imported soils will be sampled and analyzed for the full Target Compound List Volatile Organic Compounds (VOCs) to non-detect concentrations and Target Analyte List (TAL) metals parameters within or below Typical Delaware Soil Concentrations provided in Attachment 3 of DNREC's Remediation Standards Guidance under the Delaware Hazardous Substance Cleanup Act, in accordance with U.S. EPA method SW846 testing procedures.

Cover system details are presented on the attached drawings in Appendix A.

### 4.4.1 FINAL ASH/SOIL GRADING LAYER (SELECT FILL)

The coal ash that is placed in the landfill is a fine-grained material without any large-size particles that could potentially damage the geomembrane. In the July 2005 issue of the Journal of Geotechnical and Geoenvironmental Engineering, a paper was published entitled "Geotechnical Properties of Fly and Bottom Ash Mixtures for Use in Highway Embankments" by Kim, Prezzi, and Salgado, which showed that coal ash is comprised of silty sand to sandy silt sized particles. As such, it is expected that the ash material will provide adequate physical protection for the overlying barrier layer (geomembrane); however, geotechnical testing will be performed prior to installing the geomembrane to ensure no particles greater than 3/8-inches are present. Secondarily, it is possible that

the coal ash surface might become unworkable in wet weather conditions, making the placement of a soil grading layer a field requirement prior to geomembrane placement.

If necessary, based on field conditions described previously, up to a 6-inch layer of select fill will be placed over the landfilled coal ash materials. The soil grading layer is intended to provide physical protection for the overlying geomembrane. The select fill to be used for the soil grading layer will be clean imported soil, free of materials containing loams, roots, organic matter, stones, contaminants, and associated debris. The select fill, if utilized, will also be tested as defined in this document, to confirm the absence of particles greater than 3/8 inches that could potentially damage the geomembrane from beneath when the cover soils are loaded on top of the geomembrane. Placement of the soil grading layer will be based on field conditions at the time of cover system construction, such that a portion or the entire landfilled coal ash surface may not require this additional cover prior to geomembrane installation. In addition to the soil specification requirements, the geomembrane installer must approve the subgrade conditions immediately prior to geomembrane placement.

As previously discussed with DNREC in October 2010, the final cover system design for the coal ash landfill does not include a geotextile layer directly beneath the geomembrane (over the coal ash material or soil grading layer) or clay. The subgrade surface (coal ash or select fill) will be tested to ensure that no particles greater than 3/8 inches are present in the upper portion of the subgrade surface in order to prevent puncture of the overlying geomembrane. This fine-grained subgrade surface will provide protection as stipulated by DRGSW regulations. The technical specifications for geomembrane materials contained in Appendix B (Section 02072) require the contractor to ensure that the top surface of the landfill is acceptable for geomembrane placement, including appropriate quality assurance/quality control (QA/QC) testing requirements identified in the technical specifications (provided in Appendix B), and as summarized in Appendix G [Construction Quality Assurance Plan (CQAP)].

Another reason for not placing a geotextile beneath the geomembrane would be the reduced interface friction angle with respect to smooth geomembrane over non-woven, needle-punched geotextile fabric. Inclusion of a geotextile layer would increase the potential for cover system instability (i.e., sliding), as compared to smooth geomembrane placed directly on soil or coal ash. A geotechnical discussion regarding slope stability is provided in Section 4.5.2, with supporting documentation provided in Table 2 (Cover Soil Stability Calculations) and Appendix C (Global Stability Analysis). Placing the geomembrane directly over the existing coal ash would provide for greater slope stability than inclusion of a geotextile between the coal ash and geomembrane.

### 4.4.2 BARRIER LAYER (GEOMEMBRANE)

A 40-mil linear low density polyethylene (LLDPE) geomembrane will be placed over the entire landfill site as the barrier layer component of the Coal Ash Landfill cover system. LLDPE geomembrane materials have become more common for landfill cover systems due to their significantly greater flexibility, making them more suitable when there is any potential for differential settlement (i.e., as part of a cover system on top of landfilled materials, as opposed to a bottom liner system beneath a newly constructed landfill). The technical specifications for 40-mil LLDPE geomembrane are provided in Appendix B.

It should also be noted that the previously submitted Conceptual Closure Plan specified that the geomembrane material be textured, which is typical for steep slope applications (in excess of 4:1). However, with the reduced fill volume, the final grades over the large central portion of the landfill will no longer consist of steep side slopes, but will generally be much flatter (between 3 and 10 percent). More importantly, the landfill side slopes will be reduced from 3:1 to 5:1, obviating the need for a textured geomembrane over any portion of the landfill cover system. Consequently, a smooth LLDPE material will be used for the entire Coal Ash Landfill cover system.

### 4.4.3 BARRIER PROTECTION LAYER (SUBSURFACE SAND DRAINAGE LAYER)

A 12-inch layer of sand will be placed over the 40-mil LLDPE geomembrane. The sand layer provides physical protection for the geomembrane, but more importantly allows subsurface drainage of accumulated water over the geomembrane. The sand will consist of clean imported soil with permeability between $5 \times 10^{-3}$ and $1 \times 10^{-2}$ centimeters per second (cm/sec) in order to prevent any significant head of water from accumulating over the geomembrane. This will not only assist with preventing infiltration through the geomembrane into the landfilled ash material, but will also prevent sliding of the cover system over the side slopes as discussed further in subsequent sections of this FCP.

The thickness of the sand drainage material will be at least 12 inches to prevent damage to the underlying geomembrane during cover soil placement. Soil placed directly over the geomembrane will be placed in accordance with the recommendations of the geomembrane manufacturer, and as defined in the CQAP provided in Appendix G. Soils placed over geomembrane should be deployed in a manner as to suppress the formation of wrinkles in the geomembrane.

### 4.4.4 BARRIER PROTECTION LAYER (GENERAL FILL)

A 6-inch layer of general fill will be placed over the subsurface sand drainage layer such that there is a total of 18 inches of barrier protection soil cover over the geomembrane. In addition to physical protection of the barrier layer, the general fill layer also provides a rooting zone depth to support the growth of vegetation within the overlying topsoil. The general fill will be clean imported soil free of materials containing loams, roots, organic matter, rocks larger than 3-inch diameter, contaminants, and debris.

### 4.4.5 TOPSOIL AND VEGETATIVE LAYER

A 6-inch layer of topsoil will be placed over the general fill layer to support a vegetative growth over the entire landfill cover system. Topsoil will consist of 6 inches of tilled, uncompacted soil. Topsoil will be reasonably free of roots, rocks or lumps larger than 1/2-inch, weeds, and other vegetation. Manual seeding methods such as drill seeding will be used to ensure good soil contact, with a straw mulch that is crimped into the soil (instead of hydroseeding or hydromulching)

## 4.5 COVER SYSTEM PERFORMANCE

### 4.5.1 LANDFILL COVER MODELING

Hydraulic modeling using the interactive program "Hydrologic Evaluation of Landfill Performance, Version 3.04" (HELP) (USEPA, 1995) was performed during preparation of the FCP to estimate the quantity of fluid infiltration through the final cover system into the ash materials. The results of the HELP modeling are summarized in Table 1, with the complete calculations presented in Appendix D to this FCP.

The HELP modeling results indicated that the proposed cover design, including the sand drainage layer with permeability between $5 \times 10^{-3}$ and $1 \times 10^{-2}$ cm/sec would result in 99.99 percent effectiveness in eliminating infiltration through the final cover system. As a result, seepage is not expected to reach the landfill ash materials due to the efficiency of the final barrier layer and subsurface drainage systems.

Several iterations of the HELP modeling were performed to demonstrate the performance of the various layers within the proposed final cover system, both in terms of reducing infiltration through the barrier layer and into the underlying landfill ash material as well as providing cover soil stability on the side slopes by reducing the head over the geomembrane (as discussed in the subsequent sub-section of this FCP).

The following material layers were included in the HELP model simulations (from top to bottom):

- Layer 1 - Vertical percolation layer (6 inches topsoil with vegetative cover)
- Layer 2 - Vertical percolation layer (6 inches general fill for barrier protection and providing rooting zone)
- Layer 3 - Lateral drainage layer (12 inches sand material for subsurface drainage and additional cover depth)
- Layer 4 - Barrier layer consisting of geomembrane material (40-mil LLDPE)
- Layer 5 - Vertical percolation layer (landfilled coal ash or 6 inches select grading fill with no particles greater than 3/8 inches)

For all HELP model simulations, the total average annual precipitation was assumed to be 41.20 inches. Evapotranspiration typically represented approximately two-thirds of the total average annual precipitation. This was unchanged for all the HELP model runs performed. The HELP model runs that were used for the final cover system design are presented in Appendix D.

The HELP model was initially run under baseline conditions similar to the cover system presented in the 2003 Conceptual Closure Plan. The only exception was to increase the general fill layer thickness from 12 inches to 18 inches, with the additional 6-inch layer included in Layer 3.

For the baseline HELP model run, the average annual runoff was approximately 6 inches for the flat top slope area and approximately 2 inches for the side slope areas, with the corresponding drainage being approximately 6 and 12 inches, respectively. As a result of the lateral drainage layer within the HELP model, annual leakage through the barrier layer was only 0.010 to 0.042 inches. Although this represents only 0.02 to 0.10 percent of the total annual precipitation, there was still almost 12 inches of head on the barrier layer (on average) for the top slope area while the head on the barrier layer reduced to approximately 3 inches for the side slope areas. Based on 24 inches of total cover soil thickness, this represents approximately 50 percent saturation of the cover soils on the top slope area and almost 15 percent saturation of the cover soils on the side slope areas.

Further HELP model runs were performed in an attempt to reduce the elevated head levels over the barrier layer, which would be the primary cause of any increased slip failure potential due to saturation of the cover soils. In order to reduce infiltration through the cover soils, the permeability of the general fill layer was decreased to $1 \times 10^{-5}$ cm/sec (historical design used $1 \times 10^{-3}$ cm/sec, which is more representative of

sand). Although this reduced infiltration was expected to reduce the head over the barrier layer, the HELP model results showed that the head actually increased slightly for both the top slope and side slope areas.

As a further attempt at reducing the elevated head levels, the permeability of the lateral drainage layer in the HELP model was increased to facilitate the removal of subsurface water more efficiently from above the barrier layer. Two HELP model runs (#1A and #1B) were performed to provide greater lateral drainage potential using permeabilities for the sand drainage layer of $5 \times 10^{-3}$ cm/sec and $1 \times 10^{-2}$ cm/sec.

Making these changes, the average annual lateral drainage was approximately 11 inches for both the top slope and side slope areas. The annual leakage through the barrier layer ranged between 0.0102 and 0.00104 inches, with the head on the barrier layer being 3.24 and 1.60 inches for the top slope area, and reducing to 0.710 and 0.355 inches for the side slope areas. This represents 10 to 20 percent saturation of the cover soils on the top slope, but only 1 to 2 percent saturation of the cover soils on the side slopes. Therefore, a drainage material with permeability between $5 \times 10^{-3}$ cm/sec and $1 \times 10^{-2}$ cm/sec will adequately drain any infiltrating water from above the barrier layer and minimize saturation of the cover soils.

Two final HELP model runs (#2A and #2B) were performed due to past experience in some locations whereby general fill with a specified permeability of $1 \times 10^{-5}$ cm/sec has been difficult to obtain. As such, the permeability of the general fill layer in the HELP model was adjusted to $1 \times 10^{-4}$ cm/sec. This would allow increased infiltration through the cover soils, which should be addressed by the lateral drainage layer without any significant increase in head over the barrier layer and associated leakage through the barrier layer.

Making these changes, the average annual lateral drainage was approximately 12 inches for both the top slope and side slope areas. Leakage through the barrier layer increased slightly to between 0.0118 and 0.00121 inches, with the head on the barrier layer increasing slightly to 3.70 and 1.85 inches for the top slope area, and reducing to 0.809 and 0.406 inches for the side slope areas. This represents similar percentage saturation levels as the previously performed Run #1A and Run #1B. Therefore, the general fill used for the protective soil cover must have a permeability between $1 \times 10^{-4}$ cm/sec and $1 \times 10^{-5}$ cm/sec.

### 4.5.2 SLOPE STABILITY ANALYSIS

The current cover system design presented in this FCP is based on 5:1 side slopes over approximately half of the Coal Ash Landfill (from an elevation less than 10 feet amsl to 35 feet amsl), with the top area gradually reducing in slope from 10 to 3 percent or less to a peak elevation in excess of 48 feet amsl.

During construction and upon completion of the various cover system layers placed over each other, there is a potential for sliding of the cover system components at the interfaces of these different natural soils and the synthetic material (i.e., geomembrane). This is particularly critical for the side slope areas. Appendix C of this FCP presents the cover soil stability calculations performed for the 5:1 side slopes.

The final cover system sliding stability analyses were performed using the infinite slope methodology for the critical interfaces between smooth geomembrane and the overlying sand/common fill/topsoil and between geomembrane and the underlying grading fill placed or landfilled ash materials. Interface shear strength parameters were assumed based on a literature review and past experience with similar cover system components. A factor of safety in slope stability analysis can be defined as the ratio of the available shear strength to that of the applied stresses along a potential failure plane. A factor of safety of 1 or greater indicates stable conditions whereas a value of less than 1 represents unstable conditions. Results of the cover stability analyses are summarized in Table 2.

A minimum factor of safety (FS) of 1.50 was targeted for the steady-state, long-term conditions when the landfill slopes will be in an effectively dry state. Run #1A, 13B, #2A, and #2B of the previously presented HELP modeling indicated that the 20 percent side slopes would have less than 1-inch of accumulated head over the geomembrane (on average). For these effectively dry soil conditions (head between 0.355 and 0.809 inches), FS values of 1.60 and 1.58 were obtained for sliding stability at the sand/geomembrane interface. These FS values exceed the targeted value of 1.50. (It should be noted that the underlying geomembrane/grading fill (or coal ash) interface should have the same FS because the grading fill soil (or coal ash) would be expected to have the same friction angles and cohesion factors as sand. As stated in Section 4.4.1, a technical paper showed that coal ash is comprised of silty sand to sandy silt sized particles, and being a burnt product these particles are angular such that the friction angle is generally over 30 degrees).

The importance of providing varying soil types for the vertical percolation layer (general fill) and the lateral drainage layer (drainage sand) is evident by the head values over the barrier layer (geomembrane), as determined by the HELP model. Using the same soil

material for both soil layers does not sufficiently remove the head over the barrier layer to provide adequate cover system stability. Therefore, it is important that the vertical percolation layer be constructed of a common fill material with permeability between $1 \times 10^{-4}$ cm/sec and $1 \times 10^{-5}$ cm/sec, while the lateral drainage layer placed over the geomembrane must be constructed of a drainage sand material with permeability between $5 \times 10^{-3}$ cm/sec and $1 \times 10^{-2}$ cm/sec.

In summary, placing the engineered soil cover system over smooth geomembrane on a 5:1 slope, with a grading fill layer or coal ash material immediately beneath the geomembrane would be stable for typical long-term conditions when the landfill slopes is in an effectively dry state (up to 5 percent saturation, or less than 1-inch of head over the geomembrane).

In addition to the final cover system sliding stability analyses, global stability analysis of the 5:1 landfill side slope was also carried out using computer software utilizing the limit-equilibrium method. As presented in Appendix C, an FS of 2.93 was obtained for this analysis, exceeding the targeted value of 1.50.

### 4.5.3 SOIL LOSS/EROSION CONTROL

The final cover system design presented in this FCP reduces the existing 3:1 side slopes (currently placed ash material) to 5:1 side slopes around the entire Coal Ash Landfill (approximately 10 to 35 feet in elevation), and then places the remaining ash material excavated from the Coal Ash Settling Ponds at 10:1 (10 percent) slopes from 35 to 40 feet in elevation, at 15:1 (6.7 percent) slopes from 40 to 45 feet in elevation, with completion of the top portion at slopes of 3 percent (or less) to a peak elevation of approximately 46 feet (plus 2.0 to 2.5-foot cover system thickness over entire landfill area). Soil loss/erosion calculations are presented in Appendix E to this FCP, which show that the soil loss for the final landfill cover system will be 1.98 tons per acre per year, which is lower than the maximum annual allowable soil loss of 2.0 tons per acre according to current EPA guidance documents.

Although the average soil loss over the entire slope may be less than the maximum allowable, the largest contribution to any soil loss will come from the reduced 5:1 side slope areas. It is expected that the period of greatest concern for soil erosion would be immediately after topsoil placement and before the vegetation takes hold. Therefore, installation of an erosion control fabric is included over the side slopes with the installation of mechanical (drill) seeding in order to prevent erosion during this interim period.

## 4.6 STORMWATER MANAGEMENT

The proposed cover system design for closure of the Coal Ash Landfill will result in the overall height of the landfill being only 40 feet above the surrounding topography, with the estimated peak elevation being between 48 and 49 feet amsl. The footprint of the Coal Ash Landfill will be reduced from 14.5 acres, as discussed in the 2003 Engineering Report, to 11.75 acres since no new ash materials have been or will be placed in Cell 9. In addition, the current toe of landfilled ash is being pulled back inward around much of the landfill to accommodate an access road and perimeter berm.

Since the historical removal of landfilled ash materials from the Coal Ash Landfill for the Land Enhancement Project (golf course) in 1996, no subsequent placement of coal ash materials has occurred in the Cell 9 area. At that time, a separation berm was constructed between the main landfill area (all other cells) and Cell 9, such that Cell 9 was isolated from the continued coal ash placement over the remainder of the landfill. Cell 9 was set aside for potential future landfill use; however with the reduction in total ash volume due to the discontinued use of coal in the power plant, the former Cell 9 area will not be required. Therefore, this additional landfill area does not require placement of the final cover system.

As a result of the engineered cover system being constructed over the landfilled ash materials, there will be additional surface water runoff from the completed landfill cover system. In order to manage the stormwater runoff from the landfill cover system, the cover system design incorporates a shallow (12 inches in depth) but wide (3 feet at the bottom and 9 feet across the top) drainage ditch around the perimeter of the Coal Ash Landfill that will direct all collected surface water towards the area north of the existing landfill where Cell 9 was previously located (hereinafter referred to as collection area). In order to direct collected surface water from the landfill cover system via gravity to this collection area, the perimeter drainage ditch will be located partially up the side slope at the south end, gradually moving down the slope as the ditch elevation drops. In addition, a perimeter berm will prevent potential flooding of the adjacent land surface around the landfill by containing flow from the bottom portion of the side slope areas. Infiltration of collected surface water from the majority of the final cover system (as directed by the perimeter drainage ditch) will naturally occur within the collection area to the north.

The perimeter ditch will be constructed, when reducing the existing side slopes, by shaping the ditch cross-section into the ash materials within the reduced 5:1 side slopes. This raised ditch is being constructed in order to avoid any excavation of soils around

the perimeter of the landfill where a SWMU has previously been identified. As such, the geomembrane would be installed across the base of the ditch and anchored at the toe of slope.

The current design only includes a perimeter drainage ditch (no intermediate ditches), which results in drainage lengths of approximately 300 feet extending radially from the constructed peak. The soil loss calculations discussed in Section 4.5.3 (and presented in Appendix E) indicated that the average annual soil loss was acceptable. However, prior to complete establishment of the vegetative cover, preferential pathways may be created down the slopes during significant rain events that might result in unintended channels on the completed side slopes.

As the locations of these channels will be self-determined during the initial storm events after completion of the final site grading, the design will allow for the construction of engineered channels after completion of the cover system construction (but not as part of the initial construction). The cover system will need to be maintained until complete establishment of the vegetative cover, including the installation of rip-rap lined channels where preferential pathways appear as a result of storm events. These field-located channels would be constructed of 12 inches of appropriately sized rip-rap, replacing the upper layers of 6 inches of topsoil and 6 inches of common fill. Filter fabric will be installed beneath the rip-rap.

## 4.7 POST-CLOSURE PLAN

Subsequent to closure, the landfill will be managed in accordance with a Post-Closure Plan as presented in Appendix F. All post-closure activities are to be conducted in accordance with the Post-Closure Plan.

## 5.0 COVER SYSTEM CONSTRUCTION

The construction procedures in this section have been developed in support of the design drawings presented in Appendix A.

The final as-built conditions of the landfill cover system will be surveyed with respect to established concrete monuments located adjacent to the Coal Ash Landfill. It should be noted that surveying during construction of the cover system will be performed to verify the as-built placement volumes and appropriate thicknesses of the required cover system layers.

### 5.1 CONSTRUCTION PROCEDURES

The following details the specific construction procedures.

- Mobilization/Demobilization - Mobilize and demobilize equipment, personnel, trailers, etc. to complete the construction of the landfill closure system. All required plans and permits, including SWMP, must to be prepared and approved, prior to construction.
- Temporary Erosion Control and Stormwater Management - Installation of construction and silt fencing, containment berms and basins, etc., as per stormwater plan submitted by contractor for implementation during construction. Grubbing will be completed after this construction.
- Ash Placement - Place ash in lifts not exceeding 12 inches in thickness and compact to at least 92 percent of the maximum dry density prior to placement of the next 12-inch lift. If the material is too wet to meet the compaction requirement, the material must be allowed to air dry (or a drying agent may be added to facilitate the drying process). A maximum of two density tests per acre per 12-inch lift must be performed, but no less than 1 test per 15,000 c.y. of placed ash.
- Final Site Grading - As ash placement is completed, grade the landfill surface to the lines and grades shown on the design drawings.
- Grading Fill (Select Fill) (Optional) - Upon completion of coal ash placement (or periodically as ash material achieves design subgrade), place 6 inches of select fill over the compacted ash material, if required. All imported soils must be sampled and analyzed, as specified in Section 4.4. The select grading fill material must not contain any particles greater than 3/8 inches in diameter. Select fill may not be required for any portion of the coal ash surface that meets the requirement of containing only materials less than 3/8 inches and if the coal ash surface does not

become too wet as to become difficult to work on for placement of subsequent liner. This task includes testing, purchase, transportation, placement, smooth-drum rolling, and compacting (to at least 92 percent of the maximum dry density) of the select grading fill to prepare the subgrade for geomembrane installation. Testing, placement, and compaction will be performed in accordance with this plan and the CQAP presented in Appendix G.

- Geomembrane - Install a 40-mil smooth LLDPE geomembrane over the approved ash or select fill subgrade. This task includes purchase, transportation, installation and testing of the geomembrane.
- Sand Drainage - Place 12 inches of coarse-grained sand (permeability between 1 x 10-2 and 1 x 10-3 cm/sec) over installed geomembrane for subsurface drainage of infiltrating water. A total of approximately 20,000 c.y. of drainage sand is required for the 12.25 acres. All imported soils are to be sampled and analyzed, as specified in Section 4.4. This task includes testing, purchase, transportation, placement, and compaction of the drainage sand material. Testing, placement, and compaction will be performed in accordance with this closure plan and the CQAP presented in Appendix G.
- Cover Soil - Place 6 inches of cover soil (common fill) over the sand drainage layer. A total of approximately 10,000 in-place c.y. of common fill is required to cover the 11.75 acres. Assuming a bulking factor of 1.3, a total of approximately 13,000 c.y. of common fill will need to be purchased from an off-site borrow source. All imported soils will need to be sampled and analyzed, as specified in Section 4.4. This task includes testing, purchase, transportation, placement, and compaction of the common fill cover soil. Testing, placement, and compaction will be performed in accordance with the required procedures outlined in the technical specifications contained in Appendix B and the CQAP presented in Appendix G.
- Topsoil - A total of approximately 10,000 in-place c.y. of topsoil is required over the entire 11.75 acres of cap. All imported soils will need to be sampled and analyzed, as specified in Section 4.4. This task includes testing, purchase, transportation, and placement of topsoil. The existing topsoil material over the current landfill surface cannot be reused for final topsoil cover. Testing, placement, and compaction will be performed in accordance with this plan and the CQAP presented in Appendix G.
- Revegetation - Placement of seed over the topsoil on the entire 11.75 acres of landfill. Seed shall consist of the varieties and proportions by weight as recommended by local agricultural authorities for the intended purpose. Mechanical (drill) seeding will be used in lieu of hydroseeding, along with a straw mulch crimped into the topsoil for erosion control, with lime and fertilizer applied (as determined necessary by the landscape contractor). In addition, erosion control fabric is required over the

5:1 side slopes along with the installation of mechanical (drill) seeding in order to prevent erosion during this interim period.

## 5.2 SURVEY CONTROL

During ash placement and construction of the final cover system, temporary fill/cover grades may be controlled and verified using various field methods, as selected by the contractor. These methods may include placement of grade stakes, use of GPS-equipped construction equipment, periodic as-built surveying, or other grade verification method, as determined by the contractor.

The final as-built conditions of the landfill cover system will be surveyed with respect to established concrete monuments located adjacent to the Coal Ash Landfill, which are located on the Topographic Survey Plan prepared by T.A. Surveying, Inc. of Newark, DE, dated August 8, 2003 (also shown on design drawings presented in Appendix A to this FCP). The concrete monuments are labeled on the drawings with both horizontal coordinates and associated vertical elevations. Alignment of these monuments shall be verified to the Delaware State Plane Coordinate System and National Geodetic Vertical Datum 1929. A surveyor registered in the State of Delaware will prepare a survey drawing showing the closed landfill and surrounding terrain. It should be noted that surveying during construction of the cover system must also be performed to verify the as-built placement volumes and appropriate thicknesses of the required cover system layers.

## 5.3 DUST CONTROL

Migration of dust particles during ash placement will provide the greatest likelihood for airborne migration of landfill (ash) materials. In order to address the potential for dust generation, a water truck will be used, at the discretion of the field oversight personnel, to apply a fine mist of water over the placed ash to control airborne emissions. Upon completion of the select grading fill and geomembrane, the potential for fugitive dust containing ash fines will be eliminated, although there may still be dust particles generated during placement of the cover soils so the water truck will be kept available on-site until all placement of soils has been completed (and used at the contractor's discretion).

## 5.4 STORMWATER CONTROL

During ash placement, all water within the temporary perimeter containment berms, which will be primarily precipitation that falls directly on the landfill, will be directed via gravity or pumped (during construction only) to the collection area located to the north of the landfill. During construction, stormwater will be addressed by the E&S Plan, which will be prepared and submitted by the contractor and approved by the State of Delaware prior to performing the work. The E&S plan will comply with all applicable requirements of the Delaware Sediment and Stormwater Regulations (Title 7: Natural Resources and Environmental Control; 5000: Division of Soil and Water Conservation, 5101: Sediment and Stormwater Regulations).

The Coal Ash Landfill cover system is constructed with permeable materials above the impermeable geomembrane, which when constructed will allow precipitation to percolate into the cover soil to the barrier layer and be directed laterally via subsurface drainage in all but the larger storm events. The Coal Ash Landfill cover is also designed to facilitate gradual sheet flow of stormwater during the larger storm events. Most of the stormwater would be collected in the drainage ditch located at or near the toe of the landfill slopes, from which the stormwater is directed by channelized flow to the low area north of the existing landfill where the former Cell 9 was previously located. In order to facilitate gravity drainage within the perimeter ditch, the ditch originates partially up the side slope at the south end of the landfill and slowly progresses down the side slope as flow is directed around both sides of the landfill. However, stormwater on the bottom portion of the side slope areas will be contained within the perimeter berm so as not to discharge directly to the adjacent areas around the landfill.

Stormwater that flows to the collection area via the perimeter drainage ditch will infiltrate into the ground. No downstream properties will be adversely impacted by this stormwater.

Upon completion of the cover, stormwater will not come into contact with any waste or leachate of any kind due to the impermeable geomembrane located beneath the cover soils. Stormwater will flow to the retention area on the northern side of the Coal Ash Landfill. No constructed stormwater detention pond is employed because the overall water quality will not be impacted by the closed Coal Ash Landfill and because the entire cover of the Coal Ash Landfill is a pervious surface (above the geomembrane).

## 5.5 HEALTH AND SAFETY

Prior to commencing ash placement and landfill closure activities, the contractor will be required to prepare a comprehensive Health and Safety Plan (HASP), which will protect all personnel involved with the project, including any Plant and construction oversight personnel as well as their own workers. The submitted HASP must comply with all applicable Occupational Safety and Health Administration (OSHA) standards and guidelines, as well as INVISTA's own internal health and safety policies as outlined in the document entitled "Seaford Site Conditions", dated March 22, 2007 (version 1) and the health and safety requirements in Section M of the Solid Waste Permit SW-09/01. The HASP will address, at a minimum, task-specific personnel protective equipment (PPE), personnel decontamination, medical monitoring, compound hazard potential, air monitoring, emergency procedures, and regulatory compliance.

The contractor will be fully informed as to the nature and characteristics of the landfill materials. Pertinent data in the possession of the Seaford Plant regarding the ash landfill materials will be made available to the contractor prior to commencing construction.

## 5.6 CONSTRUCTION QUALITY CONTROL

Inspection procedures for closure of the Coal Ash Landfill and construction of the landfill final cover system are contained in the Construction Quality Assurance Plan (CQAP), provided as Appendix G. The CQAP addresses inspections of the various components of the cover system, field and laboratory testing, and identifies quality standards that must be attained.

Certification Report - Construction quality assurance (CQA) will be performed by construction quality assurance engineer (CQAE). The contractor, in collaboration with the CQAE, will prepare and submit the final certification report to ensure that construction of the final cover system was performed in accordance with the design. CQA services will include project management, laboratory testing, and a written certification report documenting their scope of work and results. The final certification report for the closure of the coal ash landfill will include, at a minimum, the following:

- Record (As-Built) Drawings
- Contractor Submittals
- Soils Testing Results
- Geomembrane Testing Results
- Quality Control Reports
- Photographic Documentation

## 6.0 CONSTRUCTION SCHEDULE

Closure of the Coal Ash Landfill at the INVISTA Site will take place in coordination with the removal of ash materials from and closure of the Ash Settling Ponds. Figure 3 presents a tentative schedule for the closure of the Coal Ash Landfill.

## 7.0 FINANCIAL ASSURANCE

This section provides information required in Delaware Regulation Governing Solid Waste, Section 6.10.3.4: Industrial Landfills - Closure Plan Contents (Estimated Costs).

Costs associated with performing Closure and Post-Closure activities are presented in this section. These include both capital and operating costs. The subsequent subsections present the estimates and the assumptions used in developing them.

### 7.1 CLOSURE COSTS

The total estimated cost to construct the final cover system for the Coal Ash Landfill (11.75 Acres) at the INVISTA Site is $3,175,000 in year 2011 dollars ($3,810,000 including 20 percent contingency).

These costs are based on the specific tasks listed in Table 3. A description of the specific tasks with associated assumptions is presented in Section 5.1.

### 7.2 POST-CLOSURE COSTS

Costs associated with post-closure maintenance and operation of the Coal Ash Landfill were developed based on tasks associated with on-going inspection and maintenance activities plus additional tasks required after capping. A description of the specific tasks with associated assumptions is presented below.

Annual post-closure costs were estimated to be $77,300 in year 2011 dollars (including 20 percent contingency). The total post-closure costs for the 30-year period are estimated to be $2,319,900.

A summary of the estimated post-closure costs is also presented in Table 3. A description of the specific post-closure tasks with associated assumptions is presented below.

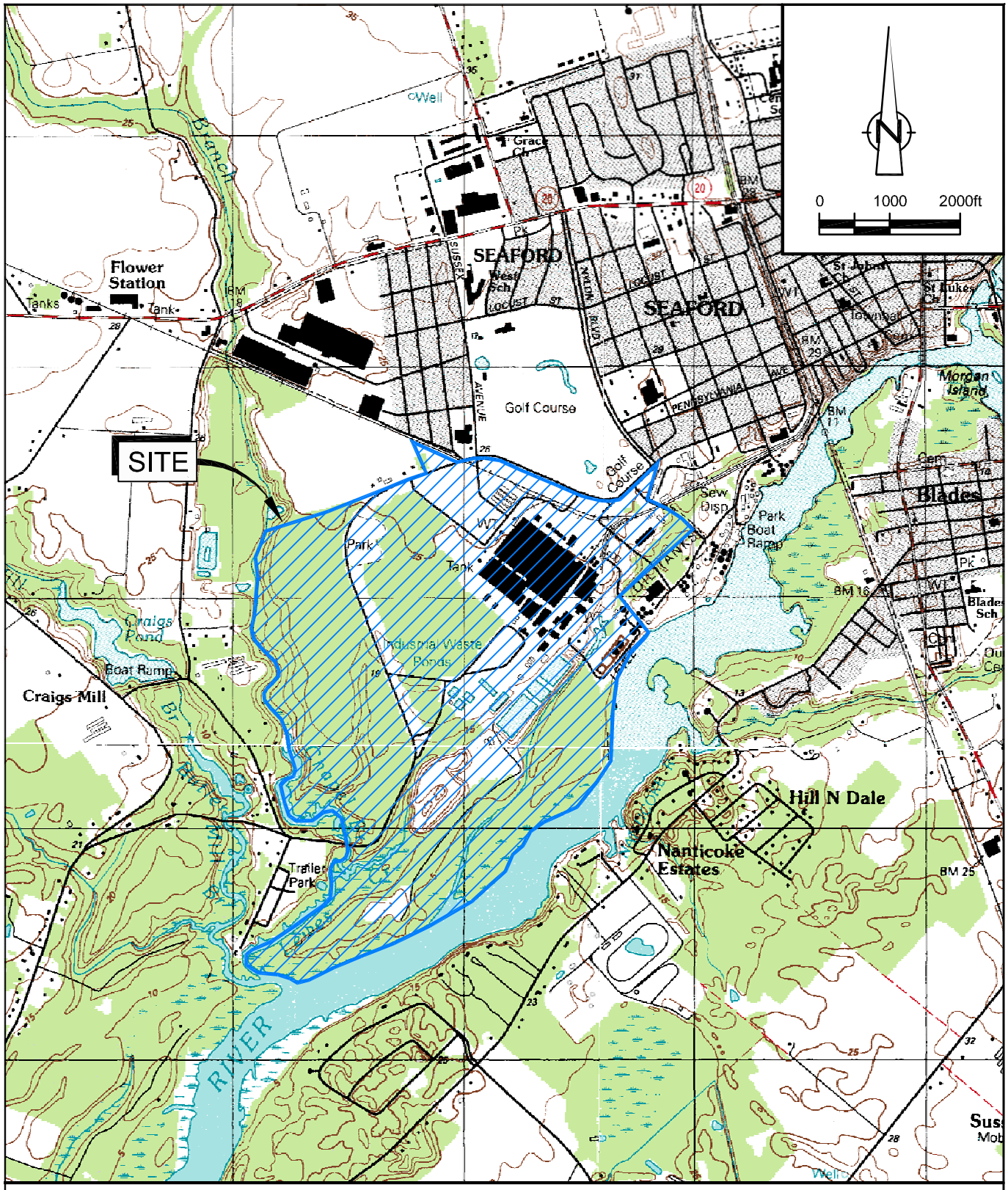
- Continue the current groundwater monitoring program, which includes field work, laboratory testing, and written reports. The estimated cost for field work and report preparation is $34,000. The estimated cost for laboratory testing is $26,800. These costs are based on the actual costs for the current groundwater and surface water monitoring that is in effect.

- Make regular inspections of the landfill cover to identify any maintenance issues. Assume one hour per week at $100 per hour for estimating purposes.
- Maintain, as necessary, all stormwater and erosion control measures implemented during closure. An allowance of $5,270 per year is assumed for erosion control maintenance.
- Cut the grass on the landfill, as necessary. Two cuttings per year are assumed for cost estimating purposes at a total cost of $2,500 per year.
- All above unit costs are in year 2011 dollars.

## 7.3 INSURANCE POLICY

Appendix H presents the financial assurance documentation.

FIGURES




SOURCE: USGS QUADRANGLE MAPS;
SEAFORD EAST AND SEAFORD WEST, DELAWARE

figure 1

SITE LOCATION MAP
COAL ASH LANDFILL REMEDIAL DESIGN
INVISTA FACILITY
*Seaford, Delaware*

58210-00(002)GN-WA002 APR 19/2011

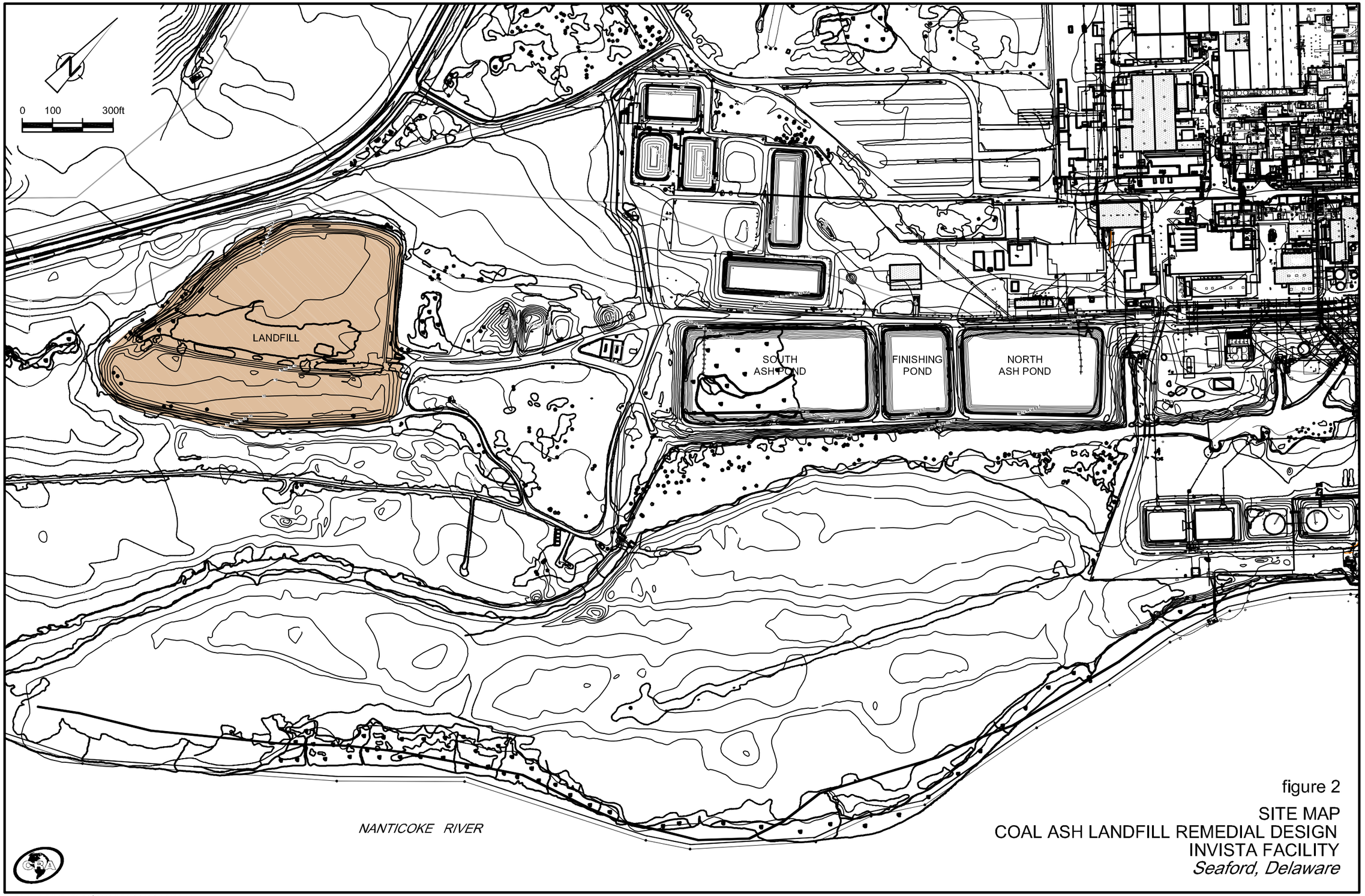



figure 2

SITE MAP
COAL ASH LANDFILL REMEDIAL DESIGN
INVISTA FACILITY
*Seaford, Delaware*

58210-00(002)GN-WA003 MAY 16/2011

**FIGURE 3**

**TENTATIVE ASH LANDFILL CLOSURE SCHEDULE**

Tasks anticipated to be completed in Calendar Year 2011*:

- Submit closure documents to DNREC Division of Solid Waste (DNREC) for approval.
- Upon receiving approval from DNREC on closure documents, complete procurement of contractors necessary to perform closure activities defined in approved closure plans.
- Conduct pre-excavation land survey of North Coal Ash Settling pond as initial step to confirm amount of ash to be removed from this pond.
- Complete dewatering of North Ash Settling pond.
- Excavate the North Coal Ash Settling Pond and placement of material in on-site Ash Landfill.
- Conduct pre-excavation land survey of South Coal Ash Settling pond as initial step to confirm amount of ash to be removed from this pond.
- Start dewatering process for South Coal Ash settling pond to extent practical.

Tasks anticipated to be completed in Calendar Year 2012 - 2013*:

- Provide DNREC with Notification of Intent to Close Landfill.
- Excavate the South Coal Ash Settling Pond and Middle Finishing Pond and complete placement of material in on-site Ash Landfill.
- Perform final grading and complete construction of ash landfill final cover system.
- Conduct certified closure of Coal Ash Landfill.
- State DNREC Solid Waste Division Inspection of Landfill Closure.

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* Schedule subject to revision due to weather and unforeseen site conditions

TABLES

**TABLE 1A**

**HELP MODEL SUMMARY - TOP SLOPE AREA**
**COAL ASH LANDFILL COVER SYSTEM**
**FINAL DESIGN PLAN**
**INVISTA SEAFORD FACILITY**
**SEAFORD, DELAWARE**

| | | | ***RUN 1A*** *(582101A1.OUT)* | ***RUN 1B*** *(582101b1.OUT)* | ***RUN 2A*** *(582102A1.OUT)* | ***RUN 2B*** *(582102B1.OUT)* |
|---|---|---|---|---|---|---|
| **Precipitation** | | **Inches:** | **41.20** | **41.20** | **41.20** | **41.20** |
| **Surface Runoff** | | **Inches:** | **3.15** | **3.06** | **2.17** | **1.97** |
| **Evapotranspiration** | | **Inches:** | **26.86** | **26.83** | **26.45** | **26.32** |
| **Lateral Drainage** | | **Inches:** | **11.20** | **11.33** | **12.60** | **12.93** |
| **Percolation Through Layer 4** | | **Inches:** | **0.0102** | **0.0049** | **0.0118** | **0.0057** |
| **Head Over Layer 4** | | **Inches:** | **3.24** | **1.60** | **3.70** | **1.85** |
| | **Layer 1** *Topsoil* | Thickness: | 6" | 6" | 6" | 6" |
| | | Type: | Vertical | Vertical | Vertical | Vertical |
| | | Material No.: | 6 | 6 | 6 | 6 |
| | | Permeability: | $7.2x10^{-4}$ | $7.2x10^{-4}$ | $7.2x10^{-4}$ | $7.2x10^{-4}$ |
| | **Layer 2** *Fill* | Thickness: | 6" | 6" | 6" | 6" |
| | | Type: | Vertical | Vertical | Vertical | Vertical |
| | | Material No.: | 0 | 0 | 0 | 0 |
| | | Permeability: | **$1 \times 10^{-5}$** | **$1 \times 10^{-5}$** | **$1 \times 10^{-4}$** | **$1 \times 10^{-4}$** |
| | **Layer 3** *Sand* | Thickness: | 12" | 12" | 12" | 12" |
| | | Type: | Lateral | Lateral | Lateral | Lateral |
| | | Material No.: | 0 | 1 | 0 | 1 |
| | | Permeability: | **$5 \times 10^{-3}$** | **$1 \times 10^{-2}$** | **$5 \times 10^{-3}$** | **$1 \times 10^{-2}$** |
| | **Layer 4** *LLDPE* | Thickness: | 0.04" | 0.04" | 0.04" | 0.04" |
| | | Type: | Geomembrane | Geomembrane | Geomembrane | Geomembrane |
| | | Material No.: | 35 | 35 | 35 | 35 |
| | | Permeability: | $4 \times 10^{-13}$ | $4 \times 10^{-13}$ | $4 \times 10^{-13}$ | $4 \times 10^{-13}$ |
| | **Layer 5** *Fill* | Thickness: | 6" | 6" | 6" | 6" |
| | | Type: | Vertical | Vertical | Vertical | Vertical |
| | | Material No.: | 0 | 0 | 0 | 0 |
| | | Permeability: | $1 \times 10^{-5}$ | $1 \times 10^{-5}$ | $1 \times 10^{-5}$ | $1 \times 10^{-5}$ |

Notes

Slope = 6%
Slope Length = 175'

**TABLE 1B**

**HELP MODEL SUMMARY - SIDE SLOPE AREA**
**COAL ASH LANDFILL COVER SYSTEM**
**FINAL DESIGN PLAN**
**INVISTA SEAFORD FACILITY**
**SEAFORD, DELAWARE**

| | | | ***RUN 1A*** *(582101A2.OUT)* | ***RUN 1B*** *(582101B2.OUT)* | ***RUN 2A*** *(582102A2.OUT)* | ***RUN 2B*** *(582102B2.OUT)* |
|---|---|---|---|---|---|---|
| **Precipitation** | | **Inches:** | **41.20** | **41.20** | **41.20** | **41.20** |
| **Surface Runoff** | | **Inches:** | **3.07** | **3.06** | **1.97** | **1.97** |
| **Evapotranspiration** | | **Inches:** | **26.84** | **26.84** | **26.36** | **26.30** |
| **Lateral Drainage** | | **Inches:** | **11.31** | **11.32** | **12.88** | **12.95** |
| **Percolation Through Layer 4** | | **Inches:** | **0.00211** | **0.00104** | **0.00243** | **0.00121** |
| **Head Over Layer 4** | | **Inches:** | **0.710** | **0.355** | **0.809** | **0.406** |
| | **Layer 1** *Topsoil* | Thickness: | 6" | 6" | 6" | 6" |
| | | Type: | Vertical | Vertical | Vertical | Vertical |
| | | Material No.: | 6 | 6 | 6 | 6 |
| | | Permeability: | $7.2 \times 10^{-4}$ | $7.2 \times 10^{-4}$ | $7.2 \times 10^{-4}$ | $7.2 \times 10^{-4}$ |
| | **Layer 2** *Fill* | Thickness: | 6" | 6" | 6" | 6" |
| | | Type: | Vertical | Vertical | Vertical | Vertical |
| | | Material No.: | 0 | 0 | 0 | 0 |
| | | Permeability: | **$1 \times 10^{-5}$** | **$1 \times 10^{-5}$** | **$1 \times 10^{-4}$** | **$1 \times 10^{-4}$** |
| | **Layer 3** *Sand* | Thickness: | 12" | 12" | 12" | 12" |
| | | Type: | Lateral | Lateral | Lateral | Lateral |
| | | Material No.: | 0 | 1 | 0 | 1 |
| | | Permeability: | **$5 \times 10^{-3}$** | **$1 \times 10^{-2}$** | **$5 \times 10^{-3}$** | **$1 \times 10^{-2}$** |
| | **Layer 4** *LLDPE* | Thickness: | 0.04" | 0.04" | 0.04" | 0.04" |
| | | Type: | Geomembrane | Geomembrane | Geomembrane | Geomembrane |
| | | Material No.: | 35 | 35 | 35 | 35 |
| | | Permeability: | $4 \times 10^{-13}$ | $4 \times 10^{-13}$ | $4 \times 10^{-13}$ | $4 \times 10^{-13}$ |
| | **Layer 5** *Fill* | Thickness: | 6" | 6" | 6" | 6" |
| | | Type: | Vertical | Vertical | Vertical | Vertical |
| | | Material No.: | 0 | 0 | 0 | 0 |
| | | Permeability: | $1 \times 10^{-5}$ | $1 \times 10^{-5}$ | $1 \times 10^{-5}$ | $1 \times 10^{-5}$ |

Notes

Slope = 20%
Slope Length = 125'

**TABLE 2**

**COVER STABILITY ANALYSES - SOIL COVER VS LLDPE LINER**
**COAL ASH LANDFILL COVER SYSTEM**
**FINAL DESIGN PLAN**
**INVISTA SEAFORD FACILITY**
**SEAFORD, DELAWARE**

| *Critical Interface* | *Cover Density $\gamma$ (lbs/ft$^3$)* | *Cover Thickness at Failure Plane (ft)* | *Depth to Failure plane z (ft) (Note 1)* | *Depth to Water $d_w$ (ft) (Notes 1, 2)* | *Interface Shear Strength* | | *Landfill Slope $\beta$* | | *Factor of Safety* |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Cohesion c (psf)* | *Angle of friction ($\phi$)* | *H:V* | *Degrees* | |
| ***Revised Design: 6"topsoil, 6" general fill, 12" sand, and 40-mil LLDPE smooth liner - total cover thickness = 2.0 ft*** | | | | | | | | | |
| Hydraulic Head of 0.355 inches (Run #1B: fill = 1 x $10^{-5}$ cm/sec / sand = 1 x $10^{-2}$ cm/sec) | | | | | | | | | |
| 6" topsoil plus 6" general fill plus 12" sand vs. 40-mil LLDPE smooth liner | 120 | 2.0 | 2.04 | 1.970 | 0 | 18 | 5.0 :1 | 11.3 | 1.60 |
| Hydraulic Head of 0.809 inches (Run #2A: fill = 1 x $10^{-4}$ cm/sec / sand = 5 x $10^{-3}$ cm/sec) | | | | | | | | | |
| 6" topsoil plus 6" general fill plus 12" sand vs. 40-mil LLDPE smooth liner | 120 | 2.0 | 2.04 | 1.933 | 0 | 18 | 5.0 :1 | 11.3 | 1.58 |

Factor of Safety (FS) =

$$\frac{c/(\gamma.z.\cos^2\beta) + \tan\phi\,[1-\gamma_w(z-d_w)/(\gamma.z)] - k_s \tan\beta \tan\phi}{k_s + \tan\beta}$$

Notes:

$\gamma_w$ (density of water lb/ft$^3$) = 62.4

1) Depth to critical surface/water measured vertically from the ground surface.
2) The calculated factors of safety results are based on assumed interface friction values from published technical literature and should be confirmed by Site-specific laboratory testing.

**TABLE 3**

**COAL ASH LANDFILL CLOSURE AND POST CLOSURE CARE COST ESTIMATES**
**COAL ASH LANDFILL COVER SYSTEM**
**INVISTA SEAFORD FACILITY**
**SEAFORD, DELAWARE**

**Closure Cost Estimate**

| *Task* | *2011 Estimated* |
|---|---|
| Mobilization/Demobilization | $ 45,000 |
| Site Prep | $ 39,000 |
| Project Planning | $ 15,000 |
| Re-grading & Geomembrane Preparation | $ 1,075,000 |
| Geomembrane Installation | $ 270,000 |
| Geomembrane Soil Protective Cover | $ 900,000 |
| Cap Re-vegetation | $ 58,000 |
| Erosion Control & Site Restoration | $ 181,000 |
| Construction & QA/QC Oversight | $ 392,000 |
| Reporting | $ 40,000 |
| Project Management | $ 160,000 |
| Subtotal | $ 3,175,000 |
| Contingency | $ 635,000 |
| **Total Estimated Closure Cost** | **$ 3,810,000** |

**Post Closure Cost Estimate**

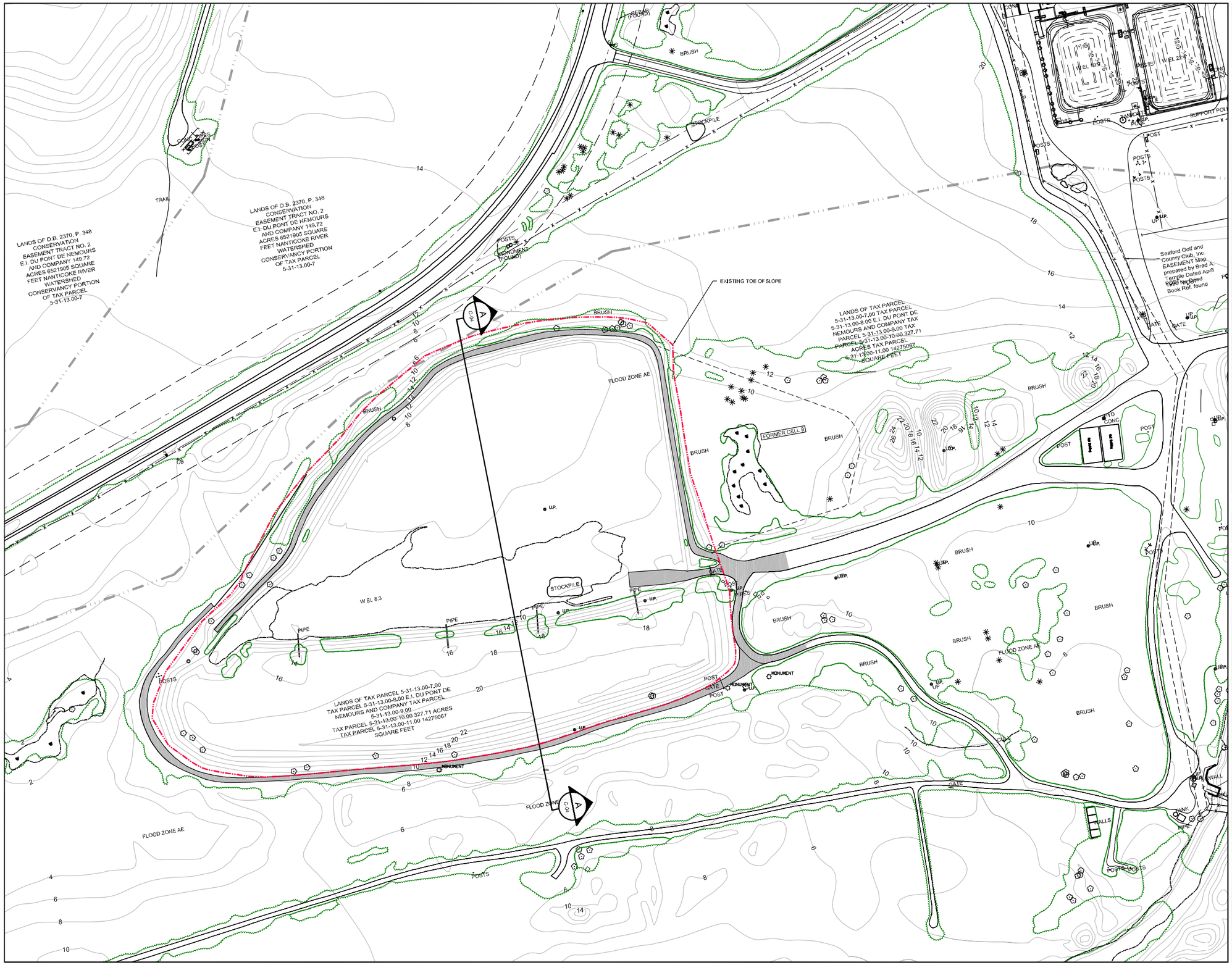
| *Task* | *2011 Estimated** | *Year 2011 x 30 yrs* |
|---|---|---|
| Groundwater Monitoring - Field Work & Reports | $ 34,000 | $ 1,020,000 |
| Groundwater Monitoring – Laboratory Costs | $ 26,800 | $ 804,000 |
| Facility Field Inspections | $ 6,260 | $ 187,800 |
| Annual Erosion Control & Facility Maintenance | $ 5,270 | $ 158,100 |
| Grass Cutting (2 cuttings per year) | $ 5,000 | $ 150,000 |
| **Total Estimated Post Closure Cost** | $ **77,330** | $ **2,319,900** |

*Includes 20% Contingency

# APPENDICES

# APPENDIX A

# DESIGN DRAWINGS




| Nº | Revision | Date | Initial |
|---|---|---|---|
| | | | |

0 40 80ft

## LEGEND

| | |
|---|---|
| 20 | EXISTING GROUND ELEVATION CONTOUR |
| | EXISTING PROPERTY LINE |
| X X | EXISTING FENCELINE |
| | EXISTING FLOODLINE |
| | EXISTING SHORELINE |
| | EXISTING 40' SETBACK |
| | EXISTING TOE OF SLOPE |
| | EXISTING VEGETATION |
| | EXISTING TREELINE |
| | EXISTING SWAMP AREA |
| U.P. | EXISTING UTILITY POLE |
| MONUMENT | EXISTING BENCHMARKS |

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

| Status | Date | Initial |
|---|---|---|
| | | |

# INVISTA SEAFORD FACILITY
# SEAFORD, DELAWARE

## COAL ASH LANDFILL FINAL CLOSURE PLAN

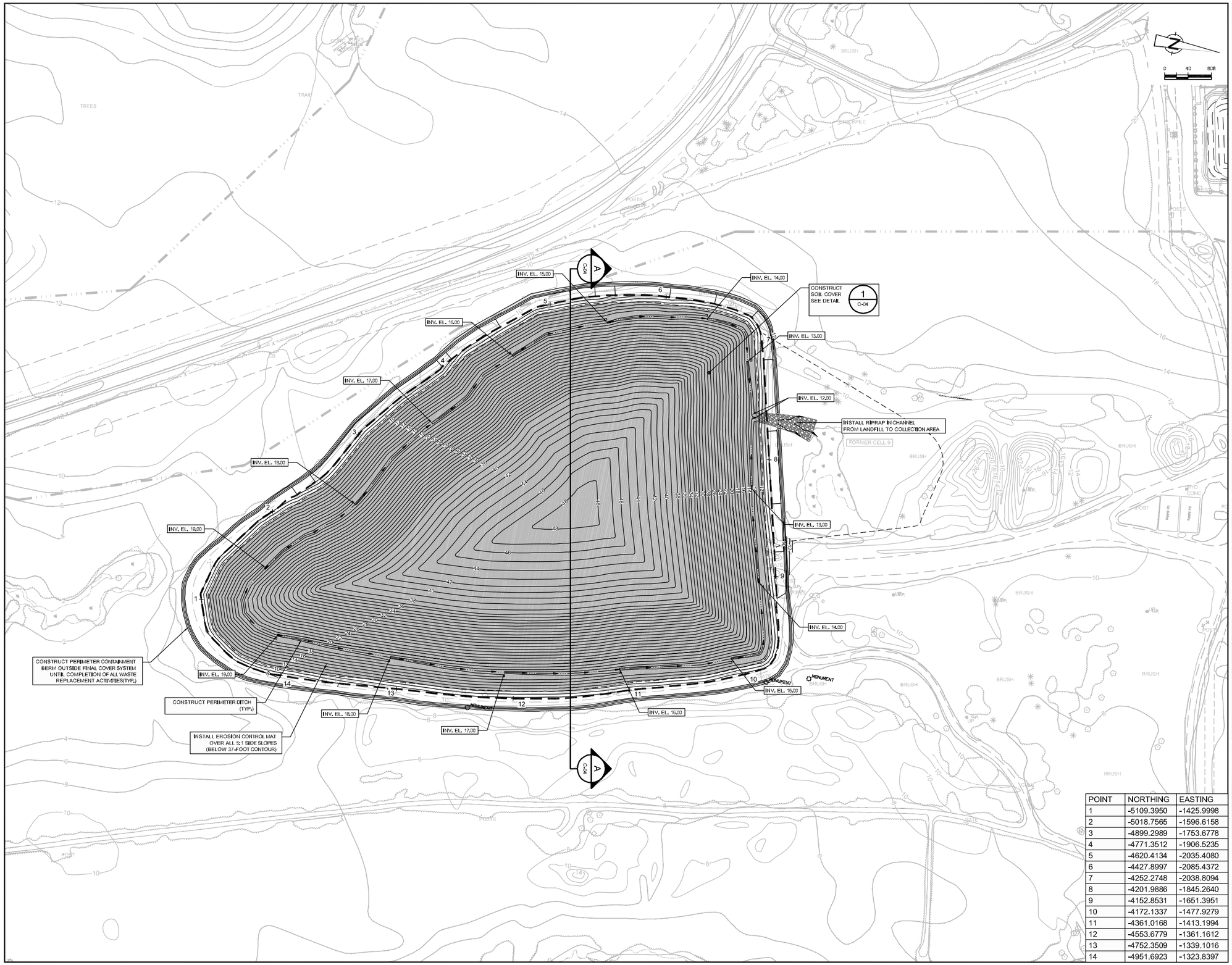
## EXISTING CONDITIONS

**CONESTOGA-ROVERS & ASSOCIATES**

Source References:
SEAFORD INVISTA SITE MAP, 2004

| Project Manager: | Reviewed By: | Date: | |
|---|---|---|---|
| R. HOEKSTRA | A. WESOLOWSKI | APRIL 2011 | |
| Scale: 1" = 80' | Project Nº: 58210-00 | Report Nº: 002 | Drawing Nº: C-01 |

58210-00(002)CI-WA001 MAY 16/2011




| POINT | NORTHING | EASTING |
|---|---|---|
| 1 | -5109.3950 | -1425.9998 |
| 2 | -5018.7565 | -1596.6158 |
| 3 | -4899.2989 | -1753.6778 |
| 4 | -4771.3512 | -1906.5235 |
| 5 | -4620.4134 | -2035.4080 |
| 6 | -4427.8997 | -2085.4372 |
| 7 | -4252.2748 | -2038.8094 |
| 8 | -4201.9886 | -1845.2640 |
| 9 | -4152.8531 | -1651.3951 |
| 10 | -4172.1337 | -1477.9279 |
| 11 | -4361.0168 | -1413.1994 |
| 12 | -4553.6779 | -1361.1612 |
| 13 | -4752.3509 | -1339.1016 |
| 14 | -4951.6923 | -1323.8397 |

| Nº | Revision | Date | Initial |
|---|---|---|---|
| 1 | ADDED PERIMETER CONTAINMENT BERM AND TABLE OF SURVEY POINTS/COORDINATES | 1/18/11 | CRH |

LEGEND

- EXISTING GROUND ELEVATION CONTOUR
- EXISTING PROPERTY LINE
- EXISTING FENCELINE
- EXISTING FLOODLINE
- EXISTING SHORELINE
- EXISTING 40' SETBACK
- EXISTING VEGETATION
- EXISTING TREELINE
- EXISTING SWAMP AREA
- EXISTING UTILITY POLE
- EXISTING BENCHMARKS
- PROPOSED FINAL CONTOURS
- PROPOSED SWALE
- PROPOSED LIMIT OF WASTE
- PROPOSED LIMIT OF COVER SYSTEM
- PERIMETER CONTAINMENT BERM

NOTE:-
FINAL HEIGHT OF LANDFILL IS DEPENDENT UPON ACTUAL VOLUME OF ASH PLACED.

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

| Status | Date | Initial |
|---|---|---|
| SUBMITTED CLOSURE PLAN TO DNREC | 3/15/10 | CRH |

# INVISTA SEAFORD FACILITY
# SEAFORD, DELAWARE

## COAL ASH LANDFILL FINAL CLOSURE PLAN

## FINAL CONTOUR SITE PLAN

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:
SEAFORD INVISTA SITE MAP, 2004

| Project Manager: | Reviewed By: | Date: | |
|---|---|---|---|
| R. HOEKSTRA | A. WESOLOWSKI | DECEMBER 2009 | |
| Scale: 1" = 80' | Project Nº: 58210-00 | Report Nº: 002 | Drawing Nº: C-02 |

58210-00(002)CI-WA007 MAY 16/2011

| No | Revision | Date | Initial |
|---|---|---|---|
| 1 | ADDED PERIMETER CONTAINMENT BERM AND | 1/18/11 | CRH |
| | SURVEY MONUMENTS | | |

LEGEND

- EXISTING GROUND ELEVATION CONTOUR
- EXISTING PROPERTY LINE
- EXISTING FENCELINE
- EXISTING FLOODLINE
- EXISTING SHORELINE
- EXISTING 40' SETBACK
- EXISTING VEGETATION
- EXISTING TREELINE
- EXISTING SWAMP AREA
- EXISTING UTILITY POLE
- EXISTING BENCHMARKS
- PROPOSED SUBGRADE ELEVATION CONTOUR
- PROPOSED SWALE
- PROPOSED LIMIT OF WASTE
- PERIMETER CONTAINMENT BERM

NOTE:-
FINAL HEIGHT OF LANDFILL IS DEPENDENT UPON ACTUAL VOLUME OF ASH PLACED.

VOLUME:
CUT = 21,700 CUBIC YARDS
FILL = 262,400 CUBIC YARDS
NET = 240,700 CUBIC YARDS FILL
(~240,000 CUBIC YARDS WASTE MATERIAL)

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

| Status | Date | Initial |
|---|---|---|
| SUBMITTED CLOSURE PLAN TO DNREC | 3/15/10 | CRH |

# INVISTA SEAFORD FACILITY
# SEAFORD, DELAWARE

## COAL ASH LANDFILL FINAL CLOSURE PLAN

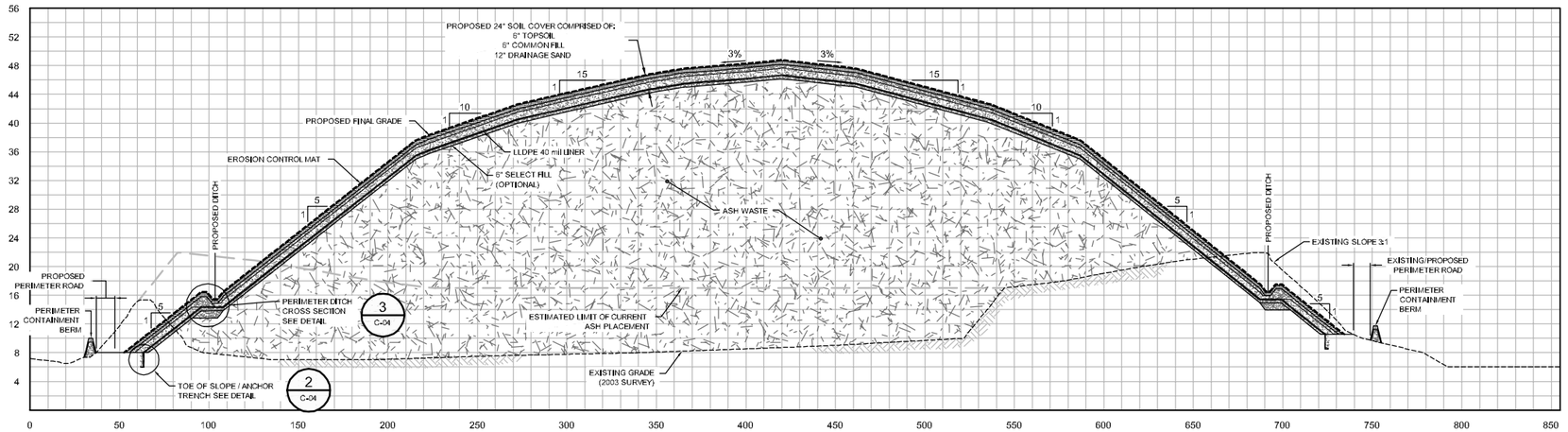
## SUBGRADE CONTOUR SITE PLAN

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:
SEAFORD INVISTA SITE MAP, 2004

| Project Manager: | Reviewed By: | Date: | |
|---|---|---|---|
| R. HOEKSTRA | A. WESOLOWSKI | DECEMBER 2009 | |
| Scale: 1" = 80' | Project No: 58210-00 | Report No: 002 | Drawing No: C-03 |

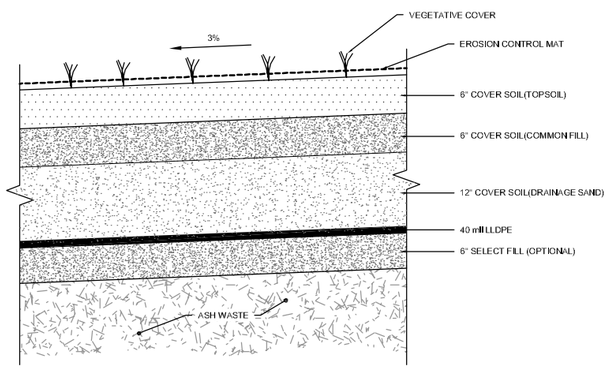
58210-00(002)CI-WA004 MAY 16/2011




## SECTION A

HORZ: 1" = 40'
VERT: 1" = 10'

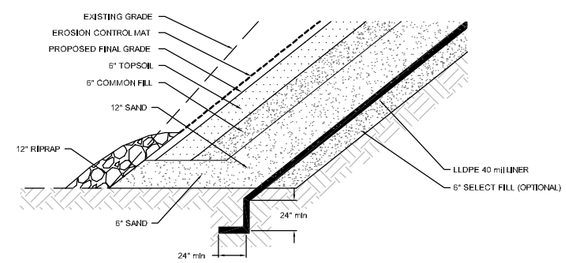
C-01, 02, 03




## DETAIL 1 — FINAL COVER SYSTEM

1" = 1'-0"

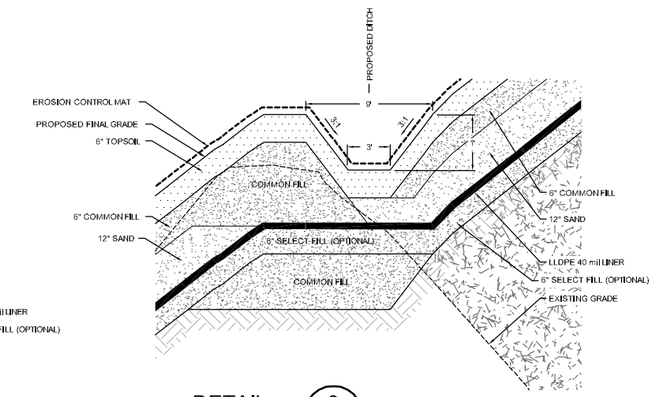
C-02




## DETAIL 2 — TYPICAL TOE OF SLOPE / ANCHOR TRENCH DETAIL

NTS

C-04




## DETAIL 3 — PERIMETER DITCH

NTS

C-04

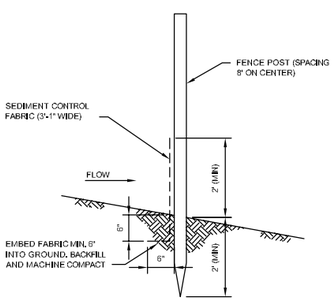



FIGURE 1

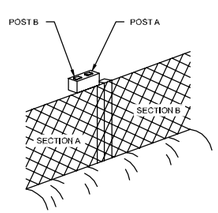



FIGURE 2

FIGURE 3

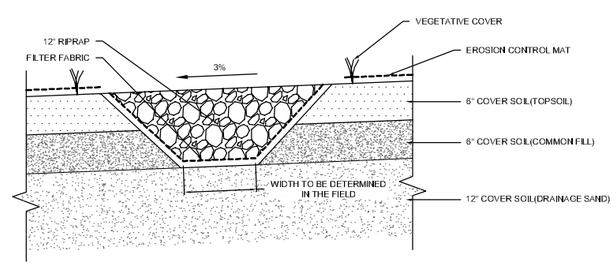
INSTALLATION SEQUENCE:
1. DIG A 6" x 6" TRENCH ALONG SILT FENCE LOCATIONS SHOWN.
2. UNROLL SILT FENCE POSITIONING THE POSTS ON THE DOWNSTREAM SIDE.
3. DRIVE POSTS INTO THE GROUND AS SHOWN ON FIGURE 1.
4. LAY THE BOTTOM 12"-2" OF FABRIC FLAP IN THE BOTTOM OF THE TRENCH, BACKFILL AND COMPACT.
5. ADJACENT SECTIONS OF THE SILT FENCE ARE JOINED AS SHOWN IN FIGURE 3. A COUPLER CAN BE USED TO SECURE ADJACENT POSTS AS SHOWN IN FIGURE 2.

## DETAIL 4 — SILT FENCE

NTS

*

* SEE SECTION 5.1 OF FINAL CLOSURE PLAN

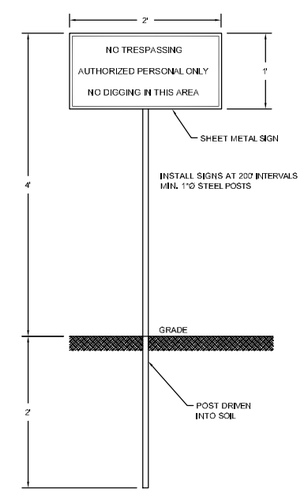



## DETAIL 5 — ENGINEERED CHANNEL DETAIL

NTS

*

* SEE SECTION 4.6 OF FINAL CLOSURE PLAN




## DETAIL 6 — SIGN DETAIL

NTS

*

* SEE SECTION 4.2 OF FINAL CLOSURE PLAN

| No | Revision | Date | Initial |
|---|---|---|---|
| 1 | ADD TYPICAL TOE OF SLOPE DETAIL, PERIMETER DITCH DETAIL AND SILT FENCE DETAIL | 1/18/11 | CRH |

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

| Status | Date | Initial |
|---|---|---|
| SUBMITTED CLOSURE PLAN TO DNREC | 3/15/10 | CRH |

INVISTA SEAFORD FACILITY
SEAFORD, DELAWARE

COAL ASH LANDFILL FINAL CLOSURE PLAN

SECTIONS AND DETAILS

CONESTOGA-ROVERS & ASSOCIATES

Source References:

| Project Manager: | Reviewed By: | Date: | |
|---|---|---|---|
| R. HOEKSTRA | A. WESOLOWSKI | DECEMBER 2009 | |
| Scale: AS SHOWN | Project No: 58210-00 | Report No: 002 | Drawing No: C-04 |

58210-00(002)CI-WA008 MAY 16/2011

# APPENDIX B

# TECHNICAL SPECIFICATIONS

SECTION 01000

GENERAL REQUIREMENTS

1.1 SECTION INCLUDES

A. Summary.

B. Administrative requirements.

C. Quality requirements.

D. Temporary utilities.

E. Temporary facilities.

F. Vehicular access.

G. Temporary barriers and enclosures.

H. Temporary controls.

I. Product requirements.

J. Execution requirements.

1.2 SUMMARY

A. Location: The Site located at 25876 DuPont Road, Seaford, Delaware.

B. Access to the Site:

1. Access to the Site is available from main entrance to the Invista Seaford Plant.

2. Make arrangements with the authorities having jurisdiction for the movement of material and equipment to and from the Site over public roadways.

C. Scope of Work: The Works to be performed under the Contract consists of Ash Landfill Cover System and associated work for Invista Seaford Facility Site, Seaford, Delaware.

D. Description of Work: Work includes, but is not limited, to the following:

1. Project startup including mobilization to the Site.

2. Development, implementation, and maintenance of a Site-specific Health and Safety Plan.

3. Provision and maintenance of temporary facilities and controls.

4. Development, implementation and maintenance of Work Plan, Construction Schedule, and Temporary Sediment and Erosion Control Plan.

5. Construction of multi-layer cover system.

6. Surface water drainage for all graded and modified areas.

7. Restoration of areas affected by the Works.

8. Demobilization and closeout.

E. Drawings: Drawings issued with and forming part of the Contract Documents are listed below:

| *Drawing No.* | *Rev. No.* | *Date of Drawing or Latest Revision* | *Title* |
|---|---|---|---|
| C-01 | 1 | January 2011 | Existing Conditions |
| C-02 | 1 | January 2011 | Final Contour Site Plan |
| C-03 | 1 | January 2011 | Sections and Details |
| C-04 | 1 | January 2011 | Subgrade Contour Site Plan |

F. CONTRACTOR's Use of the Site: When unfavorable weather, soil, drainage, or other unsuitable construction conditions exist, continue operations which will not be adversely affected by such conditions. Do not construct or cause to be constructed any portion of the Works under conditions which would adversely affect the quality of the Works, unless special means or precautions are taken to perform the Works in a proper and satisfactory manner.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Mobilization and Startup:

1. Use existing Site access roads to the designated work areas during mobilization. Complete improvements to roads as necessary for the performance of the Works.

2. Site temporary construction facilities in areas designated by Construction Manager. Obtain Construction Manager's approval prior to changing locations of temporary construction facilities. Do not use other areas without Construction Manager's prior approval.

3. Furnish submittals as required by these Specifications.

B. Coordination: Coordinate delivery of material and equipment to the Site with work sequence; schedule deliveries to limit requirement for storage at the Site to the practical minimum; limit on-Site storage of materials to areas approved by Construction Manager.

C. Progress Meetings:

1. Construction Quality Assurance Engineer (CQAE) will schedule and administer meetings throughout the progress of the Works at maximum weekly intervals or more frequently as required.

2. Attendance Required: CONTRACTOR and CONTRACTOR's health and safety officer.

D. Submittal Procedures:

1. Unless directed otherwise, transmit submittals to Construction Manager and CQAE.

2. Required submittals are identified in individual technical specification Sections.

3. Apply CONTRACTOR's approval stamp prior to initial submission, signed and dated, certifying that CONTRACTOR has satisfied CONTRACTOR's obligations under the Contract Documents including, but not limited to review and approval, verification of products required, field dimensions, adjacent construction work, and coordination of information with respect to CONTRACTOR's review and approval of that submittal. Unstamped or unsigned submittals will be returned by CQAE without action.

4. Make corrections to each submittal required by CQAE. Promptly revise and resubmit the required number of corrected copies of each submittal and submit new submittals required by such correction; identify changes made since previous submission and changes other than those requested by CQAE.

5. It is the responsibility of CONTRACTOR to review submittals made by Suppliers and Subcontractors before transmitting them to Construction Manager and CQAE to assure proper coordination of the Works and to determine that each submittal is in accordance with CONTRACTOR's desires and that there is sufficient information about materials and equipment for CQAE to determine compliance with the Drawings and Specifications. Incomplete or inadequate submittals will be returned for revision without review.

1.4 QUALITY REQUIREMENTS

A. Quality Control:

1. Monitor quality control over suppliers, manufacturers, products, services, Site conditions, and workmanship, to produce Works of specified quality.

2. Comply with manufacturers' instructions, including each step in sequence.

3. Should manufacturers' instructions conflict with the Contract Documents, request clarification from CQAE before proceeding.

4. Comply with specified standards (identified within each individual technical specification Section) as minimum quality for the Works except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

5. Perform work by persons qualified to produce workmanship of specified quality. Use persons licensed to perform the Works where required by these Specifications or Laws and Regulations.

6. Materials furnished and finished or intermediate stages of the Works shall be sampled, tested, and inspected as specified in the individual Sections and as required by reference standards.

7. Performance of tests or observations by CQAE are for the sole benefit of CQAE and are not intended to replace CONTRACTOR's quality control program. CONTRACTOR is solely responsible for establishing and implementing a quality control program to ensure that the Works are in accordance with the Contract Documents.

8. It is CONTRACTOR's responsibility to notify Construction Manager and CQAE when CONTRACTOR believes the Works (or intermediate stages or parts of the Works) are of specified quality and to permit CQAE to perform independent tests or analyses.

9. Testing by CQAE or failure to detect defective work shall not prevent rejection when defect is discovered, nor shall it obligate OWNER for final acceptance.

B. References:

1. Conform to reference standard by date of issue current as of bid closing date, except where a specific date is established by Laws and Regulations or by individual Section.

2. Specific provisions of Laws or Regulations may be referenced in the Project Specifications to assist CONTRACTOR and identify options selected by CQAE. Such references do not relieve CONTRACTOR from compliance with other applicable provisions of Laws and Regulations not specifically referenced.

3. Publications referred to in these Specifications form part of the Specifications to the extent specified in individual Sections.

4. In case of conflict or discrepancy between a reference standard and the Technical Specifications or with another reference standard, the more stringent requirements shall apply.

5. Should specified reference standards conflict with the Contract Documents, request clarification from CQAE before proceeding.

C. Inspecting and Testing by CQAE:

1. CQAE (on behalf of he OWNER) may employ and pay for services of an independent inspecting company and testing laboratory to perform inspecting and testing services as specified in each individual technical specification, where appropriate.

2. Employment of inspecting company and testing laboratory and services performed by such inspecting company and testing laboratory in no way relieves CONTRACTOR of obligation to perform the Works in accordance with requirements of the Contract Documents.

3. Reports will be submitted by the independent firm to CQAE, indicating observations and results of tests and indicating compliance or non-compliance with the specifications and Contract Documents. Copies will be provided to CONTRACTOR upon request.

4. Notify CQAE 24 hours prior to expected time for operations requiring inspecting and testing services.

5. Should CQAE's independent testing demonstrate non-conformance, retesting required because of CONTRACTOR's negligence to specified requirements will be performed by the

same inspecting company and testing laboratory on instructions by CQAE. Costs for retesting and reinspection will be payable by CONTRACTOR to OWNER on demand or OWNER may deduct cost of inspecting or testing charges from monies which are due or may become due to CONTRACTOR.

6. If defects or deficiencies are revealed during testing or inspecting, CONTRACTOR shall correct such defects and deficiencies and retest affected portions of the Works.

## 1.5 TEMPORARY UTILITIES

A. Electricity: Provide, maintain, and pay for temporary power service necessary for performance of the Works.

B. Water Service:

1. Existing potable water source will be available to CONTRACTOR at OWNER's Invista Seaford facility.

2. Potable water tanks shall be clean and contaminant free, inside and outside.

## 1.6 TEMPORARY FACILITIES

A. Equipment Decontamination Facility: Provide details with Site Operations Plan, for review and approval by Construction Manager.

B. Emergency and First-aid Equipment: Comply with OWNER's Health and Safety procedures.

C. Sanitary Facilities:

1. Provide and maintain required temporary sanitary facilities and enclosures in accordance with OSHA.

2. Remove and dispose of sanitary wastes off the Site on a periodic basis as required and in accordance with Laws and Regulations.

D. Wastewater:

1. Discharges: Do not discharge any wastewaters to on-Site sewer systems. Obtain approval of Construction Manager prior to discharge of wastewater.

2. Provide pumps and piping to convey collected wastewaters to designated wastewater facilities.

3. Connect pumps, piping, valves, miscellaneous items, and necessary utilities as required for operation of the facilities. Protect valves, pumps, piping, and other miscellaneous items from freezing and leakage.

4. Do not operate wastewater facility until inspected by Construction Manager.

## 1.7 VEHICULAR ACCESS

A. Construct and maintain existing access roads from Invista Seaford plant roadways to landfill area at a width and load bearing capacity to provide unimpeded access for construction purposes as CONTRACTOR requires for performance of the Works.

B. Construct and maintain temporary drainage structures and culverts, if necessary, to span low areas and allow unimpeded drainage.

C. Provide unimpeded access for emergency vehicles. Maintain sufficient width and turning space.

D. Remove mud and waste materials from vehicle wheels before entering public roads.

E. Obtain Construction Manager's prior approval for location and extent of temporary roads.

F. Prevent contamination of access roads. Immediately scrape up spilled material on access roads that is suspected to be coal ash material as determined by Construction Manager; transport and dispose of in current coal ash landfill facility prior to cover system installation. Clean access roads at least once per shift.

## 1.8 TEMPORARY BARRIERS AND ENCLOSURES

A. Fencing: (as required by Project/Site-Specific HASP):

1. Construction: Standard orange construction fence.

2. Provide fence to delineate work areas.

3. Enforce and require that workers and visitors observe and respect the limits marked with temporary fencing.

B. Security:

1. Access to the Site will be controlled at all times.

2. All workers and visitors shall log in and out at existing OWNER security office for access to the Site through OWNER's property.

3. Do not allow cameras on the Site or photographs taken except by prior written approval of OWNER.

4. If unauthorized personnel are observed on the Site, notify Construction Manager.

1.9 TEMPORARY CONTROLS

A. Water Control:

1. Maintain excavations free of water. Provide, operate, and maintain pumping equipment.

2. Protect the Site from puddling or running water. Grade the Site to drain. Provide water barriers as necessary to protect the Site from soil erosion.

3. Prevent surface water runoff from leaving work areas.

4. Do not discharge surface water runoff, or groundwater that may have come in contact with potentially contaminated material, off the Site.

5. Have on hand sufficient pumping equipment, machinery, and tankage in good working condition for ordinary emergencies, including power outage, and competent workers for operation of the pumping equipment.

6. Direct surface waters that have not contacted potentially contaminated materials to existing surface drainage systems.

7. Control surface drainage including ensuring that gutters are kept open at all times, water is not directed across or over pavements or sidewalks except through approved pipes or properly constructed troughs, and runoff from unstabilized areas is intercepted and diverted to a suitable outlet.

B. Dewatering:

1. Dewater the various parts of the Works including, without limitation, open excavations and work areas.

2. Employ construction methods, procedures, and precautions that will ensure the Works, including excavations, are stable, free from disturbance, and dry.

3. Take precautions necessary to prevent uplift of any structure or pipeline and protect excavations from flooding and damage due to surface runoff.

C. Dust and Particulate Control:

1. Execute the Works by methods to minimize raising dust from construction operations.

2. Implement and maintain dust and particulate control measures immediately during construction and in accordance with the State of Delaware regulations.

3. Provide positive means to prevent airborne dust from dispersing into atmosphere. Use potable water for a water misting system for dust and particulate control.

4. Prevent dust from becoming a nuisance to adjacent property owners or occupants.

5. Construction Manager may stop work at any time when CONTRACTOR's control of dusts and particulates is inadequate for the wind conditions present at the Site.

D. Pollution Control:

1. Be prepared to intercept, clean up, and dispose of spills or releases that may occur, whether on land or water. Maintain materials and equipment required for cleanup of spills or releases readily accessible on the Site.

2. Take immediate action using available resources to contain and mitigate the effects on the environment and persons from any spill or release.

1.10 PRODUCT REQUIREMENTS

A. Product Substitutions:

1. Document each request for substitutions with complete data substantiating compliance of proposed substitution with the Contract Documents.

2. A request for substitution constitutes a representation that CONTRACTOR:

1. Has investigated proposed product and determined that it meets or exceeds the quality level of the specified product.

2. Will provide the same warranty for the substitution as for the specified product.

3. Will coordinate installation and make changes to other work that may be required for the Works to be complete at CONTRACTOR's expense and at no additional cost to Project Manager and OWNER.

4. Waives claims for additional costs or time extension that may subsequently become apparent.

3. Substitutions will not be considered when they are indicated or implied on Shop Drawings or product data submittals without separate written request.

B. Product Delivery and Handling Requirements:

1. Make all arrangements for transportation, delivery, and handling of products required for performance and completion of the Works.

2. Shipments of products to CONTRACTOR or subcontractors shall be delivered to the Site only during regular working hours. Shipments shall be addressed and consigned to the proper party, giving name of Project, street number, and city.

3. Provide advance notice of delivery of products to the Site as required in other Sections.

4. Coordinate deliveries to avoid conflict with the Works and conditions at the Site and to accommodate the following:

1. Work of Other Contractors, or OWNER.

2. Limitations of storage space.

3. Availability of equipment and personnel for handling products.

4. OWNER's use of the Site.

5. Transport and handle products in accordance with manufacturers' instructions.

6. Immediately on delivery, inspect shipments to ensure that products comply with requirements of the Contract Documents and reviewed submittals, quantities are correct, and products are undamaged.

7. Provide equipment and personnel to handle products by methods to prevent soiling, disfigurement, or damage.

C. Product Storage and Handling Requirements:

1. Limit on-Site storage of products to areas approved by Construction Manager.

2. Make arrangements and provisions necessary for storage of materials and equipment.

3. Store and protect products in accordance with manufacturers' recommendations and instructions and requirements of Specifications, with seals and labels intact and legible.

4. Cover products subject to deterioration with impervious sheet covering.

5. Protect delivered products from contamination or damage.

6. CONTRACTOR shall be fully responsible for loss or damage to stored products, materials, and equipment.

1.11 EXECUTION REQUIREMENTS

A. Examination:

1. Prior to commencement of work at the Site, inspect the Site with Construction Manager and CQAE to review and establish the condition of surface features including existing roads, parking areas, buildings, wells, trees and other plants, grassed areas, fencing, service poles, wires, paving, and survey bench marks or monuments on or adjacent to the Site which may be affected by the Works. This inventory shall be mutually agreed between Construction Manager and CONTRACTOR and shall not thereafter be subject to dispute. Such inventory, as may be amended from time to time, will be used by Construction Manager to check compliance by CONTRACTOR with the requirements of the Contract Documents.

2. Provide ongoing review, inspection, and attendance during performance of the Works to properly document conditions. Promptly inform Construction Manager of any existing condition at the Site affected by the Works that may require restoration, repair, or replacement. Do not cover up any of the Works without prior approval from Construction Manager.

3. Maintain and protect existing Site structures and facilities from damage which may be affected by the Works while work is in progress. Repair or replace damage resulting from the Works to Construction Manager's approval.

4. Verify that existing Site conditions and substrate surfaces are acceptable for subsequent work. Beginning new work means acceptance by CONTRACTOR of existing conditions.

5. Examine and verify specific conditions described in individual Sections.

B. Restoration:

1. As a minimum, restoration shall mean replacement, repairs, or reconstruction to a condition at least as good as or better than the condition prior to commencement of the Works.

2. Except where specifically required otherwise by other Sections, restore areas of the Works and areas affected by the performance of the Works to conditions that existed prior to commencement of the Works and to match condition of similar adjacent, undisturbed areas.

3. Ensure that restored areas match existing grade and surface drainage characteristics, except as otherwise specified, and ensure a smooth transition from restored surfaces to existing surfaces.

4. Do not alter original conditions without prior written approval from Construction Manager.

5. Without limiting the generality of the foregoing or other requirements of the Contract Documents, preserve and protect existing features encountered at the Site during the performance of the Works including but not limited to buildings, wells, structures, curbs and gutters, fences, pavement, manholes and catch basins, utilities, roads, streets, walks, grassed areas, and other graded or improved areas.

6. Prior to commencement of restoration work, inform Construction Manager of proposed material, methods, and procedures to repair, replace, or reconstruct any disturbed, damaged, or suspected damage to the Works.

C. Field Surveying:

1. CONTRACTOR shall be responsible for laying out the Works from established reference points. Existing survey monuments are shown on Drawings

2. Verify locations of survey control points (monuments) prior to starting work. Promptly notify Construction Manager of any discrepancies discovered.

3. Locate, preserve, and protect survey control and reference points. Promptly report to Construction Manager the loss or destruction of any reference point or relocation required because of changes in grades or other reasons. Make good any errors entering into the Works through CONTRACTOR failure to notify Construction Manager concerning lack of preservation of such survey reference points. Accurately replace or relocate dislocated reference or survey control points based on original survey control by professionally

qualified personnel. Make no changes without prior written notice to and approval of Construction Manager.

4. Develop and make such additional detailed surveys as are needed for construction, such as bench marks, slope stakes, batterboards, stakes for establishing the design elevations of excavations and final grades, and other working points, lines, and elevations. Maintain bench marks and base lines, existing property boundaries, lines and grade hubs, and other references and construction or survey points.

5. CQAE may, at any time, check CONTRACTOR's survey and layout work but this shall not relieve CONTRACTOR of any of his responsibilities to carry out the Works to the lines and grades as set out in accordance with the Drawings and the Project Specifications or as otherwise necessary for performance of the Works in accordance with the Contract Documents.

6. Provide reasonable and necessary opportunities and facilities for setting points and making measurements during construction.

7. Maintain a complete and accurate log of control and survey work as it progresses.

8. Establish elevations, lines, and levels, utilizing recognized engineering survey practices.

9. At a minimum, topographic as-built surveys to be completed at 100-foot by 100-foot grid for final ash placement elevations, top of geomembrane, and final cover (i.e., topsoil) elevations. Submit paper and digital copies of registered Site drawing and certificate signed by the land surveyor engaged by CONTRACTOR that the elevations and locations of the work are in conformance with the Contract Documents. Provide digital copy on Compact Disc (CD) compatible for use with Windows 2000/XP and AutoCad 2010.

D. Equipment Decontamination (as needed):

1. Construct equipment decontamination pad(s).

2. Decontaminate equipment after working in potentially contaminated work areas and prior to subsequent work or travel on clean areas.

3. Each piece of equipment will be inspected by Construction Manager after decontamination and prior to removal from the Site and/or travel on clean areas. Construction Manager will have right to require additional decontamination to be completed if deemed necessary.

4. Transfer any accumulated coal ash sediments to landfill.

5. Furnish and equip personnel engaged in equipment decontamination with protective equipment including suitable disposable clothing, respiratory protection, and face shields.

E. Final Decontamination and Removal:

1. Perform final decontamination of construction facilities, equipment, and materials that may have come in contact with potentially contaminated materials prior to removal from the Site.

2. Perform decontamination as specified in this Section to the satisfaction of Construction Manager. Construction Manager will have right to direct CONTRACTOR to perform additional decontamination if required.

F. Final Waste Removal and Disposal:

1. Dispose of non-contaminated waste materials, litter, debris, and rubbish off the Site.

2. Dispose of contaminated personnel decontamination equipment and materials that cannot be decontaminated at licensed and permitted waste disposal facility in accordance with Laws and Regulations. Obtain from OWNER approval of facilities acceptable for off-Site disposal of wastes. Transport waste materials from the Site in accordance with Laws and Regulations.

G. Closeout Procedures: Complete and furnish submittals that are required by governing or other authorities or by the Contract Documents. Final payment shall not become due and payable until submittals have been made acceptable to Construction Manager.

H. Record Documents:

1. Maintain 1 set of the following record documents on the Site; record actual revisions to the Works:

    1. Drawings.

    2. Specifications.

    3. Change Orders and other modifications to the Contract.

    4. Approved Shop Drawings, product data, and samples.

    5. Manufacturer's instruction for assembly, installation, and adjusting.

2. Ensure entries are complete and accurate, enabling future reference by OWNER.

3. Store the record documents separate from documents used for construction.

4. Record information concurrent with construction progress.

5. Specifications: Legibly mark and record, at each Section of the Specifications, a description of actual products installed, including the following:

    1. Manufacturer's name and product model and number.

    2. Product substitutions or alternates utilized.

    3. Changes made by modifications.

6. Record Documents and Shop Drawings: Legibly mark each item to record actual construction including:

    1. Field changes of dimension and detail.

2. Details not on original Drawings.

3. Provide AutoCad files of as-built drawings on CD.

4. Provide survey drawing and certificate, in accordance with requirements described in Paragraph 1.12 C.

7. Submit record documents to Construction Manager with final invoice.

8. Site Records: Keep a complete, current, and permanent record at the Site of all data required to be maintained by the Contract Documents, including, but not limited to, the dates of commencement and completion of all aspects of the Works, daily records of the number of workers, the number and type of equipment engaged on the Works and on each division of the Works, and test results, and make such data available to Construction Manager upon request.

I. Warranties:

1. Obtain warranties, executed in duplicate by responsible Subcontractors, Suppliers, and manufacturers, within 14 days after completion of the applicable item of work.

2. Verify that documents are in proper form, contain full information, and are notarized.

3. Co-execute submittals when required.

4. Retain warranties until time specified for submittal.

5. Bind in commercial quality 8 1/2 by 11-inch 3-D ring binders with durable plastic covers. Identify each binder with typed title WARRANTIES, with title of Project; name, address, and telephone number of CONTRACTOR and equipment Supplier; and name of responsible company principal. Neatly type Table of Contents, in the sequence of the Table of Contents of the Project Specifications, with each item identified with the number and title of the Section in which specified, and the name of the project or work item. Separate each warranty with index tab sheets keyed to the Table of Contents listing. Provide full information, using separate typed sheets as necessary. List Subcontractor, Supplier, and manufacturer, with name, address, and telephone number of responsible principal.

6. Submit prior to final inspection.

END OF SECTION

SECTION 01571

TEMPORARY SEDIMENT AND STORMWATER MANAGEMENT

1.1 SECTION INCLUDES

A. References.

B. Quality assurance.

C. Regulatory requirements.

D. Sequencing and scheduling.

E. Products.

F. Examination.

G. Preparation.

H. Installation.

I. Field quality control.

1.2 REFERENCES

A. ASTM International (ASTM):

1. D6461 - Standard Specification for Silt Fence Materials.

2. D6462 - Standard Practice for Silt Fence Installation.

B. Delaware Sediment and Stormwater Regulations, Section 5101.

1.3 QUALITY ASSURANCE

A. Perform work of this Section in accordance with the State of Delaware Sediment and Stormwater Regulations, Section 5101. Prepare Sediment and Stormwater Management Plan for review and approval by Delaware Department of Natural Resources and Environmental Control (DNREC).

1.4 REGULATORY REQUIREMENTS

A. CONTRACTOR must provide certificate of compliance from State of Delaware indicating approval of the Sediment and Stormwater Management Plan.

1.5 SEQUENCING AND SCHEDULING

A. Temporary erosion control measures shall be in place and functional prior to initiation of earth work activities.

1.6 PRODUCTS

A. Silt Fence:

1. An assembled, ready to install unit consisting of geotextile attached to driveable posts, as shown on Drawings and in accordance with State of Delaware regulations.

2. Comply with ASTM D6461.

1.7 EXAMINATION

A. Verify surface water drainage pattern to ensure proper locating of soil erosion and sediment control features.

1.8 PREPARATION

A. Preserve salient natural features, keep cut-fill operations to a minimum, and ensure conformity with topography so as to create the least erosion and to adequately handle the volume and velocity of surface water runoff.

B. Whenever feasible, retain, protect, and supplement natural vegetation.

C. Performance of temporary erosion control work does not relieve CONTRACTOR of its responsibility for preventing or minimizing the potential for erosion or siltation.

1.9 INSTALLATION

A. Construct temporary erosion control in accordance with the approved Erosion and Sediment Control Plan.

B. Install silt fence in accordance with ASTM D6462.

C. Check weekly and after each rainfall greater than 0.5 inches temporary erosion and sediment control measures and restore to original conditions.

D. Unless otherwise shown on the Drawings, or directed by Construction Manager, remove all items upon completion of the Works.

1.10 FIELD QUALITY CONTROL

A. Construction Manager will inspect all temporary erosion control items for proper placement and maintenance.

END OF SECTION

SECTION 02072

LLDPE GEOMEMBRANE

PART 1 GENERAL

1.1 SECTION INCLUDES

A. LLDPE geomembrane for landfill cap.

1.2 REFERENCES

A. ASTM International (ASTM):

1. D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft$^3$ (600 kN-m/m$^3$)).

2. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastic by Displacement.

3. D1004 - Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting.

4. D1238 - Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer.

5. D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique.

6. D1603 - Standard Test Method for Carbon Black Content in Olefin Plastics.

7. D3895 - Standard Test Method for Oxidative Induction Time of Polyolefins by Differential Scanning Calorimetry.

8. D4218 - Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.

9. D4437 - Standard Practice for Non-Destructive Testing (NDT) for Determining the Integrity of Seams Used in Joining Flexible Polymeric Sheet Geomembranes.

10. D4439 – Standard Terminology for Geosynthetics.

11. D4833 - Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products.

12. D5199 - Standard Test Method for Measuring the Nominal Thickness of Geosynthetics.

13. D5321 - Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.

14. D5596 – Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.

15. D5721 – Standard Practice for Air-Oven Aging of Polyolefin Geomembranes.

16. D5885 – Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry.

17. D5994 – Standard Test Method for Measuring Core Thickness of Textured Geomembrane.

18. D6392 - Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.

19. D6693 – Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes.

20. D7238 – Standard Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus.

21. D7466 – Standard Test Method for Measuring the Asperity Height of Textured Geomembrane.

B. Geosynthetic Research Institute (GRI):

1. Test Method GM6 - Pressurized Air Channel Test for Dual Seamed Geomembranes.

2. Test Method GM9 - Standard Practice for Cold Weather Seaming on Geomembranes.

3. Test Method GM17 – Standard Specification for Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes.

## 1.3 DEFINITIONS

A. LLDPE: Linear low density polyethylene.

B. FML: Flexible membrane liner means LLDPE geomembrane.

C. SMDD: Standard Maximum Dry Density means the maximum dry unit weight determined in accordance with ASTM D698.

D. Wrinkles: Corrugations in FML which will fold over during placement of materials overlying FML.

E. Minimum Average Value: Average of test values calculated in accordance with specified standard at minimum frequency specified in GRI Test Method GM17.

F. Conform to ASTM D4439 for interpretation of terms used in this Section.

1.4 PROGRESS SUBMITTALS

A. Product Data: Submit no later than 14 days prior to ordering.

B. Manufacturer's Installation Instructions: Submit at least 14 days prior to installation.

C. Manufacturer's Certificate: Submit the following based on GRI Test Method GM17 test frequency:

1. Certificates pertaining to the FML rolls of material delivered to the Site shall accompany the rolls. Each roll shall be identified by a unique manufacturing number. The quality control certificate shall include results of at least the following tests: density, carbon black content, thickness, tensile strength, puncture resistance, and tear resistance. The quality control certificates shall be signed by a responsible party employed by the manufacturer.

2. Certificates pertaining to raw materials and manufactured rolls shall be provided by the FML manufacturer. CQAE will review the test results for completeness and for compliance with the required minimum properties for both the raw materials and manufactured FML rolls. Materials and rolls which are in non-compliance with the minimum required properties will be rejected.

D. Daily Field Installation Report: Submit to CQAE no later than 1 day following date covered by report. Include:

1. Subgrade surface acceptance form signed by manufacturer's representative (geomembrane subcontractor).

2. Total amount, type, and location of FML placed.

3. Identifiers of rolls and fabricated blankets correlated with manufacturer's number.

4. Quality control tests of materials used during the day.

5. Total amount and location of seams completed, identification of seamer, and welding equipment used.

6. Changes in layout drawings.

7. Observations of test seams, including seaming unit number and identification of names of seamers, weather conditions, speed, temperature setting, and results.

8. Location and results of non-destructive testing.

9. Location and results of destructive testing.

10. Reasons for and observations of repairs and retesting, including locations, type of repair, name of repairer, and seaming equipment or product used.

11. Observations of anchor trench excavation, backfilling, and compaction.

12. Observations of field seaming operations, including weather conditions, cleaning, overlaps, rate of seaming, names of seamers, and units used.

13. Observations of seams around appurtenances, and connection to appurtenances.

E. Layout Drawings: Drawings of the proposed FML placement pattern. Provide no later than 14 days prior to installation.

F. Installer Qualifications: Submit a copy of the manufacturer's approval letter or license to CQAE no later than 14 days prior to installation.

G. Manufacturer's Qualifications: Submit no later than 10 days prior to ordering list of previous projects totaling 3 million square feet of installation, and 5 projects including name of project, description of project, area, client's name and address, contacts, and telephone numbers; engineer's name, address, contact, and telephone number; installer's name, address, contact, and telephone number; and date installed.

## 1.5 CLOSEOUT SUBMITTALS

A. Record Documents: Indicate panel layout, including panel identifiers.

B. Warranties: Completed original warranty forms filled out in OWNER's name and registered with manufacturer.

## 1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum 20 projects, 25 million sq ft installed, and 3 years documented experience.

B. Installer:

1. Trained and qualified to install the type of FML to be used for the project, and an approved and/or licensed installer of FML manufacturer. Submit a copy of the approval letter or license.

2. Personnel performing seaming operations shall be qualified by experience or by successfully passing seaming tests.

3. At least 1 seamer shall have experience seaming at least 10 million square feet of FML of the same generic type as FML used for the project using the same type of seaming method. This master seamer shall provide direct supervision over apprentice seamers.

4. Apprentice seamers shall be qualified by attending training sessions taught by the master seamer and performing at least 2 successful seaming tests under similar weather conditions using the seaming method used for production seaming.

## 1.7 PRE-INSTALLATION MEETING

A. Convene 1 week prior to commencing installation of FML.

B. Purpose of Meeting:

1. Define the responsibilities of each party.

2. Establish lines of authority and lines of communication.

3. Review Site-specific quality assurance/quality control and monitoring procedures.

4. Define the method of acceptance of the completed liner.

5. Establish rules for writing on the liner (i.e., who is authorized to mark on the liner and in what colors).

6. Review time schedules.

7. Review PPE and applicable regulations.

8. Review safety plan and procedures.

9. Review panel layout and numbering system for panels, seams, and test samples.

10. Review methods of measuring production.

11. Review procedures for incremental acceptance.

12. Review procedures for initiating and implementing change orders.

13. Visit the Site for review of surface preparation, physical location of the Site, and Site access.

14. Review critical design details.

## 1.8 DELIVERY, STORAGE, AND HANDLING

A. Section 01000 - General Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Package and label FML rolls or blankets prior to shipment to the Site. The label shall indicate FML manufacturer, type of FML, thickness, lot number, roll number, and roll dimensions.

C. When transported to the Site, handle FML rolls or blankets by appropriate means so that no damage is caused, as recommended by FML manufacturer.

D. Protect FML from direct sunlight and heat to prevent degradation of FML material and adhesion of individual whorls of a roll.

E. Take adequate measures to keep FML materials away from possible deteriorating sources (i.e., vandalism, theft).

F. Use appropriate handling equipment when moving rolled or folded FML from one place to another.

G. Notify Construction Manager and CQAE 3 days in advance of FML delivery to the Site. Perform joint inspection with Construction Manager and CQAE upon delivery. Defects or damage from shipping and handling will be grounds for rejection of a portion of FML or of the entire FML roll at the discretion of Construction Manager and CQAE. Remove roll from the Site and replace with new material.

1.9 ENVIRONMENTAL REQUIREMENTS

A. Install FML in accordance with manufacturer's instructions.

B. Suspend installation operations whenever climatic conditions, as determined by Construction Manager or CQAE or manufacturer's representative, are unsatisfactory for placing FML to the requirements of this Section.

C. Weather Conditions for FML Placement:

1. Comply with manufacturer's recommendation.

2. Do not unroll, unfold, or place FML at an ambient temperature below 32 degrees F or above 104 degrees F, unless CONTRACTOR obtains written approval from FML manufacturer and CQAE.

3. Do not install on wet ground.

4. FML placement shall take into account Site drainage, wind direction, cover construction, access to the Site and production schedule of the Works.

5. FML placement shall not proceed if subgrade conditions have deteriorated due to moisture, or in the presence of high winds, as determined by CQAE, which might damage the FML.

6. Deployed FML should be adequately ballasted at all times to limit the risk of wind damage.

D. Weather Conditions for FML Seaming:

1. Comply with manufacturer's recommendations.

2. Make no weld below 34 degrees F unless:

1. CONTRACTOR strictly follows the guidelines for field seaming of FML in cold weather, as identified in GRI Test Method GM9.

2. CONTRACTOR obtains written approval from FML manufacturer to weld at temperature below 32 degrees F in accordance with GRI Test Method GM9.

3. Between 34 degrees F and 50 degrees F, seaming is possible if FML is preheated by either sun or hot air device, and if there is not excessive cooling resulting from wind.

4. Make no weld below 5 degrees F.

5. In all cases, FML must be dry while being welded.

1.10 SEQUENCING AND SCHEDULING

A. Coordinate the installation of FML with surface preparation work.

1.11 MANUFACTURER'S WARRANTY

A. Provide 5-year manufacturer's warranty against manufacturing defects.

B. Warranty: Include coverage for:

1. Defective product found to be not in compliance with the requirements of this Section.

2. Replacement of the FML with new material including costs associated with FML installation.

C. Fill out original warranty forms in OWNER's name and register with manufacturer.

PART 2 PRODUCTS

2.1 FML

A. Manufactured from virgin resin with no more than 10 percent rework. Rework shall be of same formulation as the parent material. No post consumer resin permitted.

B. Design and manufacture rolls specifically for the purpose of fluid containment.

C. Free of holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter.

D. Melt index value less than 1.0 g/10 minutes in accordance with ASTM D1238.

E. Smooth geomembrane shall have good appearance qualities, free of features that may affect the specified properties

F. Complying with the specifications listed in Paragraph 2.2 A.

2.2 LLDPE PROPERTIES

A. Conform to the following specifications:

| *Property* | *Unit* | *Test Method* | *Minimum Average Value*[1] |
|---|---|---|---|
| Thickness | mil | ASTM D5199 | 40 |
| • Lowest of 10 coupon values | | | 36 |
| • Lowest of 8 of 10 coupon values | | | 34 |
| Density | g/cu cm | ASTM D1505/ASTM D792 | 0.939 (maximum) |
| Tensile Strength at Break | pounds per inch | ASTM D6693 Type IV | 152 |
| Elongation at Break | percent | ASTM D6693 Type IV Gage lengths of 2.0 inches (50 mm) | 800 |
| Carbon Black Content[2] | percent | ASTM D1603/ASTM D4218 | 2 to 3 (range) |
| Carbon Black Dispersion for 10 Different Views | | ASTM D5596 | Cat 1 or 2 |
| • 9 in Categories 1 or 2 and 1 in Category 3 | | | |
| Puncturing Resistance | pound | ASTM D4833 | 56 |
| Tear Resistance | pound | ASTM D1004 | 22 |
| Oxidative Induction Time[3] (OIT) | | | |
| • Standard; or | minute | ASTM D3895 | 100 |
| • High Pressure | minute | ASTM D5885 | 400 |
| Oven Aging at 85 degrees C | NA | ASTM D5721 | NA |
| • Standard OIT retained after 90 days; or | percent | ASTM D3895 | 35 |
| • High Pressure OIT retained after 90 days | percent | ASTM D5885 | 60 |

| *Property* | *Unit* | *Test Method* | *Minimum Average Value*[1] |
|---|---|---|---|
| UV Resistance[4] | | | |
| • Standard OIT; or | percent | ASTM D3895 | NR[6] |
| • High Pressure OIT retained after 1,600 hours | percent | ASTM D5885 | 35 |

Notes:

(1) Except as indicated.
(2) Other methods such as ASTM D4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to ASTM D1603 (tube furnace) can be established.
(3) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(4) 20-hour UV cycle at 75 degrees C, followed by 4 hours condensation at 60 degrees C.

## 2.3 FACTORY SEAMS

A. Geomembrane sheets shall be factory seamed into maximum sized panels to minimize field seaming. Factory seaming shall be by methods approved by the geomembrane manufacturer. Seams shall meet the minimum shear and peel strength requirements shown in table below. Factory seams shall extend to the end of the sheet so that no unbonded edges greater than 3.2 mm wide are present.

| *LLDPE Seam Property* | *Test Value* | *Test Method* |
|---|---|---|
| Seam Shear Strength (min)[1] | 60 lb/in | ASTM D6392 |
| Seam Peel Strength (min)[1][2] | 50 lb/in | ASTM D6392 |

Notes:

(1) Seam tests for peel and shear must fail in the Film Tear Bond mode. This is a failure in the ductile mode of one of the bonded sheets by tearing or breaking prior to complete separation of the bonded area.
(2) Where applicable, both tracks of a double hot wedge seam shall be tested for peel adhesion.

## 2.4 SOURCE QUALITY CONTROL

A. Manufacturer shall perform test for parameters shown in Paragraph 2.2 A at a minimum frequency specified in GRI Test Method GM17.

## PART 3 EXECUTION

### 3.1 EXAMINATION

A. Verify existing conditions before starting work.

B. Obtain CQAE's and CONTRACTOR's approval of conditions in writing prior to installing FML and prior to placing subsequent layers on FML.

C. Coordinate activities such that CQAE can observe field testing. CQAE will observe all testing and collect Samples for destructive laboratory testing.

### 3.2 PREPARATION

A. Surface Preparation:

1. Do not begin installation of FML until a proper subbase has been prepared and approved by CQAE and FML manufacturer/installer. The prepared surface shall be free from abrupt changes in grade, water, loose earth, exposed rocks, rubble, protrusions, vegetation, and other foreign matter which may be damaging to FML. If required, place FML bedding in 1 layer to a minimum compacted depth of 6 inches, compact uniformly to a minimum of 90 percent SMDD (as described in Section 02316 - Fill) and smooth with a drum roller.

2. Do not place FML in an area which has become softened by precipitation and which will not support liner installation equipment without rutting.

### 3.3 PANEL PLACEMENT

A. Designate each roll/blanket with an individual panel number and correlate with manufacturer's identification number. Mark each designation in each roll as it is deployed. Position FML on the Site as shown on the submitted layout drawings. A panel is the unit area of in-place FML which is to be seamed (i.e., 1 roll may be cut into several panels). Follow manufacturer's instructions on the wrapping containing FML materials to assure the panels are unrolled or unfolded in the proper direction for seaming. Unroll or unfold only the panels which are to be anchored or seamed together that day. Exercise care not to damage FML during this operation. Require workers to wear shoes that will not damage FML.

B. Minimize pulling of FML panels to reduce permanent tension.

C. Take the following precautions to minimize the risk of damage by wind during panel placement:

1. Orientate work according to the direction of prevailing winds if possible, unless otherwise specified.

2. Provide adequate securement of FML panels to prevent uplift by wind; using sand bags, tires, or any other means which will not damage FML. Along the edges, ensure loading is continuous, to avoid possible windflow under the panels.

D. Replace panels which, in the judgment of CQAE, become seriously damaged (torn or twisted permanently). Repair less serious damage in accordance with Article 3.6.

E. Do not proceed with FML placement when raining or in an area of ponded water.

F. Install FML roll so that there will be no corrugations or folds at the average expected temperature of the final use condition.

## 3.4 INSTALLATION AROUND WELLS

A. Install FML around wells protruding through FML as shown on Drawings. Unless otherwise specified, initially install FML skirt around each well prior to the FML installation. After FML has been placed and seamed, complete the final field seam connection between the well skirt and the FML. Maintain a sufficient initial overlap of the well skirt so that shifts in location of FML can be accommodated.

B. Obtain CQAE's written approval for materials to be used to seal gaps between the well skirt and main FML panel.

C. Perform installation on rough surfaces carefully to minimize FML damage. Additional loosely placed FML pieces may be used by installer as protection for FML, if approved by CQAE.

D. Ensure clamps, clips, bolts, nuts, or other fasteners used to secure FML around each well have a lifespan equal to or exceeding FML.

## 3.5 FIELD SEAMING

A. Overlap the panels a minimum of 4 inches for extrusion welds and a minimum of 5 inches for hot wedge welds.

B. Panel Preparation: Prior to seaming, clean the seam area and ensure it is free of moisture, dust, dirt, debris of any kind, and foreign material.

C. Seaming Equipment and Products: Seam FML using extrusion or hot wedge welding equipment and installation methods recommended by manufacturer. Where extrusion welding is used, the composition of the extrudate shall be identical to the FML material, or all panels shall be welded together using the hot wedge welding system. Extrusion welding equipment shall include thermometers measuring the temperature of the extrudate in the machine extruder and at the nozzle. Wedge welding equipment used shall be capable of continuously monitoring and controlling the wedge temperature.

D. The direction of seaming on slopes shall be such that the flow of water over top of FML is not hindered. Orient seams downslope. Specifically for hot welded seams, FML overlap shall be on the downslope side of the seam. Extend seaming to the outside edge of panels to be placed in the anchor trench.

E. If the supporting soil is yielding, provide a firm substrate by using a homogeneous board, a conveyor belt, or similar hard surface directly under the seam overlap to effect proper rolling pressure.

F. Seaming Wrinkles: Cut fishmouths and corrugations so as to effect a flat overlap. Seam the cut fishmouths as well as possible, and then install patch of the same generic FML material extending a minimum of 6 inches beyond the cut in all directions.

G. No cross-slope seam shall occur less than 5 feet from the toe of slope unless slope is less than 10 percent. Cross-slope seams may be utilized if cut at an angle of approximately 45 degrees.

H. Label each seam with date, seamer, equipment seaming temperature and speed, and time seam started and completed.

I. Seaming Tie-ins: Seaming of FML tie-ins shall not proceed unless all panels to be seamed are at a uniform temperature (i.e., early in the morning or late in the day) so as to avoid excessive distortion in the FML due to contraction and expansion.

## 3.6 REPAIR PROCEDURES

A. Clean and dry surfaces at the time of repair.

B. Repair pinholes by applying a patch, and defective seams by reseaming, flap welding, or applying a patch, as approved by CQAE.

C. Repair tears, blisters, larger holes, undispersed raw materials, and contamination by foreign matter, or corrugations determined by CQAE to be excessive, by patches.

D. Patches:

1. Abrade surfaces as appropriate.

2. Label each patch with date, number, and seamer and equipment.

3. Ensure patches are round or oval in shape (i.e., no sharp corners).

4. Make of the same generic FML material.

5. Extend patch a minimum of 4 inches beyond the edge of defects.

## 3.7 INSTALLATION OF MATERIALS IN CONTACT WITH FML

A. Place cover material in a manner so as not to damage FML, in accordance with manufacturer's recommendation.

B. Place bedding (Select Fill) or grade and compact existing ash as specified in Section 02316 - Fill.

## 3.8 FIELD QUALITY CONTROL

A. Inspect each panel after placement and prior to seaming for damage. Mark damaged panels or portions of damaged panels which have been rejected, as judged by CQAE, and record their removal from the work area.

B. Verify that weather conditions (air temperature, non-excessive wind, and lack of precipitation) are acceptable for panel placement.

C. Field Seaming Operations: Verify that:

1. Seaming personnel have the specified qualifications.

2. Overlaps meet specified requirements.

3. Seaming area is clean and dry, as specified.

4. A hard substrate such as a board or a piece of conveyor belt is used if the supporting soil is soft or uneven.

5. Seaming equipment is available and meets specified requirements.

6. Weather conditions for seaming are acceptable, as specified.

7. Seaming procedures as specified are followed.

8. Panels are properly positioned to prevent wrinkling.

9. Equipment for testing seams is available on the Site and operational.

10. Field tensiometer has been correctly calibrated.

D. Test Seams:

1. Perform test seams in accordance with ASTM D4437 to verify that the seaming conditions are adequate. Conduct test seams at the discretion of CQAE and at least 2 times each day (at the beginning of the day and at least 4 hours thereafter) for each piece of seaming equipment used that day. Perform test seaming under the same conditions as production seaming. Extrusion weld test seams shall be at least 4 feet long. Hot wedge weld test seams shall be at least 10 feet long. Perform test seams on scrap FML material not to be incorporated into the Works.

2. Cut 1-inch wide coupons from the test seam and assign to peel or shear test alternatively as they are cut across panel. Test coupons in shear and peel using a calibrated field tensiometer.

1. Minimum strength of FML test seams when tested in shear shall be 1,500 psi (60 ppi), calculated by dividing the force at break by the specimen width and nominal sheet thickness.

2. Minimum strength of FML test seams when tested in peel shall be 1,250 psi (50 ppi), calculated by dividing the force at break by the specimen width and nominal sheet thickness.

3. Test coupons must not delaminate.

4. Passing test results must be obtained from 4 of 5 coupons when tested in shear, as well as 4 of 5 coupons when tested in peel. For FML test seams performed using a

hot wedge welder, perform peel tests on both the inside and outside welds; both welds must pass the peel test. If a test seam fails, reject the seaming equipment for field seaming until the deficiencies are corrected and a successful test seam is produced.

3. A passing test seam will be an indicator of the adequacy of the seaming unit and seamer working under prevailing Site conditions, but not necessarily an indicator of field seam adequacy.

4. Coordinate completion of test seams such that CQAE can observe such test seams. CQAE will observe all test seams. Retain a Sample from each test and label with the date, ambient temperature, number of seaming unit, seamer, and pass or fail description. One half of the Sample will be retained by CQAE.

E. Non-destructive Seam Testing:

1. Non-destructively test field seams over their full length by pressure testing in accordance with GRI Test Method GM6. Pressure test results will be written on liner near tested seam. Number or otherwise designate each seam. Record location, date, test unit, name of tester, and outcome of all non-destructive testing.

2. Passing non-destructive test of field seams, meeting or exceeding the requirement in GRI Test Method GM6, indicates the adequacy of field seams, subject to results of destructive seam testing, as identified in Paragraph 3.8 F.

3. Coordinate activities such that CQAE can observe all seam testing. CQAE will observe all testing. Non-destructive testing performed in absence of CQAE shall be repeated. Conduct testing as the seaming work progresses, not at the completion of all field seaming. Number and mark all defects found during seam testing immediately after detection. Repair, retest, and remark all defects found to indicate completion of the repair and acceptability. Following pressure testing, the hole resulting from the pressure needle must be repaired.

F. Destructive Seam Testing: Collect FML field seam samples at a frequency of approximately 1 sample per 500 linear feet of field seam, or more frequently if requested by CQAE, at locations indicated by CQAE. Field test 5 coupons in peel and 5 coupons in shear in accordance with ASTM D4437, using a calibrated field tensiometer. Perform peel tests on the inside and outside weld. If at least 4 of each of the 5 coupons do not delaminate and pass the tensile strength requirements, based on the field testing, collect additional 2-foot long sample from the same location and provide to CQAE for quality assurance laboratory shear and peel testing. Minimum shear strength of FML field seams when tested in shear shall be 1,500 psi calculated by dividing the force at break by the specimen width and nominal sheet thickness for both the field and laboratory tests. Minimum strength of FML field seams when tested in peel shall be 1,250 psi calculated by dividing the force at break by the specimen width and nominal sheet thickness for both the field and laboratory tests. If either field tests or quality assurance laboratory tests fail, isolate the defective seam and re-test as follows:

1. Collect additional samples from the field seam for testing using a field tensiometer, within 10 feet of each side of the failing sample as determined by CQAE, until passing test locations are identified. Collect additional 2-foot long sample from each passing field test location and provide to CQAE for quality assurance laboratory shear and peel testing.

2. Repair the field seam between the passing test locations (based on field tensiometer results) by extrusion welding or patching.

3. Non-destructively (pressure) test the patch or extrusion weld and repair, as required, until non-destructive test standards are achieved.

4. If the additional laboratory shear or peel tests fail, then additional destructive seam field samples will be collected and field tested to isolate the failing seam, then laboratory tested.

5. Repeat the above-noted procedure until passing field test and laboratory test results are achieved, thereby delineating extent of defective seam.

G. Verification of Seams in Special Locations:

1. Non-destructively test seams in special locations (i.e., wells) if the field seam is accessible to testing equipment. CQAE will observe all seam testing operations. If the seam cannot be tested in place, it will be observed by CQAE and CONTRACTOR for uniformity and completeness.

2. In the case of visual inspections, record the seam number, date of inspection, name of tester, and outcome of the inspection.

3. Promptly repair, retest, and re-mark defective seams to indicate completion of the repair.

H. Defects and Repairs:

1. Identification: Inspect seams as well as non-seam areas of FML for identification of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter.

2. Evaluation: Non-destructively test each suspect location, both in seam and non-seam, using the methods described in Paragraph 3.8 E. Mark and repair each location which fails the non-destructive testing.

3. Verification of Repairs: Non-destructively test each repair using the method described in Paragraph 3.8 E. Repair tests that pass the non-destructive test standards will serve as an indication of an adequate repair. Re-repair and test failed tests locations until a passing test results. Record the number of each repair, date, location, repair personnel initials, and test outcome. CQAE will observe non-destructive testing of all repairs.

I. FML Acceptance: FML will be accepted by CQAE when:

1. Installation is finished.

2. Documentation of installation is completed and submitted to CQAE.

3. Verification of the adequacy of field seams and repairs, and associated testing, is complete.

J. Quality Assurance Testing by CQAE: Quality assurance laboratory engaged by OWNER will perform laboratory tests on FML samples as identified in this Section to determine if FML seams meet specified requirements. Copies of test reports will be supplied to CONTRACTOR on request. Retesting of previously failed FML seams will be at no additional cost to OWNER.

3.9 MANUFACTURER'S FIELD SERVICES

A. Manufacturer shall provide a qualified representative to observe placement of FML, subgrade preparation, FML installation, and backfilling operations. Manufacturer's representative shall guide installer into proper installation techniques but shall not assume liability or responsibility in the overall installation.

B. Manufacturer's representative shall have extensive knowledge of FML product, specifically as it pertains to proper construction techniques for waste management applications.

C. Manufacturer's representative shall remain on Site until, in his opinion, CONTRACTOR and/or installer can adequately complete the installation in strict accordance with specifications and the installation procedure specified in this Section.

3.10 PROTECTION OF FINISHED WORK

A. Protect finished work from damage.

B. Do not permit traffic over unfinished liner installation.

END OF SECTION

SECTION 02316

FILL

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. Site Preparation, including clearing and grubbing of existing trees and brush.

B. Excavated berm material from reduction of existing landfill slopes.

C. Select fill for LLDPE geomembrane subgrade, if required.

D. Sand drainage layer over LLDPE geomembrane.

E. Common fill over sand drainage layer.

F. Topsoil for landfill cap and restoration of adjacent areas.

G. Rip rap for lining of drainage discharge to low area.

### 1.2 REFERENCES

A. ASTM International (ASTM):

1. C88 - Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.

2. C127 - Standard Test Method for Specific Gravity and Absorption of Coarse Aggregate.

3. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

4. C666 - Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.

5. D422 - Standard Test Method for Particle-Size Analysis of Soils.

6. D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft$^3$ (600 kN-m/m$^3$)).

7. D2216 - Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.

8. D2434 – Standard Test Method for Permeability of Granular Soils (Constant Head).

9. D2487 – Standard Practice for Classification of Soils For Engineering Purposes (Unified Soil Classification System).

10. D2974 - Standard Test Methods for Moisture, Ash and Organic Matter of Peat and Other Organic Soils.

11. D3740 - Standard Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction.

12. D4253 - Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.

13. D4254 - Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.

14. D4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

15. D4972 - Standard Test Method for pH of Soils.

16. D5084 - Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

17. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

C. State of Delaware Department of Transportation (DelDOT) Specifications for Road and Bridge Construction.

D. United States Environmental Protection Agency (USEPA): SW-846 - Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods, Third Edition and Promulgated Updates I-III.

## 1.3 DEFINITIONS

A. SMDD: Standard Maximum Dry Density and in the context of this Contract means the maximum dry unit weight determined in accordance with ASTM D698.

B. 'State Standard' in this Section shall mean State of Delaware Specifications for Road and Bridge Construction.

## 1.4 PROGRESS SUBMITTALS

A. Materials Sources: Submit name of proposed imported soil materials sources at least 14 days prior to commencing transport of materials to the Site.

B. Geotechnical and Chemical Data: At least 7 days prior to commencing transport of materials to the Site, submit geotechnical data for source testing as specified in Article 2.6 for each type of imported fill.

C. Independent Geotechnical and Analytical Testing Firm: At least 14 days prior to commencing transport of imported fill to the Site, submit the name and qualifications of the independent testing firms proposed by CONTRACTOR to provide testing services for work of this Section.

D. Suppliers' Certificates: Submit certificate indicating that each type of imported fill meets or exceeds specified requirements.

E. Material Source Certification: If fill materials obtained from a state certified quarry, chemical characterization specified in Paragraph 2.6 E may not be required. CONTRACTOR shall be responsible to submit to Construction Manager documentation related to the quarry operations that includes but is not limited to the following:

1. State certification.

2. Quarry location and address.

3. Owner/Operator's name and state permit/licensing number.

4. Reports of testing in accordance with specified standards, evidencing compliance with specified requirements.

5. Historical report information pertaining to the quarry certification.

6. Quality Assurance Plan identifying sampling procedures, sample network, analytical procedures, and analytical laboratory.

7. Statement from the quarry providing evidence that the source is clean. Fill materials will be considered uncontaminated if chemical analysis have been completed by a state-certified laboratory for parameters specified in Paragraph 2.6 E and the most recent test results show that the fill material meets requirements in Delaware Regulations Governing Solid Waste.

F. Weigh Tickets: Submit at the start of the work day following delivery weigh tickets generated at Supplier's weigh scale of imported fill delivered to the Site.

G. Field Quality Control: Submit field data on same day testing is performed. Submit laboratory data within 24 hours of completion of test.

## 1.5 QUALIFICATIONS

A. Independent Geotechnical Testing Firm: Company specializing in performing the work of this Section and complying with ASTM D3740 to perform testing of fill material samples including density, moisture content, permeability and particle size analysis.

B. Independent Laboratory: Company specializing in performing the work of this Section to perform chemical analysis of fill material samples for parameters specified in Paragraph 2.6 E.

## 1.6 ENVIRONMENTAL REQUIREMENTS

A. Suspend operations whenever climatic conditions, as determined by Construction Manager, are unsatisfactory for placing fill to the requirements of this Section.

## PART 2 PRODUCTS

### 2.1 GENERAL

A. Imported from an approved source.

B. Free of unsuitable materials including:

1. Frozen material or material containing snow or ice.

2. Trees, stumps, branches, roots, or other wood or lumber.

3. Wire, steel, cast iron, cans, drums, or other foreign material.

4. Materials containing hazardous or toxic constituents at hazardous or toxic concentrations.

C. Compactable to specified density at specified moisture content.

### 2.2 BEDDING SOIL (SELECT FILL)

A. Having the following gradation:

| *Sieve Size* | *Percent Passing By Weight* |
|---|---|
| 3/8-inch | 100 |

### 2.3 SAND DRAINAGE LAYER

A. Having the following gradation:

| *Sieve Size* | *Percent Passing By Weight* |
|---|---|
| 3/8-inch | 100 |
| No. 8 | 65 to 95 |
| No. 16 | 35 to 75 |
| No. 30 | 20 to 55 |
| No. 50 | 5 to 30 |
| No. 200 | 0 to 5 |

B. Clean, well graded, achieving a smooth particle size distribution curve without sharp breaks when plotted on a semi-log grading chart in accordance with ASTM E11 with a hydraulic conductivity between $5 \times 10^{-3}$ and $1 \times 10^{-2}$ cm/s after compaction.

C. Composed of clean, non-contaminated, hard, durable particles obtained from deposits of gravel, quarried rock, or other suitable granular material, and free of organic matter.

## 2.4 COMMON FILL

A. Having the following gradation:

| *Sieve Size* | *Percent Passing by Weight* |
|---|---|
| 3-inch | 100 |
| 1/2-inch | 90 to 100 |
| No. 10 | 70 to 95 |
| No. 100 | 35 to 70 |

B. Free of unsuitable materials including:

1. Materials containing organic matter.

2. Clays which are classified as inorganic clays of high plasticity in accordance with ASTM D2487.

3. Soft and/or organic clays and silts.

C. Relationship of gradation of common fill to sand drainage layer shall meet the following:

$$\frac{D_{15}\text{ (sand)}}{D_{85}\text{ (common fill)}} < 4$$

$$4 < \frac{D_{15}\text{ (sand)}}{D_{15}\text{ (common fill)}} < 25$$

$$\text{and } \frac{D_{50}\text{ (sand)}}{D_{50}\text{ (common fill)}} < 25$$

where $D_{15}$, $D_{50}$, and $D_{85}$ are grain sizes at which 15, 50, and 85 percent, respectively, are finer than the size for the soil specified. If this relationship cannot be met, change soil material source, or install a non-woven geotextile fabric having an apparent opening size (AOS) less than 3 times the $D_{85}$ of the common fill material.

D. Hydraulic conductivity between $1 \times 10^{-4}$ and $1 \times 10^{-5}$ cm/s determined in accordance with ASTM D5084.

## 2.5 TOPSOIL

A. Friable loam surface soil, neither heavy clay nor of very light sandy nature.

B. Free of unsuitable materials including:

1. Sod, leaves, or any other large or undecayed organic matter.

2. Cobbles, rock, masonry, or asphalt larger than 1 inch.

3. Seeds of noxious weeds.

C. Acidity range (pH) of 5.5 to 7.5, determined in accordance with ASTM D4972.

D. Containing a minimum of 4 percent and a maximum of 25 percent by weight organic matter, determined in accordance with ASTM D2974.

E. Capable of supporting vegetative growth.

2.6 RIP RAP

A. Unweathered, durable crushed or blasted igneous, metamorphic, or sedimentary rock.

B. Free from organic, mica, shale, or other unsuitable material.

C. Individual Rock Fragments: Hard, dense, sound, and resistant to abrasion and free of cracks, seams, and other structural defects that would tend to increase unduly their destruction by water and frost action and handling.

D. Do not use rock exhibiting marked deterioration by water or weather.

E. Bulk Specific Gravity of Rock Fragments: ASTM C127, minimum 2.6.

F. Maximum aspect ratio (greatest to least dimension) of any piece of riprap shall not be greater than 2.5 when measured on mutually perpendicular axes.

G. Gradation limits for riprap are in-place requirements. Make adjustment in production, transportation, and placement as necessary to ensure that placed materials are within specified range.

H. Rip rap:

| *Size* | *Maximum Percentage of Total Weight Smaller* |
|---|---|
| 6 inches | 100 |
| 4 inches | 85 |
| 3 inches | 50 |
| 2 inches | 15 |

I. Well graded and not exhibiting gap grading or scalping from individual size ranges.

J. Rock Quality:

1. Absorption: ASTM C127, 2 percent maximum water absorption.

2. Soundness: ASTM C88, 15 percent maximum loss at 5 cycles.

3. Freeze-Thaw: ASTM C666, 12 percent maximum loss at 35 cycles.

2.7 SOURCE QUALITY CONTROL

A. Testing and Analysis of Select Fill:

1. Maximum Dry Density and Optimum Moisture Content, ASTM D698: 1 sample per 2,500 cu yd, or portion thereof, of material required.

2. In Place Moisture Content, ASTM D2216: 1 sample per 2,500 cu yd, or portion thereof, of material required.

3. Atterberg Limits, D4318: 1 sample per 2,500 cu yd, or portion thereof, of material required.

4. Particle Size, ASTM D422: 1 sample per 2,500 cu yd, or portion thereof, of material required.

5. Soil Classification, ASTM D2487: 1 sample per 2,500 cu yd, or portion thereof, of material required.

6. Chemical Analysis, SW-846: 1 sample per source and for each change in material required in accordance with Paragraph 2.6 E.

B. Testing and Analysis of Sand Drainage Layer:

1. Sieve Analysis, ASTM C136: 1 sample per 2,500 cu yd, or portion thereof, of material required.

2. Maximum Dry Density and Optimum Moisture Content, ASTM D698: 1 sample per 2,500 cu yd, or portion thereof, of material required.

3. Recompacted Permeability, ASTM D2434: 1 sample per 10,000 cu yd, or portion thereof, of material required.

4. Chemical Analysis, SW-846: 1 sample per source and for each change in material required in accordance with Paragraph 2.6 E.

C. Testing and Analysis of Common Fill:

1. Maximum Dry Density and Optimum Moisture Content, ASTM D698: 1 sample per 2,500 cu yd, or portion thereof, of material required.

2. In Place Moisture Content, ASTM D2216: 1 sample per 2,500 cu yd, or portion thereof, of material required.

3. Atterberg Limits, ASTM 4318: 1 sample per 2,500 cu yd, or portion thereof, of material required.

4. Particle Size, ASTM D422: 1 sample per 2,500 cu yd, or portion thereof, of material required.

5. Soil Classification, ASTM D2487: 1 sample per 2,500 cu yd, or portion thereof, of material required.

6. Hydraulic Conductivity, ASTM D5084: 1 sample per 10,000 cu yd, or portion thereof, of material required.

7. Chemical Analysis, SW-846: 1 sample per source and for each change in material required in accordance with Paragraph 2.6 E.

D. Testing and Analysis of Topsoil:

1. Particle Size, ASTM D422: 1 sample per 2,500 cu yd, or portion thereof, of material required.

2. pH, ASTM D4972: 1 sample per 2,500 cu yd, or portion thereof, of material required.

3. Organic Matter, ASTM D2974: 1 sample per 2,500 cu yd, or portion thereof, of material required.

4. Potassium, Phosphorus, Calcium, Magnesium: In accordance with State of Delaware accredited method. 1 sample per 2,500 cu yd, or portion thereof, of material required.

5. Chemical Analysis, SW-846: 1 sample per source and for each change in material required in accordance with Paragraph 2.6 F.

E. Chemical characterization in the laboratory in accordance with the following methods:

| *Parameter* | *Extraction/Preparation*[1] | *Analysis*[1] |
|---|---|---|
| TCL[2] Volatile Organic Compounds | 5035 | 8260B |
| TAL[3] Metals Series | 3050B or 3051 | 6010B/7000 |

Notes:

(1) USEPA SW-846.
(2) TCL - Target Compound List.
(3) TAL - Target Analyte List.

F. If tests indicate materials do not meet specified requirements, change material or material source and retest.

G. Provide materials of each type from the same source throughout the Works.

H. In the event of changes to approved sources of materials during the performance of the Works, immediately advise Construction Manager or CQAE of revised locations and obtain approval of such locations and materials prior to use in the Works.

## PART 3 EXECUTION

### 3.1 EXAMINATION

A. Verify existing conditions before starting work.

B. Do not allow or cause any of the work performed or installed to be covered up or enclosed by work of this Section prior to required inspections, measurements, tests, or approvals.

C. Obtain approval from CQAE for previously placed material prior to placement of successive lifts.

D. Ensure areas to be backfilled are free from debris, snow, ice, water, soft soils, organic materials, or frozen ground.

### 3.2 PREPARATION

A. Remove debris, snow, ice, water, soft soils, organic materials, or frozen ground from areas to be backfilled.

B. Compact subgrade to density requirements for subsequent backfill materials.

C. Cut out soft areas of subgrade not capable of compaction in place. Backfill with common fill and compact to density equal to or greater than requirements for subsequent fill material.

### 3.3 CLEARING AND GRUBBING

A. Cut all trees and brush on berm and along all slopes to be cut back for construction of perimeter access. Remove stumps, including main root ball and dispose with felled trees.

B. Remove from the site all grubbed material, together with logs and other organic or non-organic debris not suitable for placement in landfill.

C. Dispose of trees, logs, stumps, roots, brush, rotten wood, and other refuse from the clearing and grubbing operations, as directed by Construction Manager.

### 3.4 FILLING

A. Fill areas to grades and elevations shown on the Drawings.

B. Excavated Ash: Place and compact material in equal continuous layers not exceeding 12 inches compacted depth.

C. Select Fill: Where needed, place and compact fill material in 1 layer to a minimum compacted depth of 6 inches. Select fill may not be required for a portion of the coal ash surface that meets the requirement of containing only materials less than 3/8 inches or less and if coal ash surface does not become too wet as to become difficult to work on during placement of subsequent liner. If select fill is placed on only a portion of the coal ash surface, provide a smooth transition from select fill surface to coal ash already in place. Proof roll compacted select fill layer as specified in Article 3.5 in preparation of placement of geomembrane.

D. Sand Drainage Layer: Place and compact material in 1 layer to a minimum compacted depth of 12 inches employing placement methods that do not damage the FML (in accordance with manufacturer's guidelines for cover soil placement).

E. Common Fill: Place and compact material in 1 layer to a minimum compacted depth of 6 inches.

F. Topsoil: Place topsoil on landfill cap and adjacent disturbed areas to a minimum settled depth of 6 inches during dry conditions. Grade topsoil to eliminate rough, low, or soft areas, and to ensure positive drainage, and rake smooth.

G. Employ a placement method that does not disturb or damage other work.

H. Maintain optimum moisture content of backfill materials to attain required compaction density.

I. Compact each layer to density specified in Article 3.5 before placing succeeding layers.

## 3.5 COMPACTION

A. Excavated Ash: Compact to 92 percent SMDD.

B. Select Fill: Compact to 92 percent SMDD.

C. Sand Drainage Layer: Spreading only, no compaction equipment to prevent damage to underlying geomembrane.

D. Common Fill: Compact to 90 percent SMDD.

E. Apply water as necessary during compaction to obtain specified density. If material to be compacted is excessively moist, aerate with suitable equipment and methods until the moisture content is corrected. In areas not accessible to rolling equipment, compact material to specified density with mechanical tampers.

## 3.6 TOLERANCES

A. Top Surface of Backfilling: Plus or minus 1 inch from required elevations.

B. Cap Layer Thickness: Plus or minus 1 inch from required thickness although not uniformly thicker or thinner.

## 3.7 FIELD QUALITY CONTROL

A. Field inspection and testing to be performed to verify quality control in accordance with methods, frequencies, and standards listed elsewhere in this Section.

B. Testing by CONTRACTOR:

1. Select samples of uncompacted fill intended for placement and samples of compacted fill.

2. Perform tests in the field and in the laboratory on samples of backfill and imported fill to determine if materials meet specification. Testing of imported fill will include analyses for the presence of contaminants, grain size analyses, moisture content determination, bulk wet density, maximum dry density, and hydraulic conductivity. Testing of backfill will include moisture content determination, maximum dry density, and bulk wet density. Cover layer thickness shall be measured in place.

3. Copies of all test reports will be provided to Construction Manager and CQAE.

C. Testing by CQAE:

1. CQAE may select samples of uncompacted fill intended for placement and samples of compacted fill.

2. CQAE may perform tests in the field and in the laboratory on samples of backfill and imported fill to determine if materials meet specification.

3. Copies of test reports will be supplied to CONTRACTOR on request.

4. Testing by CQAE will in no way relieve CONTRACTOR of his responsibility to test all material prior to notifying CQAE of materials' suitability for the work involved.

D. Methods of Testing:

1. Maximum dry density and optimum moisture content or maximum and minimum index densities will be determined in the laboratory in accordance with ASTM D698 or ASTM D4253/ASTM D4254 (Test Method A).

2. Moisture content will be determined in the laboratory in accordance with ASTM D2216.

3. Bulk wet density will be determined in the field in accordance with ASTM D6938.

4. Moisture content will be determined in the field in accordance with ASTM D6938.

5. Particle size analysis will be performed in accordance with ASTM D422.

6. Layer thickness measurement will be determined by physical examination or survey of comparative layers.

7. Hydraulic conductivity will be determined in accordance with ASTM D2434 or D5084, as appropriate, on a representative sample compacted in the laboratory to the field bulk wet density and moisture.

E. Frequency of Testing:

1. At least 1 density test and 1 moisture content determination for each lift placed of ash material shall be made for each 1/2 acre (2,400 sq yd) of area, or portion thereof.

2. At least 1 density test and 1 moisture content determination for each lift placed of select fill material shall be made for each 1/2 acre (2,400 sq yd) of area, or portion thereof.

3. At least 1 density test and 1 moisture content determination for each lift placed of common fill material shall be made for each 1/2 acre (2,400 sq yd) of area, or portion thereof.

4. At least 1 layer thickness measurement of each node point of a 100 by 100-foot grid over the landfill cover.

F. Failure to Meet Specified Requirements: If tests indicate that material specifications have not been achieved or cannot be obtained with equipment in use, procedure being followed, or material being incorporated, remove and replace work and modify operations so that the equipment, procedures, and materials will produce the required results. Additional testing required by ENGINEER will be to CONTRACTOR's account.

## 3.8 ADJUSTING

A. Finish compacted surfaces to within ±1 inch of grades shown on the Drawings but not uniformly high or low. Correct surface irregularities by loosening and adding or removing material until the surface is within specified grade.

B. Leave work areas in a properly graded condition sloped as required to permit proper drainage and free of depressions that will pond or collect water or debris that will restrict flow.

END OF SECTION

SECTION 02921

SEEDING

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. Placing topsoil.

B. Seeding.

C. Installation of erosion control blanket.

D. Maintenance for seed establishment.

### 1.2 REFERENCES

A. Official Seed Analysis of North America.

B. State of Delaware Department of Transportation (DelDOT): Specifications for Road and Bridge Construction.

### 1.3 DEFINITIONS

A. Weeds: Include, but are not limited to, Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

B. Noxious Weeds:

1. Harmful, undesirable, hard to control.

2. Include but are not limited to: Johnson Grass or Johnson Grass Crosses, Canadian Thistle, Quackgrass, Wild Garlic and Wild Onion, Bermuda Grass, Annual Blue Grass, Corn Cockle, Dodder, and Blindweed.

C. 'State Standard' in this Section shall mean State of Delaware Specifications for Road and Bridge Construction.

## 1.4 PROGRESS SUBMITTALS

A. Seeding and Erosion Control Plan: At least 14 days prior to placing topsoil, submit to Construction Manager for approval CONTRACTOR's Seeding and Erosion Control Plan including, but not limited to, the following:

1. Seed mixture(s) and fertilizers for the Site and adjacent areas and application rates.

2. Time of year for planting such mixtures.

3. Methods of preparing seedbed, seeding, and rolling seeded areas.

4. Methods to provide erosion control until seed is placed and grass is established (i.e., use of any or a combination of emulsifiers, tackifiers, mulches, adhesives, and nurse crop seed).

B. Seed Certificates: At least 14 days prior to seeding submit certificates from seed vendors for each seed mixture required, stating botanical and common name, percentage by weight and percentages of purity, germination, and weed seed for each species.

C. Fertilizer Certificate: At least 14 days prior to placing fertilizer, submit certificate confirming conformance with recommendations provided by laboratory based on topsoil analysis.

D. Erosion Control Blanket: At least 14 days prior to delivering erosion control blanket, submit manufacturer product data and delivery, handling, storage, installation, and repair methods.

E. Test Results: At least 14 days prior to commencing transport to the Site, submit test results of imported topsoil. Indicate, by test results, information necessary to determine suitability, including, but not limited to, organic content, pH, phosphorus, potassium, calcium, and magnesium; and laboratory or supplier recommendation for fertilizer application rate for specified seed mixture.

## 1.5 QUALITY ASSURANCE

A. Perform work of this Section in accordance with the State Standards.

B. Provide seed mixture in weatherproof containers showing percentage of seed mix, year of production, net weight, date of packaging, and location of packaging.

## 1.6 REGULATORY REQUIREMENTS

A. Comply with regulatory agencies for fertilizer and herbicide composition.

## 1.7 SEQUENCING AND SCHEDULING

A. Schedule topsoil placing to permit seeding operations under optimum conditions during normal planting seasons.

B. Coordinate planting with specified maintenance periods to provide maintenance until acceptance by Construction Manager.

C. Seed areas within 10 days of completion of topsoiling.

D. Apply fertilizer at least 1 week after application of lime, if required.

## PART 2 PRODUCTS

### 2.1 SEED MIXTURE

A. Seed: The latest season's crop of K-31 Fescue. Weed seed content not to exceed 1 percent by weight. Complying with the tolerance for purity and germination established by Official Seed Analysis of North America. Germination to exceed 75 percent. Remove any seed that is wet, moldy, unlabeled, or otherwise damaged.

B. Base seeding rates on pure live seed as follows:

$$\text{Minimum actual seeding rate} = \frac{\text{specified seeding rate}}{(\%\text{purity}/100)\text{x}(\%\text{germination}/100)}$$

### 2.2 TOPSOIL

A. Conform to Section 02316.

### 2.3 EROSION CONTROL BLANKET

A. Meets specifications similar to C125 BN, North American Green.

## PART 3 EXECUTION

### 3.1 EXAMINATION

A. Verify existing conditions before starting work.

B. Verify that prepared soil base is ready to receive work of this Section.

### 3.2 PLACING TOPSOIL

A. Place and grade topsoil in accordance with Section 02316.

B. Obtain Construction Manager's approval of topsoil grade and depth before starting seeding.

### 3.3 SEEDING

A. Apply seed uniformly with a mechanical drill seeder, along with straw mulch crimped into upper topsoil layer. Uniformly drill seed to a depth of 1/2- to 3/4-inch using equipment having

drills not more than 6 1/2 inches apart. Use row markers with the drill seeder. Do not reroll areas seeded with seed drills equipped with rollers.

3.4 EROSION CONTROL BLANKET

A. Identify seeded areas with stakes and string around area periphery.

B. Install erosion control blanket and anchor in accordance with manufacturer's instructions.

3.5 OVERLAP

A. Seeding, temporary cover, and erosion control blanket shall overlap adjoining vegetation by 12 inches.

3.6 MAINTENANCE FOR SEED ESTABLISHMENT

A. Start maintenance immediately after area seeded.

B. Maintain seeded area for not less than the period stated below and longer, as required to establish an acceptable stand, as determined by Construction Manager:

1. Not less than 60 days after last area seeded.

2. If planted in fall and not given full 60 days of maintenance, or if not considered acceptable by ENGINEER as specified in Paragraph 3.7 E, at completion of 60 days, continue regular maintenance the following spring until acceptable vegetative cover is established.

C. Vegetative cover will be accepted by Construction Manager provided all requirements have been complied with, including completion of 60-day maintenance period, and the following.

1. Vegetative cover is properly established.

2. Turf is free of eroded, bare, or dead spots and 98 percent free of weeds.

D. Immediately re-seed areas which show signs of bare spots.

E. CONTRACTOR (or Construction Manager approved subcontractor) shall remain responsible until germination is achieved and shall maintain and reseed, as necessary, until complete vegetative cover is approved by Construction Manager.

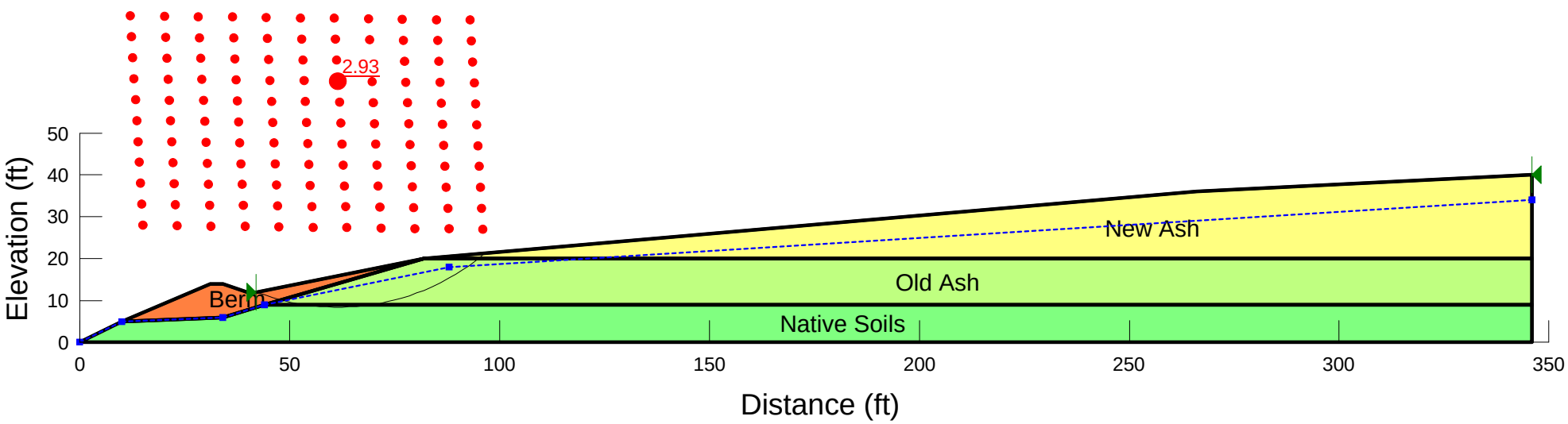
END OF SECTION

# APPENDIX C

# COVER SOIL STABILITY CALCULATIONS

058210 Invista Seaford Powerhouse Landfill
Global Stability Analysis

Name: New Ash Unit Weight: 100 pcf Cohesion: 20 psf Phi: 18 °
Name: Old Ash Unit Weight: 100 pcf Cohesion: 20 psf Phi: 30 °
Name: Native Soils Unit Weight: 120 pcf Cohesion: 0 psf Phi: 32 °
Name: Berm Unit Weight: 120 pcf Cohesion: 0 psf Phi: 30 °



# APPENDIX D

# HELP MODELING CALCULATIONS

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:    I:\SOFTWARE\HELP3\58210P1.D4
TEMPERATURE DATA FILE:      i:\software\help3\58210T1.D7
SOLAR RADIATION DATA FILE:  i:\software\help3\58210R1.D13
EVAPOTRANSPIRATION DATA:    i:\software\help3\58210E1.D11
SOIL AND DESIGN DATA FILE:  I:\SOFTWARE\HELP3\58210S10.D10
OUTPUT DATA FILE:           i:\software\help3\58210R10.OUT


TIME:  16:22     DATE:   4/14/2011


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

     TITLE:  58210 - INVISTA SEAFORD FACILITY - Run 1A 6% 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   6
           THICKNESS                  =      6.00   INCHES
           POROSITY                   =      0.4530 VOL/VOL
           FIELD CAPACITY             =      0.1900 VOL/VOL
           WILTING POINT              =      0.0850 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.2638 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.720000011000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

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

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      6.00   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 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.4170 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.499999989000E-02 CM/SEC
SLOPE                       =      6.00   PERCENT
DRAINAGE LENGTH             =    175.0    FEET


                        LAYER  4
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                   =      0.04   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    =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  2 - EXCELLENT


                        LAYER  5
                        --------
```

```
            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER   0
  THICKNESS                   =      6.00   INCHES
  POROSITY                    =      0.4750 VOL/VOL
  FIELD CAPACITY              =      0.3780 VOL/VOL
  WILTING POINT               =      0.2650 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.3397 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-05 CM/SEC
```

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  6.%
          AND A SLOPE LENGTH OF  175. FEET.

SCS RUNOFF CURVE NUMBER             =     63.40
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      3.750  ACRES
EVAPORATIVE ZONE DEPTH              =     18.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      6.935  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      8.070  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      2.208  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     11.475  INCHES
TOTAL INITIAL WATER                 =     11.475  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
```

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

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          WILMINGTON            DELAWARE

     STATION LATITUDE                       =  39.80 DEGREES
     MAXIMUM LEAF AREA INDEX                =   2.00
     START OF GROWING SEASON (JULIAN DATE)  =    107
     END OF GROWING SEASON (JULIAN DATE)    =    298
     EVAPORATIVE ZONE DEPTH                 =  18.0  INCHES
     AVERAGE ANNUAL WIND SPEED              =   9.20 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  67.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  67.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  72.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  71.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    WILMINGTON          DELAWARE
```

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 3.11 | 2.99 | 3.87 | 3.39 | 3.23 | 3.51 |
| 3.90 | 4.03 | 3.59 | 2.89 | 3.33 | 3.54 |

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 31.20 | 33.20 | 41.80 | 52.40 | 62.20 | 71.20 |
| 76.00 | 74.80 | 67.80 | 56.30 | 45.60 | 35.50 |

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE
AND STATION LATITUDE = 39.80 DEGREES

**********

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

| | JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|---|
| **PRECIPITATION** | | | | | | |
| TOTALS | 3.26 | 3.00 | 4.08 | 3.39 | 3.39 | 3.46 |
| | 3.88 | 3.97 | 3.47 | 2.85 | 3.12 | 3.35 |
| STD. DEVIATIONS | 1.67 | 1.45 | 1.88 | 1.46 | 1.63 | 1.83 |
| | 1.87 | 2.39 | 2.16 | 1.84 | 1.64 | 1.72 |
| **RUNOFF** | | | | | | |
| TOTALS | 0.542 | 1.040 | 0.710 | 0.023 | 0.006 | 0.030 |
| | 0.085 | 0.114 | 0.164 | 0.146 | 0.085 | 0.206 |
| STD. DEVIATIONS | 0.824 | 1.284 | 1.177 | 0.122 | 0.041 | 0.137 |
| | 0.357 | 0.384 | 0.441 | 0.409 | 0.311 | 0.541 |
| **EVAPOTRANSPIRATION** | | | | | | |
| TOTALS | 0.806 | 0.787 | 2.307 | 3.168 | 3.352 | 3.689 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 3.363 | 3.517 | 2.289 | 1.442 | 1.239 | 0.906 |
| STD. DEVIATIONS | 0.267 | 0.419 | 0.425 | 0.755 | 1.153 | 1.325 |
| | 1.278 | 1.409 | 1.053 | 0.437 | 0.229 | 0.185 |

LATERAL DRAINAGE COLLECTED FROM LAYER 3

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 1.3683 | 1.0697 | 1.7706 | 1.6073 | 0.9786 | 0.5899 |
| | 0.3836 | 0.3199 | 0.3638 | 0.5848 | 0.8600 | 1.3019 |
| STD. DEVIATIONS | 0.7623 | 0.7224 | 0.7206 | 0.7152 | 0.4921 | 0.3485 |
| | 0.2399 | 0.2429 | 0.4068 | 0.5996 | 0.7090 | 0.9165 |

PERCOLATION/LEAKAGE THROUGH LAYER 4

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 0.0013 | 0.0010 | 0.0017 | 0.0015 | 0.0008 | 0.0005 |
| | 0.0003 | 0.0003 | 0.0003 | 0.0005 | 0.0008 | 0.0012 |
| STD. DEVIATIONS | 0.0008 | 0.0009 | 0.0009 | 0.0009 | 0.0005 | 0.0003 |
| | 0.0002 | 0.0002 | 0.0004 | 0.0006 | 0.0007 | 0.0011 |

PERCOLATION/LEAKAGE THROUGH LAYER 5

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 0.0007 | 0.0008 | 0.0005 | 0.0005 | 0.0009 | 0.0012 |
| | 0.0014 | 0.0014 | 0.0013 | 0.0012 | 0.0009 | 0.0007 |
| STD. DEVIATIONS | 0.0007 | 0.0007 | 0.0007 | 0.0007 | 0.0007 | 0.0005 |
| | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0006 | 0.0006 |

---

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

---

DAILY AVERAGE HEAD ON TOP OF LAYER 4

| | | | | | | |
|---|---|---|---|---|---|---|
| AVERAGES | 4.6930 | 4.0596 | 6.0759 | 5.6901 | 3.2671 | 2.0305 |
| | 1.2777 | 1.0658 | 1.2524 | 1.9726 | 2.9755 | 4.5272 |
| STD. DEVIATIONS | 2.8129 | 3.1363 | 2.8399 | 2.9886 | 1.6637 | 1.1997 |
| | 0.7993 | 0.8090 | 1.4002 | 2.1010 | 2.4750 | 3.6246 |

**********

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

| | INCHES | | CU. FEET | PERCENT |
|---|---|---|---|---|
| PRECIPITATION | 41.20 | ( 6.096) | 560881.2 | 100.00 |
| RUNOFF | 3.152 | ( 2.3501) | 42903.32 | 7.649 |

| | | | | |
|---|---|---|---|---|
| EVAPOTRANSPIRATION | 26.864 | ( 3.4903) | 365689.41 | 65.199 |
| LATERAL DRAINAGE COLLECTED FROM LAYER 3 | 11.19842 | ( 2.97075) | 152438.437 | 27.17838 |
| PERCOLATION/LEAKAGE THROUGH LAYER 4 | 0.01019 | ( 0.00323) | 138.766 | 0.02474 |
| AVERAGE HEAD ON TOP OF LAYER 4 | 3.241 | ( 0.943) | | |
| PERCOLATION/LEAKAGE THROUGH LAYER 5 | 0.01150 | ( 0.00579) | 156.516 | 0.02791 |
| CHANGE IN WATER STORAGE | -0.023 | ( 2.1072) | -306.45 | -0.055 |

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                PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
   ----------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                              5.26         71601.750

      RUNOFF                                     3.084        41977.5898

      DRAINAGE COLLECTED FROM LAYER  3           0.14116       1921.55444

      PERCOLATION/LEAKAGE THROUGH LAYER  4       0.000253         3.44354

      AVERAGE HEAD ON TOP OF LAYER  4           23.945

      MAXIMUM HEAD ON TOP OF LAYER  4           32.687

      LOCATION OF MAXIMUM HEAD IN LAYER  3
            (DISTANCE FROM DRAIN)               55.1 FEET

      PERCOLATION/LEAKAGE THROUGH LAYER  5       0.000197         2.68129

      SNOW WATER                                 6.75         91860.4687


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.4483

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1227

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

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

*******************************************************************************
```

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FINAL WATER STORAGE AT END OF YEAR 100

| LAYER | (INCHES) | (VOL/VOL) |
|---|---|---|
| 1 | 1.0859 | 0.1810 |
| 2 | 2.5586 | 0.4264 |
| 3 | 3.6713 | 0.3059 |
| 4 | 0.0000 | 0.0000 |
| 5 | 1.9080 | 0.3180 |
| 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:    I:\SOFTWARE\HELP3\58210P1.D4
TEMPERATURE DATA FILE:      i:\software\help3\58210T1.D7
SOLAR RADIATION DATA FILE:  i:\software\help3\58210R1.D13
EVAPOTRANSPIRATION DATA:    i:\software\help3\58210E1.D11
SOIL AND DESIGN DATA FILE:  I:\SOFTWARE\HELP3\58210S20.D10
OUTPUT DATA FILE:           i:\software\help3\58210R20.OUT


TIME:  16:16     DATE:   4/14/2011


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

     TITLE:  58210 - INVISTA SEAFORD FACILITY - Run 1A - 20% 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   6
           THICKNESS                  =      6.00   INCHES
           POROSITY                   =      0.4530 VOL/VOL
           FIELD CAPACITY             =      0.1900 VOL/VOL
           WILTING POINT              =      0.0850 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.2096 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.720000011000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

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

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      6.00   INCHES
POROSITY                    =      0.4750 VOL/VOL
FIELD CAPACITY              =      0.3780 VOL/VOL
WILTING POINT               =      0.2650 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.4625 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-05 CM/SEC


                        LAYER  3
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2762 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.499999989000E-02 CM/SEC
SLOPE                       =     20.00   PERCENT
DRAINAGE LENGTH             =    125.0    FEET


                        LAYER  4
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                   =      0.04   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    =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  2 - EXCELLENT


                        LAYER  5
                        --------
```

```
            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER   0
  THICKNESS                   =      6.00   INCHES
  POROSITY                    =      0.4750 VOL/VOL
  FIELD CAPACITY              =      0.3780 VOL/VOL
  WILTING POINT               =      0.2650 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.3388 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-05 CM/SEC
```

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF 20.%
          AND A SLOPE LENGTH OF  125. FEET.

SCS RUNOFF CURVE NUMBER             =     65.70
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      8.000  ACRES
EVAPORATIVE ZONE DEPTH              =     18.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      5.018  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      8.070  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      2.208  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =      9.380  INCHES
TOTAL INITIAL WATER                 =      9.380  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
```

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

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          WILMINGTON            DELAWARE

     STATION LATITUDE                       =  39.80 DEGREES
     MAXIMUM LEAF AREA INDEX                =   2.00
     START OF GROWING SEASON (JULIAN DATE)  =    107
     END OF GROWING SEASON (JULIAN DATE)    =    298
     EVAPORATIVE ZONE DEPTH                 =  18.0  INCHES
     AVERAGE ANNUAL WIND SPEED              =   9.20 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  67.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  67.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  72.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  71.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    WILMINGTON          DELAWARE
```

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 3.11 | 2.99 | 3.87 | 3.39 | 3.23 | 3.51 |
| 3.90 | 4.03 | 3.59 | 2.89 | 3.33 | 3.54 |

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 31.20 | 33.20 | 41.80 | 52.40 | 62.20 | 71.20 |
| 76.00 | 74.80 | 67.80 | 56.30 | 45.60 | 35.50 |

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE
AND STATION LATITUDE = 39.80 DEGREES

**********

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

| | JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|---|
| **PRECIPITATION** | | | | | | |
| TOTALS | 3.26 | 3.00 | 4.08 | 3.39 | 3.39 | 3.46 |
| | 3.88 | 3.97 | 3.47 | 2.85 | 3.12 | 3.35 |
| STD. DEVIATIONS | 1.67 | 1.45 | 1.88 | 1.46 | 1.63 | 1.83 |
| | 1.87 | 2.39 | 2.16 | 1.84 | 1.64 | 1.72 |
| **RUNOFF** | | | | | | |
| TOTALS | 0.524 | 1.024 | 0.679 | 0.015 | 0.006 | 0.030 |
| | 0.086 | 0.114 | 0.164 | 0.146 | 0.085 | 0.195 |
| STD. DEVIATIONS | 0.796 | 1.268 | 1.125 | 0.084 | 0.041 | 0.137 |
| | 0.362 | 0.384 | 0.441 | 0.409 | 0.312 | 0.529 |
| **EVAPOTRANSPIRATION** | | | | | | |
| TOTALS | 0.805 | 0.787 | 2.305 | 3.168 | 3.350 | 3.681 |

```
                          3.359    3.514    2.290    1.440    1.235    0.905

    STD. DEVIATIONS       0.266    0.419    0.426    0.754    1.152    1.324
                          1.272    1.408    1.054    0.439    0.229    0.185

  LATERAL DRAINAGE COLLECTED FROM LAYER  3
  ----------------------------------------
    TOTALS                1.4617   1.0031   2.2890   1.2702   0.4317   0.3150
                          0.1740   0.3112   0.4246   0.8062   1.1655   1.6617

    STD. DEVIATIONS       1.1246   1.0879   1.1702   0.9822   0.5045   0.4332
                          0.1910   0.5138   0.6537   1.0310   1.1368   1.2914

  PERCOLATION/LEAKAGE THROUGH LAYER  4
  -------------------------------------
    TOTALS                0.0003   0.0002   0.0004   0.0002   0.0001   0.0001
                          0.0000   0.0001   0.0001   0.0002   0.0002   0.0003

    STD. DEVIATIONS       0.0002   0.0002   0.0002   0.0002   0.0001   0.0001
                          0.0000   0.0001   0.0001   0.0002   0.0002   0.0002

  PERCOLATION/LEAKAGE THROUGH LAYER  5
  -------------------------------------
    TOTALS                0.0003   0.0004   0.0003   0.0003   0.0004   0.0004
                          0.0005   0.0004   0.0004   0.0004   0.0003   0.0003

    STD. DEVIATIONS       0.0007   0.0007   0.0007   0.0006   0.0006   0.0005
                          0.0006   0.0005   0.0005   0.0005   0.0005   0.0005


-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES              1.0812   0.8149   1.6932   0.9709   0.3194   0.2408
                          0.1287   0.2302   0.3246   0.5964   0.8909   1.2291

    STD. DEVIATIONS       0.8318   0.8842   0.8656   0.7508   0.3732   0.3311
                          0.1413   0.3801   0.4997   0.7626   0.8690   0.9552

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


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     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH  100
-------------------------------------------------------------------------------
                                     INCHES            CU. FEET       PERCENT
                                 -------------------   -------------   ---------
 PRECIPITATION                    41.20    (   6.096)    1196546.7     100.00

 RUNOFF                            3.068   (  2.2931)      89088.13      7.445
```

| | | | | |
|---|---|---|---|---|
| EVAPOTRANSPIRATION | 26.839 | ( 3.4717) | 779391.81 | 65.137 |
| LATERAL DRAINAGE COLLECTED FROM LAYER 3 | 11.31398 | ( 3.36203) | 328557.875 | 27.45884 |
| PERCOLATION/LEAKAGE THROUGH LAYER 4 | 0.00211 | ( 0.00064) | 61.211 | 0.00512 |
| AVERAGE HEAD ON TOP OF LAYER 4 | 0.710 | ( 0.212) | | |
| PERCOLATION/LEAKAGE THROUGH LAYER 5 | 0.00449 | ( 0.00673) | 130.294 | 0.01089 |
| CHANGE IN WATER STORAGE | -0.021 | ( 1.3632) | -621.35 | -0.052 |

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

                PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
   ----------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                              5.26        152750.406

      RUNOFF                                     3.084        89550.5391

      DRAINAGE COLLECTED FROM LAYER  3           0.31117       9036.44922

      PERCOLATION/LEAKAGE THROUGH LAYER  4       0.000062         1.80968

      AVERAGE HEAD ON TOP OF LAYER  4            7.135

      MAXIMUM HEAD ON TOP OF LAYER  4           12.768

      LOCATION OF MAXIMUM HEAD IN LAYER  3
            (DISTANCE FROM DRAIN)                8.7 FEET

      PERCOLATION/LEAKAGE THROUGH LAYER  5       0.000208         6.03480

      SNOW WATER                                 6.75        195969.0000


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3992

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1227


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

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

*******************************************************************************
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                  FINAL WATER STORAGE AT END OF YEAR  100
    ---------------------------------------------------------------------
                   LAYER        (INCHES)       (VOL/VOL)
                   -----        --------       ---------
                     1            1.0858         0.1810

                     2            2.5589         0.4265

                     3            1.8004         0.1500

                     4            0.0000         0.0000

                     5            1.7950         0.2992

                  SNOW WATER       0.000

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```

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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:    I:\SOFTWARE\HELP3\58210P1.D4
TEMPERATURE DATA FILE:      i:\software\help3\58210T1.D7
SOLAR RADIATION DATA FILE:  i:\software\help3\58210R1.D13
EVAPOTRANSPIRATION DATA:    i:\software\help3\58210E1.D11
SOIL AND DESIGN DATA FILE:  I:\SOFTWARE\HELP3\58210S11.D10
OUTPUT DATA FILE:           i:\software\help3\58210R11.OUT


TIME:  15:32     DATE:   4/18/2011


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

     TITLE:  58210 - INVISTA SEAFORD FACILITY - Run 1B 6% 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   6
           THICKNESS                  =      6.00   INCHES
           POROSITY                   =      0.4530 VOL/VOL
           FIELD CAPACITY             =      0.1900 VOL/VOL
           WILTING POINT              =      0.0850 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.2096 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.720000011000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

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

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      6.00   INCHES
POROSITY                    =      0.4750 VOL/VOL
FIELD CAPACITY              =      0.3780 VOL/VOL
WILTING POINT               =      0.2650 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.4625 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-05 CM/SEC


                        LAYER  3
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3569 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC
SLOPE                       =      6.00   PERCENT
DRAINAGE LENGTH             =    175.0    FEET


                        LAYER  4
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                   =      0.04   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    =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  2 - EXCELLENT


                        LAYER  5
                        --------
```

```
            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER   0
  THICKNESS                   =      6.00   INCHES
  POROSITY                    =      0.4750 VOL/VOL
  FIELD CAPACITY              =      0.3780 VOL/VOL
  WILTING POINT               =      0.2650 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.3392 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-05 CM/SEC
```

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  6.%
          AND A SLOPE LENGTH OF  175. FEET.

SCS RUNOFF CURVE NUMBER             =     63.40
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      3.750  ACRES
EVAPORATIVE ZONE DEPTH              =     18.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      5.813  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      8.070  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      2.208  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     10.350  INCHES
TOTAL INITIAL WATER                 =     10.350  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
```

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

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          WILMINGTON            DELAWARE

     STATION LATITUDE                       =  39.80 DEGREES
     MAXIMUM LEAF AREA INDEX                =   2.00
     START OF GROWING SEASON (JULIAN DATE)  =    107
     END OF GROWING SEASON (JULIAN DATE)    =    298
     EVAPORATIVE ZONE DEPTH                 =  18.0  INCHES
     AVERAGE ANNUAL WIND SPEED              =   9.20 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  67.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  67.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  72.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  71.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    WILMINGTON          DELAWARE
```

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 3.11 | 2.99 | 3.87 | 3.39 | 3.23 | 3.51 |
| 3.90 | 4.03 | 3.59 | 2.89 | 3.33 | 3.54 |

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 31.20 | 33.20 | 41.80 | 52.40 | 62.20 | 71.20 |
| 76.00 | 74.80 | 67.80 | 56.30 | 45.60 | 35.50 |

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE
AND STATION LATITUDE = 39.80 DEGREES

**********

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

| | JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|---|
| **PRECIPITATION** | | | | | | |
| TOTALS | 3.26 | 3.00 | 4.08 | 3.39 | 3.39 | 3.46 |
| | 3.88 | 3.97 | 3.47 | 2.85 | 3.12 | 3.35 |
| STD. DEVIATIONS | 1.67 | 1.45 | 1.88 | 1.46 | 1.63 | 1.83 |
| | 1.87 | 2.39 | 2.16 | 1.84 | 1.64 | 1.72 |
| **RUNOFF** | | | | | | |
| TOTALS | 0.523 | 1.020 | 0.677 | 0.015 | 0.006 | 0.029 |
| | 0.086 | 0.114 | 0.163 | 0.147 | 0.085 | 0.195 |
| STD. DEVIATIONS | 0.794 | 1.263 | 1.125 | 0.084 | 0.041 | 0.137 |
| | 0.357 | 0.384 | 0.440 | 0.409 | 0.311 | 0.529 |
| **EVAPOTRANSPIRATION** | | | | | | |
| TOTALS | 0.806 | 0.787 | 2.308 | 3.168 | 3.342 | 3.656 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 3.364 | 3.516 | 2.293 | 1.443 | 1.242 | 0.908 |
| STD. DEVIATIONS | 0.267 | 0.419 | 0.426 | 0.756 | 1.157 | 1.325 |
| | 1.278 | 1.404 | 1.057 | 0.441 | 0.227 | 0.185 |

LATERAL DRAINAGE COLLECTED FROM LAYER 3

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 1.5156 | 1.0835 | 1.9768 | 1.5354 | 0.6772 | 0.3700 |
| | 0.2245 | 0.2766 | 0.3893 | 0.7070 | 1.0378 | 1.5321 |
| STD. DEVIATIONS | 0.9553 | 0.9210 | 0.9131 | 0.9082 | 0.5136 | 0.3780 |
| | 0.2284 | 0.3759 | 0.5500 | 0.8283 | 0.9149 | 1.1333 |

PERCOLATION/LEAKAGE THROUGH LAYER 4

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 0.0007 | 0.0005 | 0.0009 | 0.0007 | 0.0003 | 0.0002 |
| | 0.0001 | 0.0001 | 0.0002 | 0.0003 | 0.0004 | 0.0007 |
| STD. DEVIATIONS | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0002 | 0.0002 |
| | 0.0001 | 0.0002 | 0.0002 | 0.0004 | 0.0004 | 0.0005 |

PERCOLATION/LEAKAGE THROUGH LAYER 5

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 0.0004 | 0.0005 | 0.0003 | 0.0004 | 0.0006 | 0.0007 |
| | 0.0008 | 0.0008 | 0.0007 | 0.0006 | 0.0005 | 0.0004 |
| STD. DEVIATIONS | 0.0007 | 0.0006 | 0.0007 | 0.0006 | 0.0006 | 0.0005 |
| | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0005 |

---

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

---

DAILY AVERAGE HEAD ON TOP OF LAYER 4

| | | | | | | |
|---|---|---|---|---|---|---|
| AVERAGES | 2.5244 | 1.9813 | 3.2924 | 2.6425 | 1.1279 | 0.6368 |
| | 0.3738 | 0.4607 | 0.6699 | 1.1776 | 1.7861 | 2.5519 |
| STD. DEVIATIONS | 1.5911 | 1.6842 | 1.5208 | 1.5631 | 0.8555 | 0.6506 |
| | 0.3804 | 0.6261 | 0.9465 | 1.3796 | 1.5747 | 1.8876 |

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

| | INCHES | | CU. FEET | PERCENT |
|---|---|---|---|---|
| PRECIPITATION | 41.20 | ( 6.096) | 560881.2 | 100.00 |
| RUNOFF | 3.060 | ( 2.2899) | 41652.91 | 7.426 |

| | | | | |
|---|---|---|---|---|
| EVAPOTRANSPIRATION | 26.834 | ( 3.4960) | 365274.87 | 65.125 |
| LATERAL DRAINAGE COLLECTED FROM LAYER 3 | 11.32564 | ( 3.21315) | 154170.266 | 27.48715 |
| PERCOLATION/LEAKAGE THROUGH LAYER 4 | 0.00486 | ( 0.00143) | 66.160 | 0.01180 |
| AVERAGE HEAD ON TOP OF LAYER 4 | 1.602 | ( 0.456) | | |
| PERCOLATION/LEAKAGE THROUGH LAYER 5 | 0.00666 | ( 0.00632) | 90.636 | 0.01616 |
| CHANGE IN WATER STORAGE | -0.023 | ( 1.6424) | -307.44 | -0.055 |

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                PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
   ---------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                              5.26         71601.750

      RUNOFF                                     3.084        41976.1328

      DRAINAGE COLLECTED FROM LAYER  3           0.22730       3094.10840

      PERCOLATION/LEAKAGE THROUGH LAYER  4       0.000109         1.47861

      AVERAGE HEAD ON TOP OF LAYER  4           11.736

      MAXIMUM HEAD ON TOP OF LAYER  4           18.093

      LOCATION OF MAXIMUM HEAD IN LAYER  3
            (DISTANCE FROM DRAIN)               39.6 FEET

      PERCOLATION/LEAKAGE THROUGH LAYER  5       0.000199         2.71303

      SNOW WATER                                 6.75         91860.4687


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.4123

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1227

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

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

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FINAL WATER STORAGE AT END OF YEAR 100

| LAYER | (INCHES) | (VOL/VOL) |
|---|---|---|
| 1 | 1.0773 | 0.1795 |
| 2 | 2.5565 | 0.4261 |
| 3 | 2.6028 | 0.2169 |
| 4 | 0.0000 | 0.0000 |
| 5 | 1.8552 | 0.3092 |
| 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:    I:\SOFTWARE\HELP3\58210P1.D4
TEMPERATURE DATA FILE:      i:\software\help3\58210T1.D7
SOLAR RADIATION DATA FILE:  i:\software\help3\58210R1.D13
EVAPOTRANSPIRATION DATA:    i:\software\help3\58210E1.D11
SOIL AND DESIGN DATA FILE:  I:\SOFTWARE\HELP3\58210S21.D10
OUTPUT DATA FILE:           i:\software\help3\58210R21.OUT


TIME:  16:15     DATE:   4/18/2011


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

     TITLE:  58210 - INVISTA SEAFORD FACILITY - Run 1B 20% 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   6
           THICKNESS                  =      6.00   INCHES
           POROSITY                   =      0.4530 VOL/VOL
           FIELD CAPACITY             =      0.1900 VOL/VOL
           WILTING POINT              =      0.0850 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.2096 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.720000011000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

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

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      6.00   INCHES
POROSITY                    =      0.4750 VOL/VOL
FIELD CAPACITY              =      0.3780 VOL/VOL
WILTING POINT               =      0.2650 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.4625 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-05 CM/SEC


                        LAYER  3
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2022 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC
SLOPE                       =     20.00   PERCENT
DRAINAGE LENGTH             =    125.0    FEET


                        LAYER  4
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                   =      0.04   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    =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  2 - EXCELLENT


                        LAYER  5
                        --------
```

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            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER   0
  THICKNESS                   =      6.00   INCHES
  POROSITY                    =      0.4750 VOL/VOL
  FIELD CAPACITY              =      0.3780 VOL/VOL
  WILTING POINT               =      0.2650 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.3387 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-05 CM/SEC
```

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF 20.%
          AND A SLOPE LENGTH OF  125. FEET.

SCS RUNOFF CURVE NUMBER             =     65.70
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      8.000  ACRES
EVAPORATIVE ZONE DEPTH              =     18.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      4.932  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      8.070  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      2.208  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =      8.490  INCHES
TOTAL INITIAL WATER                 =      8.490  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
```

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

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          WILMINGTON            DELAWARE

     STATION LATITUDE                       =  39.80 DEGREES
     MAXIMUM LEAF AREA INDEX                =   2.00
     START OF GROWING SEASON (JULIAN DATE)  =    107
     END OF GROWING SEASON (JULIAN DATE)    =    298
     EVAPORATIVE ZONE DEPTH                 =  18.0  INCHES
     AVERAGE ANNUAL WIND SPEED              =   9.20 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  67.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  67.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  72.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  71.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    WILMINGTON          DELAWARE
```

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 3.11 | 2.99 | 3.87 | 3.39 | 3.23 | 3.51 |
| 3.90 | 4.03 | 3.59 | 2.89 | 3.33 | 3.54 |

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 31.20 | 33.20 | 41.80 | 52.40 | 62.20 | 71.20 |
| 76.00 | 74.80 | 67.80 | 56.30 | 45.60 | 35.50 |

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE
AND STATION LATITUDE = 39.80 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

| | JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|---|
| **PRECIPITATION** | | | | | | |
| TOTALS | 3.26 | 3.00 | 4.08 | 3.39 | 3.39 | 3.46 |
| | 3.88 | 3.97 | 3.47 | 2.85 | 3.12 | 3.35 |
| STD. DEVIATIONS | 1.67 | 1.45 | 1.88 | 1.46 | 1.63 | 1.83 |
| | 1.87 | 2.39 | 2.16 | 1.84 | 1.64 | 1.72 |
| **RUNOFF** | | | | | | |
| TOTALS | 0.522 | 1.020 | 0.677 | 0.015 | 0.006 | 0.030 |
| | 0.086 | 0.114 | 0.163 | 0.147 | 0.085 | 0.195 |
| STD. DEVIATIONS | 0.793 | 1.264 | 1.122 | 0.084 | 0.041 | 0.137 |
| | 0.362 | 0.384 | 0.441 | 0.409 | 0.311 | 0.529 |
| **EVAPOTRANSPIRATION** | | | | | | |
| TOTALS | 0.806 | 0.787 | 2.308 | 3.168 | 3.343 | 3.657 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 3.366 | 3.518 | 2.293 | 1.444 | 1.242 | 0.908 |
| STD. DEVIATIONS | 0.267 | 0.419 | 0.426 | 0.756 | 1.158 | 1.325 |
| | 1.279 | 1.401 | 1.057 | 0.441 | 0.229 | 0.186 |

LATERAL DRAINAGE COLLECTED FROM LAYER 3

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 1.3923 | 1.0041 | 2.4530 | 1.0361 | 0.3526 | 0.3058 |
| | 0.1408 | 0.3424 | 0.4559 | 0.8675 | 1.2553 | 1.7127 |
| STD. DEVIATIONS | 1.2231 | 1.1832 | 1.3386 | 0.9646 | 0.5046 | 0.4745 |
| | 0.1837 | 0.6144 | 0.7295 | 1.1488 | 1.2851 | 1.3510 |

PERCOLATION/LEAKAGE THROUGH LAYER 4

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 0.0001 | 0.0001 | 0.0002 | 0.0001 | 0.0000 | 0.0000 |
| | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0002 |
| STD. DEVIATIONS | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 |
| | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |

PERCOLATION/LEAKAGE THROUGH LAYER 5

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0004 | 0.0004 |
| | 0.0004 | 0.0004 | 0.0003 | 0.0003 | 0.0003 | 0.0003 |
| STD. DEVIATIONS | 0.0008 | 0.0007 | 0.0007 | 0.0006 | 0.0006 | 0.0006 |
| | 0.0006 | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0005 |

---

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

---

DAILY AVERAGE HEAD ON TOP OF LAYER 4

| | | | | | | |
|---|---|---|---|---|---|---|
| AVERAGES | 0.5149 | 0.4079 | 0.9073 | 0.3960 | 0.1304 | 0.1169 |
| | 0.0521 | 0.1266 | 0.1742 | 0.3209 | 0.4798 | 0.6334 |
| STD. DEVIATIONS | 0.4524 | 0.4808 | 0.4951 | 0.3687 | 0.1866 | 0.1813 |
| | 0.0679 | 0.2272 | 0.2788 | 0.4249 | 0.4912 | 0.4997 |

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

| | INCHES | | CU. FEET | PERCENT |
|---|---|---|---|---|
| PRECIPITATION | 41.20 | ( 6.096) | 1196546.7 | 100.00 |
| RUNOFF | 3.059 | ( 2.2874) | 88839.24 | 7.425 |

| | | | | |
|---|---|---|---|---|
| EVAPOTRANSPIRATION | 26.839 | ( 3.4913) | 779417.69 | 65.139 |
| LATERAL DRAINAGE COLLECTED FROM LAYER 3 | 11.31851 | ( 3.42906) | 328689.406 | 27.46984 |
| PERCOLATION/LEAKAGE THROUGH LAYER 4 | 0.00104 | ( 0.00032) | 30.269 | 0.00253 |
| AVERAGE HEAD ON TOP OF LAYER 4 | 0.355 | ( 0.108) | | |
| PERCOLATION/LEAKAGE THROUGH LAYER 5 | 0.00384 | ( 0.00688) | 111.394 | 0.00931 |
| CHANGE IN WATER STORAGE | -0.018 | ( 1.2374) | -510.97 | -0.043 |

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                PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
   ---------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                              5.26        152750.406

      RUNOFF                                     3.084        89550.4297

      DRAINAGE COLLECTED FROM LAYER  3           0.32263       9369.08789

      PERCOLATION/LEAKAGE THROUGH LAYER  4       0.000031         0.89397

      AVERAGE HEAD ON TOP OF LAYER  4            3.699

      MAXIMUM HEAD ON TOP OF LAYER  4            6.890

      LOCATION OF MAXIMUM HEAD IN LAYER  3
            (DISTANCE FROM DRAIN)                3.9 FEET

      PERCOLATION/LEAKAGE THROUGH LAYER  5       0.000212         6.14556

      SNOW WATER                                 6.75        195969.0000


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3972

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1227

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

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

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FINAL WATER STORAGE AT END OF YEAR 100

| LAYER | (INCHES) | (VOL/VOL) |
|---|---|---|
| 1 | 1.0770 | 0.1795 |
| 2 | 2.5563 | 0.4261 |
| 3 | 1.3451 | 0.1121 |
| 4 | 0.0000 | 0.0000 |
| 5 | 1.7526 | 0.2921 |
| 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:    I:\SOFTWARE\HELP3\58210P1.D4
TEMPERATURE DATA FILE:      i:\software\help3\58210T1.D7
SOLAR RADIATION DATA FILE:  i:\software\help3\58210R1.D13
EVAPOTRANSPIRATION DATA:    i:\software\help3\58210E1.D11
SOIL AND DESIGN DATA FILE:  I:\SOFTWARE\HELP3\58210S12.D10
OUTPUT DATA FILE:           i:\software\help3\58210R12.OUT


TIME:  16:20     DATE:   4/18/2011


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

     TITLE:  58210 - INVISTA SEAFORD FACILITY - Run 2A - 6% 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   6
           THICKNESS                  =      6.00   INCHES
           POROSITY                   =      0.4530 VOL/VOL
           FIELD CAPACITY             =      0.1900 VOL/VOL
           WILTING POINT              =      0.0850 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.2170 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.720000011000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

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

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      6.00   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-04 CM/SEC


                        LAYER  3
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.4170 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.499999989000E-02 CM/SEC
SLOPE                       =      6.00   PERCENT
DRAINAGE LENGTH             =    175.0    FEET


                        LAYER  4
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                   =      0.04   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    =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  2 - EXCELLENT


                        LAYER  5
                        --------
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            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER   0
  THICKNESS                   =      6.00   INCHES
  POROSITY                    =      0.4750 VOL/VOL
  FIELD CAPACITY              =      0.3780 VOL/VOL
  WILTING POINT               =      0.2650 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.3400 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-05 CM/SEC


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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  6.%
          AND A SLOPE LENGTH OF  175. FEET.

SCS RUNOFF CURVE NUMBER             =     63.40
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      3.750  ACRES
EVAPORATIVE ZONE DEPTH              =     18.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      6.654  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      8.070  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      2.208  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     11.196  INCHES
TOTAL INITIAL WATER                 =     11.196  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


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

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          WILMINGTON            DELAWARE

     STATION LATITUDE                       =  39.80 DEGREES
     MAXIMUM LEAF AREA INDEX                =   2.00
     START OF GROWING SEASON (JULIAN DATE)  =    107
     END OF GROWING SEASON (JULIAN DATE)    =    298
     EVAPORATIVE ZONE DEPTH                 =  18.0  INCHES
     AVERAGE ANNUAL WIND SPEED              =   9.20 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  67.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  67.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  72.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  71.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    WILMINGTON          DELAWARE
```

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 3.11 | 2.99 | 3.87 | 3.39 | 3.23 | 3.51 |
| 3.90 | 4.03 | 3.59 | 2.89 | 3.33 | 3.54 |

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 31.20 | 33.20 | 41.80 | 52.40 | 62.20 | 71.20 |
| 76.00 | 74.80 | 67.80 | 56.30 | 45.60 | 35.50 |

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE
AND STATION LATITUDE = 39.80 DEGREES

**********

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

| | JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|---|
| **PRECIPITATION** | | | | | | |
| TOTALS | 3.26 | 3.00 | 4.08 | 3.39 | 3.39 | 3.46 |
| | 3.88 | 3.97 | 3.47 | 2.85 | 3.12 | 3.35 |
| STD. DEVIATIONS | 1.67 | 1.45 | 1.88 | 1.46 | 1.63 | 1.83 |
| | 1.87 | 2.39 | 2.16 | 1.84 | 1.64 | 1.72 |
| **RUNOFF** | | | | | | |
| TOTALS | 0.459 | 0.971 | 0.583 | 0.017 | 0.000 | 0.000 |
| | 0.004 | 0.010 | 0.003 | 0.031 | 0.000 | 0.090 |
| STD. DEVIATIONS | 0.787 | 1.224 | 1.055 | 0.143 | 0.000 | 0.003 |
| | 0.035 | 0.093 | 0.016 | 0.210 | 0.002 | 0.316 |
| **EVAPOTRANSPIRATION** | | | | | | |
| TOTALS | 0.809 | 0.790 | 2.335 | 3.246 | 3.251 | 3.379 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 3.283 | 3.395 | 2.269 | 1.491 | 1.276 | 0.923 |
| STD. DEVIATIONS | 0.270 | 0.422 | 0.434 | 0.781 | 1.251 | 1.282 |
| | 1.238 | 1.357 | 1.067 | 0.483 | 0.235 | 0.189 |

LATERAL DRAINAGE COLLECTED FROM LAYER 3

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 1.4526 | 1.1627 | 1.9739 | 1.6150 | 0.9738 | 0.6348 |
| | 0.4778 | 0.5212 | 0.5754 | 0.7942 | 1.0144 | 1.4044 |
| STD. DEVIATIONS | 0.8068 | 0.7459 | 0.7506 | 0.7443 | 0.5152 | 0.3833 |
| | 0.3290 | 0.4879 | 0.5793 | 0.7988 | 0.8217 | 0.9652 |

PERCOLATION/LEAKAGE THROUGH LAYER 4

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 0.0014 | 0.0011 | 0.0019 | 0.0015 | 0.0008 | 0.0005 |
| | 0.0004 | 0.0005 | 0.0005 | 0.0007 | 0.0009 | 0.0014 |
| STD. DEVIATIONS | 0.0009 | 0.0009 | 0.0010 | 0.0009 | 0.0005 | 0.0003 |
| | 0.0003 | 0.0005 | 0.0006 | 0.0009 | 0.0009 | 0.0012 |

PERCOLATION/LEAKAGE THROUGH LAYER 5

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 0.0008 | 0.0009 | 0.0006 | 0.0007 | 0.0012 | 0.0014 |
| | 0.0016 | 0.0015 | 0.0014 | 0.0012 | 0.0010 | 0.0008 |
| STD. DEVIATIONS | 0.0007 | 0.0007 | 0.0007 | 0.0007 | 0.0007 | 0.0006 |
| | 0.0005 | 0.0006 | 0.0006 | 0.0006 | 0.0007 | 0.0007 |

---

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

---

DAILY AVERAGE HEAD ON TOP OF LAYER 4

| | | | | | | |
|---|---|---|---|---|---|---|
| AVERAGES | 5.0613 | 4.4382 | 6.9591 | 5.7433 | 3.2495 | 2.1852 |
| | 1.5949 | 1.7711 | 2.0404 | 2.7617 | 3.6018 | 4.9673 |
| STD. DEVIATIONS | 3.0839 | 3.2658 | 3.2885 | 3.1393 | 1.7346 | 1.3192 |
| | 1.1123 | 1.8071 | 2.2782 | 3.0866 | 3.0696 | 3.9032 |

**********

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

| | INCHES | | CU. FEET | PERCENT |
|---|---|---|---|---|
| PRECIPITATION | 41.20 | ( 6.096) | 560881.2 | 100.00 |
| RUNOFF | 2.169 | ( 2.0726) | 29528.49 | 5.265 |

| | | | | |
|---|---|---|---|---|
| EVAPOTRANSPIRATION | 26.445 | ( 3.4818) | 359978.87 | 64.181 |
| LATERAL DRAINAGE COLLECTED FROM LAYER 3 | 12.60035 | ( 3.37251) | 171522.250 | 30.58085 |
| PERCOLATION/LEAKAGE THROUGH LAYER 4 | 0.01177 | ( 0.00381) | 160.245 | 0.02857 |
| AVERAGE HEAD ON TOP OF LAYER 4 | 3.698 | ( 1.098) | | |
| PERCOLATION/LEAKAGE THROUGH LAYER 5 | 0.01301 | ( 0.00581) | 177.079 | 0.03157 |
| CHANGE IN WATER STORAGE | -0.024 | ( 2.2548) | -325.42 | -0.058 |

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                PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
   ----------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                              5.26         71601.750

      RUNOFF                                     2.501        34041.5273

      DRAINAGE COLLECTED FROM LAYER  3           0.14244       1938.92407

      PERCOLATION/LEAKAGE THROUGH LAYER  4       0.000254         3.45333

      AVERAGE HEAD ON TOP OF LAYER  4           24.000

      MAXIMUM HEAD ON TOP OF LAYER  4           32.748

      LOCATION OF MAXIMUM HEAD IN LAYER  3
            (DISTANCE FROM DRAIN)               55.2 FEET

      PERCOLATION/LEAKAGE THROUGH LAYER  5       0.000201         2.73343

      SNOW WATER                                 6.75         91860.4687


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.4483

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1227

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

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

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                  FINAL WATER STORAGE AT END OF YEAR  100
    -------------------------------------------------------------------
                   LAYER        (INCHES)       (VOL/VOL)
                   -----        --------       ---------
                     1            1.0755         0.1792

                     2            2.3097         0.3849

                     3            3.5036         0.2920

                     4            0.0000         0.0000

                     5            1.9165         0.3194

                  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:    I:\SOFTWARE\HELP3\58210P1.D4
TEMPERATURE DATA FILE:      i:\software\help3\58210T1.D7
SOLAR RADIATION DATA FILE:  i:\software\help3\58210R1.D13
EVAPOTRANSPIRATION DATA:    i:\software\help3\58210E1.D11
SOIL AND DESIGN DATA FILE:  I:\SOFTWARE\HELP3\58210S22.D10
OUTPUT DATA FILE:           i:\software\help3\58210R22.OUT


TIME:  16:25     DATE:   4/18/2011


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

     TITLE:  58210 - INVISTA SEAFORD FACILITY - Run 2A - 20% 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   6
           THICKNESS                  =      6.00   INCHES
           POROSITY                   =      0.4530 VOL/VOL
           FIELD CAPACITY             =      0.1900 VOL/VOL
           WILTING POINT              =      0.0850 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.1827 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.720000011000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

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

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      6.00   INCHES
POROSITY                    =      0.4750 VOL/VOL
FIELD CAPACITY              =      0.3780 VOL/VOL
WILTING POINT               =      0.2650 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3860 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC


                        LAYER  3
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2563 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.499999989000E-02 CM/SEC
SLOPE                       =     20.00   PERCENT
DRAINAGE LENGTH             =    125.0    FEET


                        LAYER  4
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                   =      0.04   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    =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  2 - EXCELLENT


                        LAYER  5
                        --------
```

```
            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER   0
  THICKNESS                   =      6.00   INCHES
  POROSITY                    =      0.4750 VOL/VOL
  FIELD CAPACITY              =      0.3780 VOL/VOL
  WILTING POINT               =      0.2650 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.3389 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-05 CM/SEC
```

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF 20.%
          AND A SLOPE LENGTH OF  125. FEET.

SCS RUNOFF CURVE NUMBER             =     65.70
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      8.000  ACRES
EVAPORATIVE ZONE DEPTH              =     18.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      4.236  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      8.070  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      2.208  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =      8.521  INCHES
TOTAL INITIAL WATER                 =      8.521  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
```

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

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          WILMINGTON            DELAWARE

     STATION LATITUDE                       =  39.80 DEGREES
     MAXIMUM LEAF AREA INDEX                =   2.00
     START OF GROWING SEASON (JULIAN DATE)  =    107
     END OF GROWING SEASON (JULIAN DATE)    =    298
     EVAPORATIVE ZONE DEPTH                 =  18.0  INCHES
     AVERAGE ANNUAL WIND SPEED              =   9.20 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  67.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  67.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  72.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  71.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    WILMINGTON          DELAWARE
```

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 3.11 | 2.99 | 3.87 | 3.39 | 3.23 | 3.51 |
| 3.90 | 4.03 | 3.59 | 2.89 | 3.33 | 3.54 |

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 31.20 | 33.20 | 41.80 | 52.40 | 62.20 | 71.20 |
| 76.00 | 74.80 | 67.80 | 56.30 | 45.60 | 35.50 |

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE
AND STATION LATITUDE = 39.80 DEGREES

**********

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

| | JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|---|
| **PRECIPITATION** | | | | | | |
| TOTALS | 3.26 | 3.00 | 4.08 | 3.39 | 3.39 | 3.46 |
| | 3.88 | 3.97 | 3.47 | 2.85 | 3.12 | 3.35 |
| STD. DEVIATIONS | 1.67 | 1.45 | 1.88 | 1.46 | 1.63 | 1.83 |
| | 1.87 | 2.39 | 2.16 | 1.84 | 1.64 | 1.72 |
| **RUNOFF** | | | | | | |
| TOTALS | 0.426 | 0.944 | 0.508 | 0.001 | 0.000 | 0.001 |
| | 0.007 | 0.003 | 0.006 | 0.007 | 0.001 | 0.069 |
| STD. DEVIATIONS | 0.737 | 1.192 | 0.968 | 0.009 | 0.000 | 0.006 |
| | 0.047 | 0.016 | 0.031 | 0.043 | 0.005 | 0.295 |
| **EVAPOTRANSPIRATION** | | | | | | |
| TOTALS | 0.810 | 0.790 | 2.332 | 3.236 | 3.227 | 3.355 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 3.267 | 3.386 | 2.268 | 1.492 | 1.277 | 0.925 |
| STD. DEVIATIONS | 0.271 | 0.422 | 0.431 | 0.786 | 1.256 | 1.269 |
| | 1.217 | 1.344 | 1.067 | 0.486 | 0.238 | 0.189 |

LATERAL DRAINAGE COLLECTED FROM LAYER 3

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 1.5507 | 1.1572 | 2.5624 | 1.1348 | 0.4132 | 0.4137 |
| | 0.3426 | 0.6043 | 0.6691 | 0.9953 | 1.2845 | 1.7521 |
| STD. DEVIATIONS | 1.2854 | 1.1937 | 1.4595 | 1.0065 | 0.5107 | 0.5745 |
| | 0.4953 | 1.0017 | 0.9131 | 1.3822 | 1.3202 | 1.3820 |

PERCOLATION/LEAKAGE THROUGH LAYER 4

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 0.0003 | 0.0002 | 0.0005 | 0.0002 | 0.0001 | 0.0001 |
| | 0.0001 | 0.0001 | 0.0001 | 0.0002 | 0.0002 | 0.0003 |
| STD. DEVIATIONS | 0.0002 | 0.0002 | 0.0003 | 0.0002 | 0.0001 | 0.0001 |
| | 0.0001 | 0.0002 | 0.0002 | 0.0003 | 0.0003 | 0.0003 |

PERCOLATION/LEAKAGE THROUGH LAYER 5

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 0.0004 | 0.0004 | 0.0003 | 0.0004 | 0.0005 | 0.0005 |
| | 0.0005 | 0.0004 | 0.0004 | 0.0004 | 0.0003 | 0.0003 |
| STD. DEVIATIONS | 0.0007 | 0.0007 | 0.0007 | 0.0006 | 0.0006 | 0.0005 |
| | 0.0005 | 0.0005 | 0.0005 | 0.0004 | 0.0005 | 0.0005 |

---

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

---

DAILY AVERAGE HEAD ON TOP OF LAYER 4

| | | | | | | |
|---|---|---|---|---|---|---|
| AVERAGES | 1.1470 | 0.9400 | 1.8988 | 0.8674 | 0.3057 | 0.3163 |
| | 0.2534 | 0.4493 | 0.5118 | 0.7413 | 0.9818 | 1.2993 |
| STD. DEVIATIONS | 0.9508 | 0.9705 | 1.0958 | 0.7693 | 0.3778 | 0.4391 |
| | 0.3664 | 0.7549 | 0.6981 | 1.0454 | 1.0091 | 1.0242 |

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

| | INCHES | | CU. FEET | PERCENT |
|---|---|---|---|---|
| PRECIPITATION | 41.20 | ( 6.096) | 1196546.7 | 100.00 |
| RUNOFF | 1.972 | ( 1.9521) | 57265.85 | 4.786 |

| | | | | |
|---|---|---|---|---|
| EVAPOTRANSPIRATION | 26.364 | ( 3.4495) | 765596.75 | 63.984 |
| LATERAL DRAINAGE COLLECTED FROM LAYER 3 | 12.87996 | ( 3.97039) | 374034.094 | 31.25946 |
| PERCOLATION/LEAKAGE THROUGH LAYER 4 | 0.00243 | ( 0.00077) | 70.533 | 0.00589 |
| AVERAGE HEAD ON TOP OF LAYER 4 | 0.809 | ( 0.250) | | |
| PERCOLATION/LEAKAGE THROUGH LAYER 5 | 0.00473 | ( 0.00669) | 137.357 | 0.01148 |
| CHANGE IN WATER STORAGE | -0.017 | ( 1.3209) | -487.13 | -0.041 |

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                PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
   ----------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                              5.26        152750.406

      RUNOFF                                     2.500        72589.9531

      DRAINAGE COLLECTED FROM LAYER  3           0.55006      15973.69340

      PERCOLATION/LEAKAGE THROUGH LAYER  4       0.000193         5.59247

      AVERAGE HEAD ON TOP OF LAYER  4           19.144

      MAXIMUM HEAD ON TOP OF LAYER  4           31.148

      LOCATION OF MAXIMUM HEAD IN LAYER  3
            (DISTANCE FROM DRAIN)               19.2 FEET

      PERCOLATION/LEAKAGE THROUGH LAYER  5       0.000211         6.11993

      SNOW WATER                                 6.75        195969.0000


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3980

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1227


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

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

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                  FINAL WATER STORAGE AT END OF YEAR  100
    -------------------------------------------------------------------
                   LAYER        (INCHES)       (VOL/VOL)
                   -----        --------       ---------
                     1            1.0752         0.1792

                     2            2.3092         0.3849

                     3            1.6562         0.1380

                     4            0.0000         0.0000

                     5            1.8033         0.3005

                  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:    I:\SOFTWARE\HELP3\58210P1.D4
TEMPERATURE DATA FILE:      i:\software\help3\58210T1.D7
SOLAR RADIATION DATA FILE:  i:\software\help3\58210R1.D13
EVAPOTRANSPIRATION DATA:    i:\software\help3\58210E1.D11
SOIL AND DESIGN DATA FILE:  I:\SOFTWARE\HELP3\58210S13.D10
OUTPUT DATA FILE:           i:\software\help3\58210R13.OUT


TIME:  16:28     DATE:   4/18/2011


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

     TITLE:  58210 - INVISTA SEAFORD FACILITY - Run 2B - 6% 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   6
           THICKNESS                  =      6.00   INCHES
           POROSITY                   =      0.4530 VOL/VOL
           FIELD CAPACITY             =      0.1900 VOL/VOL
           WILTING POINT              =      0.0850 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.1827 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.720000011000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

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

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      6.00   INCHES
POROSITY                    =      0.4750 VOL/VOL
FIELD CAPACITY              =      0.3780 VOL/VOL
WILTING POINT               =      0.2650 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3860 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC


                        LAYER  3
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3602 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC
SLOPE                       =      6.00   PERCENT
DRAINAGE LENGTH             =    175.0    FEET


                        LAYER  4
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                   =      0.04   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    =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  2 - EXCELLENT


                        LAYER  5
                        --------
```

```
            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER   0
  THICKNESS                   =      6.00   INCHES
  POROSITY                    =      0.4750 VOL/VOL
  FIELD CAPACITY              =      0.3780 VOL/VOL
  WILTING POINT               =      0.2650 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.3393 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-05 CM/SEC
```

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  6.%
          AND A SLOPE LENGTH OF  175. FEET.

SCS RUNOFF CURVE NUMBER             =     63.40
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      3.750  ACRES
EVAPORATIVE ZONE DEPTH              =     18.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      5.233  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      8.070  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      2.208  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =      9.770  INCHES
TOTAL INITIAL WATER                 =      9.770  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
```

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

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          WILMINGTON            DELAWARE

     STATION LATITUDE                       =  39.80 DEGREES
     MAXIMUM LEAF AREA INDEX                =   2.00
     START OF GROWING SEASON (JULIAN DATE)  =    107
     END OF GROWING SEASON (JULIAN DATE)    =    298
     EVAPORATIVE ZONE DEPTH                 =  18.0  INCHES
     AVERAGE ANNUAL WIND SPEED              =   9.20 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  67.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  67.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  72.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  71.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    WILMINGTON          DELAWARE
```

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 3.11 | 2.99 | 3.87 | 3.39 | 3.23 | 3.51 |
| 3.90 | 4.03 | 3.59 | 2.89 | 3.33 | 3.54 |

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 31.20 | 33.20 | 41.80 | 52.40 | 62.20 | 71.20 |
| 76.00 | 74.80 | 67.80 | 56.30 | 45.60 | 35.50 |

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE
AND STATION LATITUDE = 39.80 DEGREES

**********

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

| | JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|---|
| **PRECIPITATION** | | | | | | |
| TOTALS | 3.26 | 3.00 | 4.08 | 3.39 | 3.39 | 3.46 |
| | 3.88 | 3.97 | 3.47 | 2.85 | 3.12 | 3.35 |
| STD. DEVIATIONS | 1.67 | 1.45 | 1.88 | 1.46 | 1.63 | 1.83 |
| | 1.87 | 2.39 | 2.16 | 1.84 | 1.64 | 1.72 |
| **RUNOFF** | | | | | | |
| TOTALS | 0.425 | 0.942 | 0.515 | 0.001 | 0.000 | 0.000 |
| | 0.004 | 0.001 | 0.003 | 0.007 | 0.000 | 0.067 |
| STD. DEVIATIONS | 0.736 | 1.189 | 0.970 | 0.009 | 0.000 | 0.003 |
| | 0.035 | 0.009 | 0.022 | 0.047 | 0.001 | 0.292 |
| **EVAPOTRANSPIRATION** | | | | | | |
| TOTALS | 0.809 | 0.790 | 2.332 | 3.228 | 3.211 | 3.344 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 3.267 | 3.378 | 2.265 | 1.492 | 1.280 | 0.926 |
| STD. DEVIATIONS | 0.270 | 0.422 | 0.432 | 0.793 | 1.248 | 1.262 |
| | 1.218 | 1.335 | 1.064 | 0.485 | 0.238 | 0.187 |

LATERAL DRAINAGE COLLECTED FROM LAYER 3

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 1.6098 | 1.2119 | 2.2445 | 1.4749 | 0.6446 | 0.4464 |
| | 0.3744 | 0.5522 | 0.6400 | 0.9246 | 1.1818 | 1.6226 |
| STD. DEVIATIONS | 1.0642 | 0.9951 | 1.0655 | 0.9666 | 0.5132 | 0.4623 |
| | 0.4322 | 0.7759 | 0.7902 | 1.1251 | 1.0776 | 1.2168 |

PERCOLATION/LEAKAGE THROUGH LAYER 4

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 0.0007 | 0.0005 | 0.0010 | 0.0006 | 0.0003 | 0.0002 |
| | 0.0002 | 0.0002 | 0.0003 | 0.0004 | 0.0005 | 0.0007 |
| STD. DEVIATIONS | 0.0005 | 0.0005 | 0.0006 | 0.0005 | 0.0002 | 0.0002 |
| | 0.0002 | 0.0004 | 0.0004 | 0.0006 | 0.0005 | 0.0006 |

PERCOLATION/LEAKAGE THROUGH LAYER 5

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 0.0005 | 0.0005 | 0.0004 | 0.0005 | 0.0008 | 0.0008 |
| | 0.0008 | 0.0008 | 0.0007 | 0.0007 | 0.0005 | 0.0004 |
| STD. DEVIATIONS | 0.0007 | 0.0007 | 0.0007 | 0.0007 | 0.0006 | 0.0005 |
| | 0.0005 | 0.0005 | 0.0005 | 0.0004 | 0.0005 | 0.0005 |

---

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

---

DAILY AVERAGE HEAD ON TOP OF LAYER 4

| | | | | | | |
|---|---|---|---|---|---|---|
| AVERAGES | 2.6948 | 2.2246 | 3.7888 | 2.5604 | 1.0736 | 0.7684 |
| | 0.6236 | 0.9420 | 1.1034 | 1.6010 | 2.0357 | 2.7260 |
| STD. DEVIATIONS | 1.7974 | 1.8502 | 1.9689 | 1.7813 | 0.8548 | 0.7956 |
| | 0.7198 | 1.4222 | 1.3611 | 2.1602 | 1.8594 | 2.0611 |

**********

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

| | INCHES | | CU. FEET | PERCENT |
|---|---|---|---|---|
| PRECIPITATION | 41.20 | ( 6.096) | 560881.2 | 100.00 |
| RUNOFF | 1.966 | ( 1.9566) | 26766.84 | 4.772 |

| | | | | |
|---|---|---|---|---|
| EVAPOTRANSPIRATION | 26.322 | ( 3.4414) | 358312.66 | 63.884 |
| LATERAL DRAINAGE COLLECTED FROM LAYER 3 | 12.92781 | ( 3.83815) | 175979.766 | 31.37558 |
| PERCOLATION/LEAKAGE THROUGH LAYER 4 | 0.00567 | ( 0.00181) | 77.165 | 0.01376 |
| AVERAGE HEAD ON TOP OF LAYER 4 | 1.845 | ( 0.561) | | |
| PERCOLATION/LEAKAGE THROUGH LAYER 5 | 0.00737 | ( 0.00622) | 100.273 | 0.01788 |
| CHANGE IN WATER STORAGE | -0.020 | ( 1.6998) | -278.29 | -0.050 |

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                PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
   ---------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                              5.26         71601.750

      RUNOFF                                     2.498        34000.1797

      DRAINAGE COLLECTED FROM LAYER  3           0.25755       3505.93237

      PERCOLATION/LEAKAGE THROUGH LAYER  4       0.000250         3.40714

      AVERAGE HEAD ON TOP OF LAYER  4           23.739

      MAXIMUM HEAD ON TOP OF LAYER  4           32.461

      LOCATION OF MAXIMUM HEAD IN LAYER  3
            (DISTANCE FROM DRAIN)               54.9 FEET

      PERCOLATION/LEAKAGE THROUGH LAYER  5       0.000203         2.75681

      SNOW WATER                                 6.75         91860.4687


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.4483

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1227

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

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

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

                  FINAL WATER STORAGE AT END OF YEAR  100
    -------------------------------------------------------------------
                   LAYER        (INCHES)       (VOL/VOL)
                   -----        --------       ---------
                     1            1.0752         0.1792

                     2            2.3093         0.3849

                     3            2.4753         0.2063

                     4            0.0000         0.0000

                     5            1.8662         0.3110

                  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:    I:\SOFTWARE\HELP3\58210P1.D4
TEMPERATURE DATA FILE:      i:\software\help3\58210T1.D7
SOLAR RADIATION DATA FILE:  i:\software\help3\58210R1.D13
EVAPOTRANSPIRATION DATA:    i:\software\help3\58210E1.D11
SOIL AND DESIGN DATA FILE:  I:\SOFTWARE\HELP3\58210S23.D10
OUTPUT DATA FILE:           i:\software\help3\58210R23.OUT


TIME:  16:31     DATE:   4/18/2011


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

     TITLE:  58210 - INVISTA SEAFORD FACILITY - Run 2B - 20% 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   6
           THICKNESS                   =      6.00   INCHES
           POROSITY                    =      0.4530 VOL/VOL
           FIELD CAPACITY              =      0.1900 VOL/VOL
           WILTING POINT               =      0.0850 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.1827 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.720000011000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

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

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      6.00   INCHES
POROSITY                    =      0.4750 VOL/VOL
FIELD CAPACITY              =      0.3780 VOL/VOL
WILTING POINT               =      0.2650 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3860 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC


                        LAYER  3
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1713 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC
SLOPE                       =     20.00   PERCENT
DRAINAGE LENGTH             =    125.0    FEET


                        LAYER  4
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                   =      0.04   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    =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  2 - EXCELLENT


                        LAYER  5
                        --------
```

```
            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER   0
  THICKNESS                   =      6.00   INCHES
  POROSITY                    =      0.4750 VOL/VOL
  FIELD CAPACITY              =      0.3780 VOL/VOL
  WILTING POINT               =      0.2650 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.3387 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-05 CM/SEC
```

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF 20.%
          AND A SLOPE LENGTH OF  125. FEET.

SCS RUNOFF CURVE NUMBER             =     65.70
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      8.000  ACRES
EVAPORATIVE ZONE DEPTH              =     18.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      4.163  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      8.070  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      2.208  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =      7.500  INCHES
TOTAL INITIAL WATER                 =      7.500  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
```

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

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          WILMINGTON            DELAWARE

     STATION LATITUDE                       =  39.80 DEGREES
     MAXIMUM LEAF AREA INDEX                =   2.00
     START OF GROWING SEASON (JULIAN DATE)  =    107
     END OF GROWING SEASON (JULIAN DATE)    =    298
     EVAPORATIVE ZONE DEPTH                 =  18.0  INCHES
     AVERAGE ANNUAL WIND SPEED              =   9.20 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  67.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  67.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  72.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  71.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    WILMINGTON          DELAWARE
```

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 3.11 | 2.99 | 3.87 | 3.39 | 3.23 | 3.51 |
| 3.90 | 4.03 | 3.59 | 2.89 | 3.33 | 3.54 |

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 31.20 | 33.20 | 41.80 | 52.40 | 62.20 | 71.20 |
| 76.00 | 74.80 | 67.80 | 56.30 | 45.60 | 35.50 |

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WILMINGTON DELAWARE
AND STATION LATITUDE = 39.80 DEGREES

**********

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

| | JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|---|
| **PRECIPITATION** | | | | | | |
| TOTALS | 3.26 | 3.00 | 4.08 | 3.39 | 3.39 | 3.46 |
| | 3.88 | 3.97 | 3.47 | 2.85 | 3.12 | 3.35 |
| STD. DEVIATIONS | 1.67 | 1.45 | 1.88 | 1.46 | 1.63 | 1.83 |
| | 1.87 | 2.39 | 2.16 | 1.84 | 1.64 | 1.72 |
| **RUNOFF** | | | | | | |
| TOTALS | 0.424 | 0.941 | 0.506 | 0.001 | 0.000 | 0.001 |
| | 0.007 | 0.003 | 0.006 | 0.007 | 0.001 | 0.069 |
| STD. DEVIATIONS | 0.735 | 1.188 | 0.965 | 0.009 | 0.000 | 0.006 |
| | 0.047 | 0.015 | 0.032 | 0.043 | 0.005 | 0.294 |
| **EVAPOTRANSPIRATION** | | | | | | |
| TOTALS | 0.809 | 0.790 | 2.330 | 3.226 | 3.202 | 3.346 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 3.260 | 3.376 | 2.265 | 1.490 | 1.278 | 0.925 |
| STD. DEVIATIONS | 0.270 | 0.422 | 0.431 | 0.792 | 1.249 | 1.257 |
| | 1.213 | 1.337 | 1.062 | 0.484 | 0.238 | 0.188 |

LATERAL DRAINAGE COLLECTED FROM LAYER 3

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 1.4655 | 1.1733 | 2.7033 | 0.8873 | 0.3622 | 0.4219 |
| | 0.3509 | 0.6355 | 0.7268 | 1.0407 | 1.3597 | 1.8209 |
| STD. DEVIATIONS | 1.4006 | 1.3241 | 1.6703 | 0.9779 | 0.5434 | 0.6600 |
| | 0.5646 | 1.1037 | 1.0268 | 1.4649 | 1.4448 | 1.4592 |

PERCOLATION/LEAKAGE THROUGH LAYER 4

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 0.0001 | 0.0001 | 0.0003 | 0.0001 | 0.0000 | 0.0000 |
| | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0002 |
| STD. DEVIATIONS | 0.0001 | 0.0001 | 0.0002 | 0.0001 | 0.0001 | 0.0001 |
| | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |

PERCOLATION/LEAKAGE THROUGH LAYER 5

| | | | | | | |
|---|---|---|---|---|---|---|
| TOTALS | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0004 | 0.0004 |
| | 0.0004 | 0.0004 | 0.0003 | 0.0003 | 0.0003 | 0.0003 |
| STD. DEVIATIONS | 0.0008 | 0.0007 | 0.0007 | 0.0006 | 0.0006 | 0.0006 |
| | 0.0006 | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0005 |

---

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

---

DAILY AVERAGE HEAD ON TOP OF LAYER 4

| | | | | | | |
|---|---|---|---|---|---|---|
| AVERAGES | 0.5420 | 0.4765 | 0.9998 | 0.3391 | 0.1339 | 0.1612 |
| | 0.1298 | 0.2350 | 0.2778 | 0.3849 | 0.5197 | 0.6738 |
| STD. DEVIATIONS | 0.5180 | 0.5382 | 0.6178 | 0.3737 | 0.2010 | 0.2522 |
| | 0.2088 | 0.4082 | 0.3925 | 0.5418 | 0.5522 | 0.5401 |

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

| | INCHES | | CU. FEET | PERCENT |
|---|---|---|---|---|
| PRECIPITATION | 41.20 | ( 6.096) | 1196546.7 | 100.00 |
| RUNOFF | 1.965 | ( 1.9457) | 57060.20 | 4.769 |

| | | | | |
|---|---|---|---|---|
| EVAPOTRANSPIRATION | 26.298 | ( 3.4383) | 763697.50 | 63.825 |
| LATERAL DRAINAGE COLLECTED FROM LAYER 3 | 12.94784 | ( 4.03564) | 376005.281 | 31.42420 |
| PERCOLATION/LEAKAGE THROUGH LAYER 4 | 0.00121 | ( 0.00038) | 35.030 | 0.00293 |
| AVERAGE HEAD ON TOP OF LAYER 4 | 0.406 | ( 0.127) | | |
| PERCOLATION/LEAKAGE THROUGH LAYER 5 | 0.00395 | ( 0.00686) | 114.670 | 0.00958 |
| CHANGE IN WATER STORAGE | -0.011 | ( 1.1528) | -330.98 | -0.028 |

**********

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

                PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
   ---------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                              5.26        152750.406

      RUNOFF                                     2.498        72555.0625

      DRAINAGE COLLECTED FROM LAYER  3           1.02911      29885.27730

      PERCOLATION/LEAKAGE THROUGH LAYER  4       0.000121         3.50157

      AVERAGE HEAD ON TOP OF LAYER  4           12.839

      MAXIMUM HEAD ON TOP OF LAYER  4           21.493

      LOCATION OF MAXIMUM HEAD IN LAYER  3
            (DISTANCE FROM DRAIN)               14.3 FEET

      PERCOLATION/LEAKAGE THROUGH LAYER  5       0.000214         6.21582

      SNOW WATER                                 6.75        195969.0000


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3918

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1227

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

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

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FINAL WATER STORAGE AT END OF YEAR 100

| LAYER | (INCHES) | (VOL/VOL) |
|---|---|---|
| 1 | 1.0751 | 0.1792 |
| 2 | 2.3090 | 0.3848 |
| 3 | 1.2186 | 0.1015 |
| 4 | 0.0000 | 0.0000 |
| 5 | 1.7579 | 0.2930 |
| SNOW WATER | 0.000 | |

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# APPENDIX E

# SOIL LOSS/EROSION CALCULATIONS

# ENGINEERING DESIGN CALCULATION

## PROJECT IDENTIFICATION

Client: Seaford Facility 058210

Project: Ash Landfill Location: Seaford, Delaware

## CALCULATION IDENTIFICATION

Calculation Ref. No.: _____ No. Pages: 9
(Including calculation cover sheet)

Calculation Description:

ANNUAL SOIL LOSS FROM FINAL COVER

Design: A.Wesolowski Date: Dec 14/09

Checked: R. Hoekstra Date: Dec 14/09

## RECORD OF REVISION

| Revision No. | Revision Date | Design | Checked | Supervised | Project Control | Detail of Revision |
|---|---|---|---|---|---|---|
| 0 | -- | -- | -- | -- | -- | Original (per above) |
| 1 | 02/22/10 | A.W. | R.H. | | | Reduced 3:1 to 5:1 slopes |
| 2 | 11/08/10 | A.W. | R.H. | | | Reduced top slope to 3% |
| 3 | 04/14/11 | R.H. | A.W. | | | Reduced overall footprint |
| | | | | | | so more 5:1 & less 3% slopes |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

## 1. ANNUAL SOIL LOSS FROM FINAL COVER

### 1.1 Data input

- formula and factors from USEPA SW-867 "Evaluation Cover Systems for Solid and Hazardous Waste" dated Sept 1982

$$A = R \times K \times LS \times C \times P$$

Where:

A = average annual soil loss, in tons/acre
R = rainfall and runoff erosivity index, for Ash Landfill Site = 250 (fig.20)
K = soil erodibility factor in tons/acre (Table 5), for post construction conditions , sandy clay loam, organic matter 4% K= 0.21

LS = length /slope factor (Table 6) or calculated using USEPA recommended method for non-linear slope

| Path | Total Length (ft.) | No. of Segments | Slope (%) | LS Factor | Multiplier | Corrected LS Factor | Avg Factor |
|---|---|---|---|---|---|---|---|
| 1 | 290 (120+50+120) | 3 | 5 | 0.91 | 0.58 | 0.53 | |
| | | | 10 | 2.35 | 1.06 | 2.49 | |
| | | | 20 | 6.97 | 1.37 | 9.55 | |
| | | | | | | | 4.19 |

C = cover management factor (Table 7), for post construction conditions, grass fully established , C = 0.01 ( for meadows – grass moderate productivity level)

P = practice factor (Table 8) , for post construction conditions , P = 1.0 assumes no support practice, but side slopes will have erosion control blanket, so assume P=0.90.

## 2. SOIL LOSS CALCULATIONS

Table 1 summarizes results for post construction conditions.

**TABLE 1**

| Path No. | R | K | LS | C | P | Average annual loss (tons/acre) |
|---|---|---|---|---|---|---|
| 1 | 250 | 0.21 | 3.92 | 0.01 | 0.9 | 1.98 |

This is an acceptable level.

United States Environmental Protection Agency
Office of Solid Waste and Emergency Response Washington DC 20460
SW-867 September 1982 Revised Edition

# EPA Evaluating Cover Systems for Solid and Hazardous Waste

Evaluate Erosion Potential — Step 18

The USDA universal soil loss equation (USLE) is a convenient tool for use in evaluating erosion potential. The USLE predicts average annual soil loss as the product of six quantifiable factors. The equation is:

$$A = R\ K\ L\ S\ C\ P$$

where A = average annual soil loss, in tons/acre
R = rainfall and runoff erosivity index
K = soil erodibility factor, tons/acre
L = slope-length factor
S = slope-steepness factor
C = cover/management factor
P = practice factor

The data necessary as input to this equation are available to the evaluator in a figure and tables included below. Note that the evaluations in Step 8 on soil composition and Steps 23-29 on vegetation all impact on the evaluation of erosion also.

Factor R in the USLE can be calculated empirically from climatological data. For average annual soil loss determinations, however, R can be obtained directly from Figure 20. Factor K, the average soil loss for a given soil in

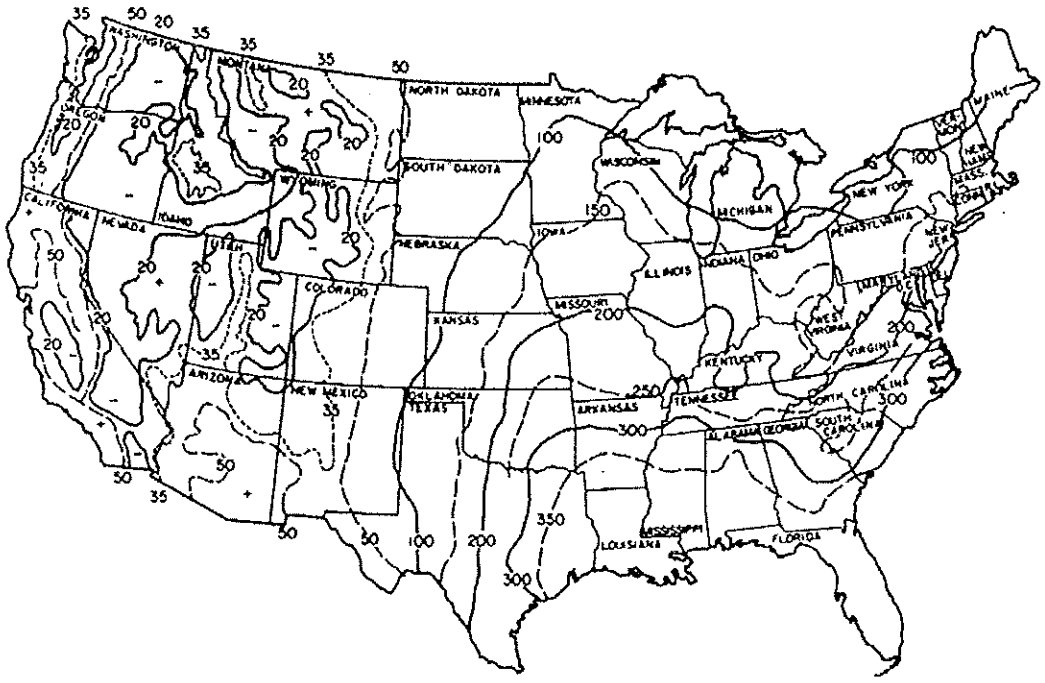



Figure 20. Average annual values of rainfall-erosivity factor R.[11]

a unit plot, pinpoints differences in erosion according to differences in soil type. Long-term plot studies under natural rainfall have produced K values generalized in Table 5 for the USDA soil types.

TABLE 5. APPROXIMATE VALUES OF FACTOR K FOR USDA TEXTURAL CLASSES[11]

| Texture class | Organic matter content | | |
|---|---|---|---|
| | <0.5% | 2% | 4% |
| | K | K | K |
| Sand | 0.05 | 0.03 | 0.02 |
| Fine sand | .16 | .14 | .10 |
| Very fine sand | .42 | .36 | .28 |
| Loamy sand | .12 | .10 | .08 |
| Loamy fine sand | .24 | .20 | .16 |
| Loamy very fine sand | .44 | .38 | .30 |
| Sandy loam | .27 | .24 | .19 |
| Fine sandy loam | .35 | .30 | .24 |
| Very fine sandy loam | .47 | .41 | .33 |
| Loam | .38 | .34 | .29 |
| Silt loam | .48 | .42 | .33 |
| Silt | .60 | .52 | .42 |
| Sandy clay loam | .27 | .25 | .21 |
| Clay loam | .28 | .25 | .21 |
| Silty clay loam | .37 | .32 | .26 |
| Sandy clay | .14 | .13 | .12 |
| Silty clay | .25 | .23 | .19 |
| Clay | | 0.13-0.29 | |

The values shown are estimated averages of broad ranges of specific-soil values. When a texture is near the borderline of two texture classes, use the average of the two K values.

The evaluator must next consider the shape of the slope in terms of length and inclination. The appropriate LS factor is obtained from Table 6. A nonlinear slope may have to be evaluated as a series of segments, each with uniform gradient. Two or three segments should be sufficient for most engineered landfills, provided the segments are selected so that they are also of equal length (Table 6 can be used, with certain adjustments). Enter Table 6 with the total slope length and read LS values corresponding to the percent slope of each segment. For three segments, multiply the chart LS values for the upper, middle, and lower segments by 0.58, 1.06, and 1.37,

TABLE 6. VALUES OF THE FACTOR LS FOR SPECIFIC COMBINATIONS OF SLOPE LENGTH AND STEEPNESS[11]

| % Slope | Slope length (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25 | 50 | 75 | 100 | 150 | 200 | 300 | 400 | 500 | 600 | 800 | 1000 |
| 0.5 | 0.07 | 0.08 | 0.09 | 0.10 | 0.11 | 0.12 | 0.14 | 0.15 | 0.16 | 0.17 | 0.19 | 0.20 |
| 1 | 0.09 | 0.10 | 0.12 | 0.13 | 0.15 | 0.16 | 0.18 | 0.20 | 0.21 | 0.22 | 0.24 | 0.26 |
| 2 | 0.13 | 0.16 | 0.19 | 0.20 | 0.23 | 0.25 | 0.28 | 0.31 | 0.33 | 0.34 | 0.38 | 0.40 |
| 3 | 0.19 | 0.23 | 0.26 | 0.29 | 0.33 | 0.35 | 0.40 | 0.44 | 0.47 | 0.49 | 0.54 | 0.57 |
| 4 | 0.23 | 0.30 | 0.36 | 0.40 | 0.47 | 0.53 | 0.62 | 0.70 | 0.76 | 0.82 | 0.92 | 1.0 |
| 5 | 0.27 | 0.38 | 0.46 | 0.54 | 0.66 | 0.76 | 0.93 | 1.1 | 1.2 | 1.3 | 1.5 | 1.7 |
| 6 | 0.34 | 0.48 | 0.58 | 0.67 | 0.82 | 0.95 | 1.2 | 1.4 | 1.5 | 1.7 | 1.9 | 2.1 |
| 8 | 0.50 | 0.70 | 0.86 | 0.99 | 1.2 | 1.4 | 1.7 | 2.0 | 2.2 | 2.4 | 2.8 | 3.1 |
| 10 | 0.69 | 0.97 | 1.2 | 1.4 | 1.7 | 1.9 | 2.4 | 2.7 | 3.1 | 3.4 | 3.9 | 4.3 |
| 12 | 0.90 | 1.3 | 1.6 | 1.8 | 2.2 | 2.6 | 3.1 | 3.6 | 4.0 | 4.4 | 5.1 | 5.7 |
| 14 | 1.2 | 1.6 | 2.0 | 2.3 | 2.8 | 3.3 | 4.0 | 4.6 | 5.1 | 5.6 | 6.5 | 7.3 |
| 16 | 1.4 | 2.0 | 2.5 | 2.8 | 3.5 | 4.0 | 4.9 | 5.7 | 6.4 | 7.0 | 8.0 | 9.0 |
| 18 | 1.7 | 2.4 | 3.0 | 3.4 | 4.2 | 4.9 | 6.0 | 6.9 | 7.7 | 8.4 | 9.7 | 11.0 |
| 20 | 2.0 | 2.9 | 3.5 | 4.1 | 5.0 | 5.8 | 7.1 | 8.2 | 9.1 | 10.0 | 12.0 | 13.0 |
| 25 | 3.0 | 4.2 | 5.1 | 5.9 | 7.2 | 8.3 | 10.0 | 12.0 | 13.0 | 14.0 | 17.0 | 19.0 |
| 30 | 4.0 | 5.6 | 6.9 | 8.0 | 9.7 | 11.0 | 14.0 | 16.0 | 18.0 | 20.0 | 23.0 | 25.0 |
| 40 | 6.3 | 9.0 | 11.0 | 13.0 | 16.0 | 18.0 | 22.0 | 25.0 | 28.0 | 31.0 | .. | .. |
| 50 | 8.9 | 13.0 | 15.0 | 18.0 | 22.0 | 25.0 | 31.0 | .. | .. | .. | .. | .. |
| 60 | 12.0 | 16.0 | 20.0 | 23.0 | 28.0 | .. | .. | .. | .. | .. | .. | .. |

Values given for slopes longer than 300 feet or steeper than 18% are extrapolations beyond the range of the research data and, therefore, less certain than the others.

respectively. The average of the three products is a good estimate of the overall effective LS value. If two segments are sufficient, multiply by 0.71 and 1.29.

Factor C in the USLE is the ratio of soil loss from land cropped under specified conditions to that from clean-tilled, continuous fallow. Therefore, C combines effects of vegetation, crop sequence, management, and agricultural (as opposed to engineering) erosion-control practices. On landfills, freshly covered and without vegetation or special erosion-reducing procedures of cover placement, C will usually be about unity. Where there is vegetative cover or significant amounts of gravel, roots, or plant residues or where cultural practices increase infiltration and reduce runoff velocity, C is much less than unity. Estimate C by reference to Table 7 for cover management conditions anticipated in the application, and consider changes that may take place in time. See Reference 1 for additional guidance.

Factor P in the USLE is similar to C except that it accounts for additional erosion-reducing effects of land management practices that are superimposed on the cultural practices, e.g., contouring, terracing, and

TABLE 7. GENERALIZED VALUES OF FACTOR C FOR STATES EAST OF THE ROCKY MOUNTAINS[11]

| Crop, rotation, and management | Productivity level | |
|---|---|---|
| | High | Mod. |
| | C value | |
| Base value: continuous fallow, tilled up and down slope | 1.00 | 1.00 |
| **CORN** | | |
| C, RdR, fall TP, conv | 0.54 | 0.62 |
| C, RdR, spring TP, conv | .50 | .59 |
| C, RdL, fall TP, conv | .42 | .52 |
| C, RdR, wc seeding, spring TP, conv | .40 | .49 |
| C, RdL, standing, spring TP, conv | .38 | .48 |
| C-W-M-M, RdL, TP for C, disk for W | .039 | .074 |
| C-W-M-M-M, RdL, TP for C, disk for W | .032 | .061 |
| C, no-till pl in c-k sod, 95-80% rc | .017 | .053 |
| **COTTON** | | |
| Cot, conv (Western Plains) | 0.42 | 0.49 |
| Cot, conv (South) | .34 | .40 |
| **MEADOW** | | |
| Grass & Legume mix | 0.004 | 0.01 |
| Alfalfa, lespedeza or Sericea | .020 | |
| Sweet clover | .025 | |
| **SORGHUM, GRAIN (Western Plains)** | | |
| RdL, spring TP, conv | 0.43 | 0.53 |
| No-till pl in shredded 70-50% rc | .11 | .18 |
| **SOYBEANS** | | |
| B, RdL, spring TP, conv | 0.48 | 0.54 |
| C-B, TP annually, conv | .43 | .51 |
| B, no-till pl | .22 | .28 |
| C-B, no-till pl, fall shred C stalks | .18 | .22 |
| **WHEAT** | | |
| W-F, fall TP after W | 0.38 | |
| W-F, stubble mulch, 500 lbs rc | .32 | |
| W-F, stubble mulch, 1000 lbs rc | .21 | |

Abbreviations defined:

B - soybeans
C - corn
c-k - chemically killed
conv - conventional
cot - cotton
F - fallow
M - grass & legume hay
pl - plant
W - wheat
wc - winter cover

lbs rc - pounds of crop residue per acre remaining on surface after new crop seeding
% rc - percentage of soil surface covered by residue mulch after new crop seeding
70-50% rc - 70% cover for C values in first column; 50% for second column
RdR - residues (corn stover, straw, etc.) removed or burned
RdL - all residues left on field (on surface or incorporated)
TP - turn plowed (upper 5 or more inches of soil inverted, covering residues)

contour strip-cropping. Approximate values of P, related only to slope steepness, are listed in Table 8. These values are based on rather limited field data, but P has a narrower range of possible values than the other five factors.

TABLE 8. VALUES OF FACTOR P[11]

| Practice | Land slope (percent) | | | | |
|---|---|---|---|---|---|
| | 1.1-2 | 2.1-7 | 7.1-12 | 12.1-18 | 18.1-24 |
| | (Factor P) | | | | |
| Contouring ($P_c$) | 0.60 | 0.50 | 0.60 | 0.80 | 0.90 |
| Contour strip cropping ($P_{sc}$) | | | | | |
| R-R-M-M[1] | 0.30 | 0.25 | 0.30 | 0.40 | 0.45 |
| R-W-M-M | 0.30 | 0.25 | 0.30 | 0.40 | 0.45 |
| R-R-W-M | 0.45 | 0.38 | 0.45 | 0.60 | 0.68 |
| R-W | 0.52 | 0.44 | 0.52 | 0.70 | 0.90 |
| R-O | 0.60 | 0.50 | 0.60 | 0.80 | 0.90 |
| Contour listing or ridge planting ($P_{cl}$) | 0.30 | 0.25 | 0.30 | 0.40 | 0.45 |
| Contour terracing ($P_t$)[2] | [3] $0.6/\sqrt{n}$ | $0.5/\sqrt{n}$ | $0.6/\sqrt{n}$ | $0.8/\sqrt{n}$ | $0.9/\sqrt{n}$ |
| No support practice | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |

[1] R = rowcrop, W = fall-seeded grain, O = spring-seeded grain, M = meadow. The crops are grown in rotation and so arranged on the field that rowcrop strips are always separated by a meadow or winter-grain strip.

[2] These $P_t$ values estimate the amount of soil eroded to the terrace channels and are used for conservation planning. For prediction of off-field sediment, the $P_t$ values are multiplied by 0.2.

[3] n = number of approximately equal-length intervals into which the field slope is divided by the terraces. Tillage operations must be parallel to the terraces.

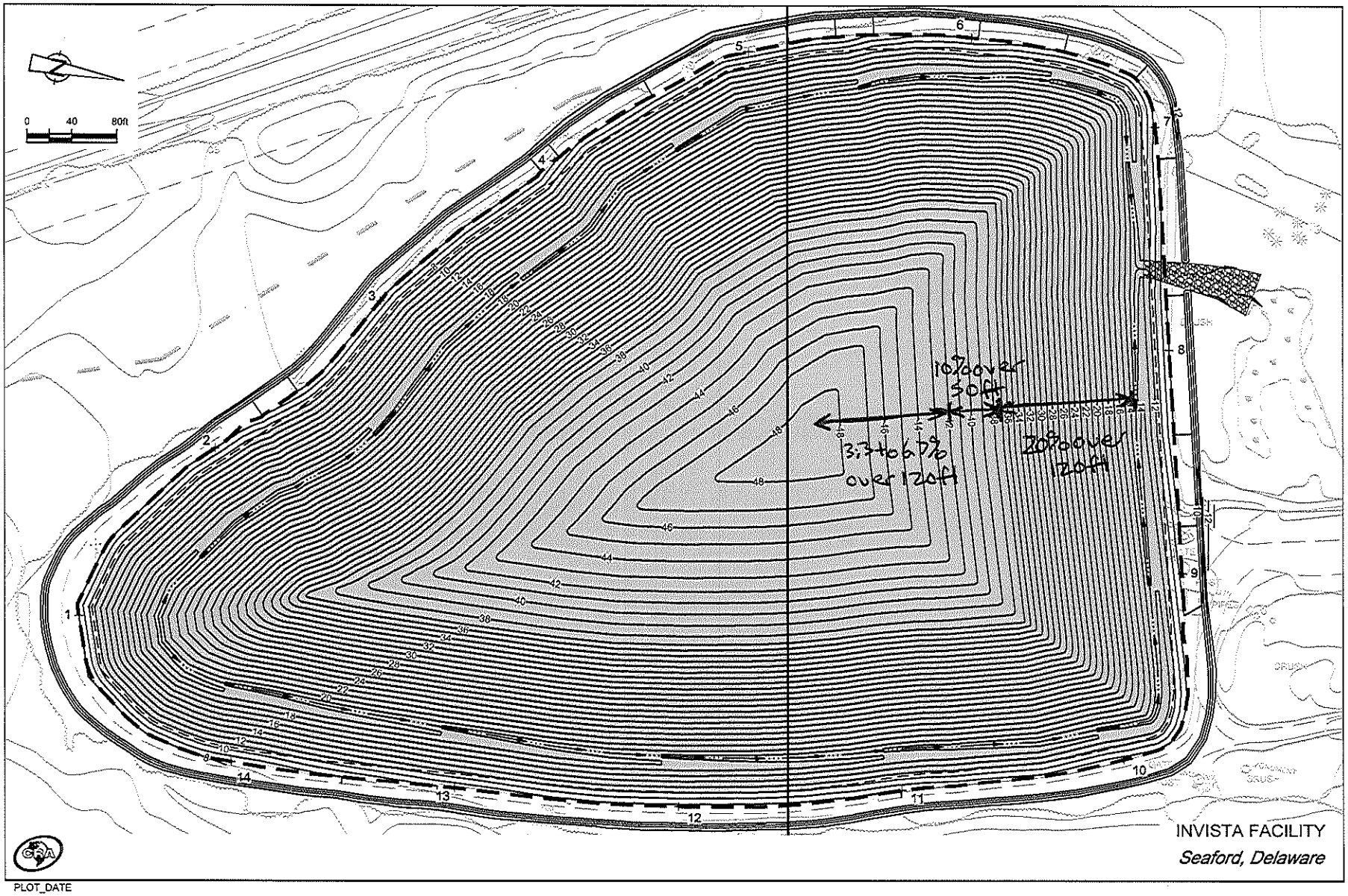
Example: An owner/operator proposes to close one section of his small landfill with a sandy clay subsoil cover having the surface configuration shown in Figure 21. The factor R has been established as 200 for this locality. The evaluator questions anticipated erosion along the steep side and assigns the following values to the other factors in the USLE after inspecting Tables 5 through 8:

$$K = 0.14 \quad LS = 8.3 \quad C = 1.00 \quad P = 0.90$$

The rate of erosion for the steep slope of the landfill is calculated as follows:

$$A = 200\ (0.14\ \text{tons/acre})\ (8.3)\ (1.00)\ (0.90) = 209\ \text{tons/acre}$$

This erosion not only exceeds a limit recommended by the permitting authority but also indicates a potential




INVISTA FACILITY

*Seaford, Delaware*

PLOT_DATE

# APPENDIX F

# POST-CLOSURE PLAN

# POST-CLOSURE PLAN
# COAL ASH LANDFILL

## INVISTA SEAFORD PLANT
## SEAFORD, DELAWARE

**Prepared For:**
**INVISTA S.à.r.l**

**MAY 2011**
**REF. NO. 058210 (2 – App. F)**
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TABLE OF CONTENTS


Page

1.0 INTRODUCTION ..... F-1

2.0 POST-CLOSURE CARE ..... F-2
- 2.1 MAINTENANCE OF VEGETATION AND COVER SOILS ..... F-2
- 2.2 MAINTENANCE OF CAPPING SYSTEM ..... F-2
- 2.3 LANDFILL GAS CONTROL ..... F-2
- 2.4 SURFACE WATER MANAGEMENT ..... F-2

3.0 POST-CLOSURE MONITORING PROGRAM ..... F-4
- 3.1 GROUNDWATER MONITORING ..... F-4
- 3.2 SURFACE WATER MONITORING ..... F-6

4.0 POST-CLOSURE INSPECTIONS ..... F-7

5.0 REPORTING ..... F-8

6.0 POST-CLOSURE LAND USE AND PROHIBITIONS ..... F-9
- 6.1 PROHIBITIONS ..... F-9
- 6.2 LAND USE ..... F-9
- 6.3 DEED NOTICE ..... F-9

## LIST OF FIGURES
(Following Text)

FIGURE F-1 SAMPLING LOCATIONS

## LIST OF ATTACHMENTS
(Following Text)

ATTACHMENT A CONTACT INFORMATION

ATTACHMENT B SAMPLING PROCEDURES

## 1.0 INTRODUCTION

Post-closure activities will be conducted at the Coal Ash Landfill to assure that the landfill cover system is properly maintained. These activities will consist of:

- Continuation of the current groundwater and surface water monitoring program as previously described in the monitoring plan for the Coal Ash Landfill dated May 30, 2006 and as modified in Solid Waste Permit SW-09/01 as issued by DNREC on May 15, 2009.
- Regular inspections of the landfill cover to identify any maintenance issues.
- Cutting the grass on the landfill cover, as necessary
- Management of surface water to prevent erosion and sedimentation
- Maintenance, as necessary, of all stormwater and erosion control measures
- Placement of a notice in the Site property deed

The Post-Closure Plan (Plan) will remain in force for 30 years after the completion of the closure of the Coal Ash Landfill.

Attachment A of this Plan provides the title, address, and telephone number of the person to contact during the post-closure period. This person is responsible for assuring that the activities of the Post-Closure Plan are conducted.

## 2.0 POST-CLOSURE CARE

### 2.1 MAINTENANCE OF VEGETATION AND COVER SOILS

The Coal Ash Landfill will be mowed as needed to cut the grass and any sapling trees that may have sprouted. Rodent holes will be filled to prevent destruction of the geomembrane.

### 2.2 MAINTENANCE OF CAPPING SYSTEM

General maintenance of the Coal Ash Landfill area will include the following activities on an as-required basis, as determined through inspections:

- Addition of soil to eroded areas
- Reseeding of bare areas exposed due to erosion or other causes
- Repairs to capping system, if required
- Repairs to monitoring wells
- Rodent control

### 2.3 LANDFILL GAS CONTROL

Since the Coal Ash Landfill contains only coal ash materials, there is no likelihood for generation of methane gas or any other types of gases. Therefore, no control of gas is needed and no gas extraction system has been constructed.

### 2.4 SURFACE WATER MANAGEMENT

The surface water management system has been designed and will be constructed and maintained to:

- Prevent erosion of the cover or the waste beneath the cover
- Prevent collection of standing water
- Ensure proper management of stormwater flowing off the cover

The Coal Ash Landfill cover system is constructed with permeable materials above the impermeable geomembrane, which will allow precipitation to percolate into the cover soil to and be directed laterally via subsurface drainage in all but the larger storm events. The Coal Ash Landfill is also designed to facilitate gradual sheet flow of stormwater during the larger storm events. Most of the stormwater would be collected in the drainage ditches located at or near the toe of the landfill slopes, from which the stormwater is directed by channelized flow to the area north of the existing landfill where the former Cell 9 was previously located. In order to facilitate gravity drainage within the perimeter ditches, the ditch originates partially up the side slope at the south end of the landfill and slowly progresses down the side slope as flow is directed around both sides of the landfill. As a result, storm water on the bottom portion of the side slope areas will sheet flow directly to the adjacent areas around the landfill. Stormwater flows to the area in which the former Cell 9 was previously located where it will be absorbed into the ground. No downstream properties will be adversely impacted by this stormwater.

## 3.0 POST-CLOSURE MONITORING PROGRAM

INVISTA will perform monitoring at the following locations[1]:

- Semi--annual gauging of 13 monitoring wells and 2 plant production wells (PW-11 and PW-12) located west of the Coal Ash Landfill
- Collection of annual surface water quality samples from 2 locations in the effluent ditch, one upstream of the Coal Ash Landfill and one downstream of the Coal Ash Landfill, in April of each calendar year
- Collection of annual water quality samples from 10 monitoring wells and 2 plant production wells surrounding and adjacent to the Coal Ash Landfill in April of each calendar year
- Collection of semi-annual water quality samples from 5 monitoring wells adjacent to and surrounding the Coal Ash Landfill in October of each calendar year

The location of these monitoring wells locations are shown on Figure F-1.

### 3.1 GROUNDWATER MONITORING

Water Level Measurements: Prior to any purging or sampling activities, a full round of water levels will be collected from all wells to determine the static water level. Water level measurements will be taken from 13 monitoring wells surrounding the Coal Ash Landfill and Plant Production Wells PW-11 and PW-12, as required in Permit SW-09/01. All gauging locations are listed below.

**Semi-annual Water Level Gauging Locations:**

| | |
|---|---|
| MW-1S | MW-9S |
| MW-2S | MW-17S |
| MW-3SR | MW-2D |
| MW-4S | MW-3D |
| MW-5S | MW-5D |
| MW-6S | PW-11 |
| MW-7S | PW-12 |
| MW-8S | |

1 Analytical parameters and reporting requirements are defined by the DNREC solid water permit for this facility and are subject to change for permits amendments and renewals.

Production Wells PW-11 and PW-12 are located west of the Coal Ash Landfill and are screened in the lower zone of the Aquifer Unit.

Groundwater Monitoring: Groundwater samples will be collected as shown below:

Shallow Aquifer Zone: All wells are sampled in April. Wells noted "*" are also sampled in October.

| | |
|---|---|
| MW-2S | MW-8S* |
| MW-3SR* | MW-9S |
| MW-4S | MW-17S* |
| MW-5S* | |

Deep Aquifer Zone: All wells are sampled in April. Wells noted "*" are also sampled in October.

MW-2D
MW-3D*
MW-5D
PW-11
PW-12

Production Wells PW-11 and PW-12 are sampled only when they are in service.

The groundwater samples will be analyzed for the following parameters when wells are sampled annually in April:

| | |
|---|---|
| Arsenic | Chloride |
| Barium | Nitrate (N) |
| Calcium | pH (field and lab) |
| Iron | Conductivity (field and lab) |
| Magnesium | Sulfate |
| Manganese | Temperature (field) |
| Sodium | Total Dissolved Solids (TDS) |
| Alkalinity as CaCO3 at pH 4.5 | Turbidity (field) |
| Alkalinity as CaCO3 at pH 8.3 | Zinc |

The groundwater samples will be analyzed for the following additional parameters when wells are sampled annually in October:

| | |
|---|---|
| Beryllium | Lead |
| Boron | Molybdenum |
| Cadmium | Thallium |
| Cobalt | Vanadium |

Sampling procedures and data deliverables for groundwater samples are presented in Attachment B.

## 3.2 SURFACE WATER MONITORING

The Site's discharge to the Nanticoke River is permitted under the National Pollutant Discharge Elimination System (NPDES) permit. The final effluent water will be sampled in accordance with the solid waste permit annually, during April, in two locations, upstream of the Coal Ash Landfill (Ditch-Upstream) and downstream of the Coal Ash Landfill (Ditch-Downstream).

Analytical parameters for the surface water samples:

| | |
|---|---|
| Arsenic | Chloride |
| Barium | pH (field + lab) |
| Calcium | Conductivity (field + lab) |
| Iron | Sulfate |
| Magnesium | Temperature (field) |
| Sodium | TDS |
| Zinc | Hardness as CaCO3 |

Sampling procedures and data deliverables for surface water samples are presented in Attachment B.

After establishment of the cap, INVISTA will request that DNREC remove the surface water monitoring requirement from the annual monitoring program.

## 4.0 POST-CLOSURE INSPECTIONS

The Coal Ash Landfill will be inspected on a monthly basis and after any severe storm event for the first two years following closure, and on a quarterly basis for the remainder of the 30-year post-closure period. Each inspection will be conducted by the Plant environmental engineer or a designated representative. Inspection activities will be documented and maintained on-site. INVISTA will submit an annual summary confirming inspections and any necessary corrective actions.

General inspection of the Coal Ash Landfill will include the following activities:

- visual inspection of the cover integrity (vegetation, erosion, subsidence, etc.)
- visual inspection of the need for grass mowing and/or rodent control
- visual inspection of runon/runoff controls (drain conditions, swales, etc.)
- visual inspection of the condition of monitoring wells (caps, locks, bumpers, etc.)

No significant settlement of the coal ash materials has been measured at the Seaford landfill site over the last 20 years of operation. Inspection by topographic survey will be performed 3 years after closure and compared to the as-built survey performed upon completion of construction. The need for topographic surveys after Year 3 will be based on the results from the Year 3 survey. As a compliment to the topographic survey, if visual inspections identify low spots/settlement issues, then appropriate corrective action will be taken to correct low spots and settlement issues.

## 5.0 REPORTING

The activities performed in accordance with Sections 3.0 and 4.0 will be reported as required by the facility's Post-Closure Solid Waste Permit.

## 6.0 POST-CLOSURE LAND USE AND PROHIBITIONS

### 6.1 PROHIBITIONS

Neither standing water nor open burning will be allowed on the Coal Ash Landfill.

### 6.2 LAND USE

Under current plans, the Coal Ash Landfill will remain unused undeveloped land, thereby ensuring the integrity of the capping systems, geomembrane, containment system, and the monitoring system remains uncompromised.

Access to the area in which the Coal Ash Landfill is located is restricted on the northern and western sides of the Coal Ash Landfill by fencing and on the eastern and southern sides by the ditch, the Nanticoke River, and its tributary, Chapel Branch. Unauthorized persons are restricted from entry to the area of the Coal Ash Landfill, and signage notifies all persons that there is not trespassing. The signs will read

NO TRESPASSING
AUTHORIZED PERSONNEL ONLY
NO DIGGING IN THIS AREA

As described in the following section, the title to the land will have a deed notice that specifically states that any future land usage must not impact the integrity of the final cover system or the monitoring systems and must ensure proper access restrictions for the Coal Ash Landfill are maintained if ownership or land use changes.

### 6.3 DEED NOTICE

A deed notice will be prepared for the property on which the Coal Ash Landfill is located in accordance with the requirements of DRGSW, Section 6.11.5.1. This deed notice will consist of an Environmental Covenant (EC), and state that the land has been used as a solid waste disposal site and that the use of this land is restricted under the aforementioned regulation. The deed notice will include an as-built survey of the Coal Ash Landfill, which will be completed at the conclusion of the closure of the Coal Ash Landfill. This survey will incorporate permanent monument markers.

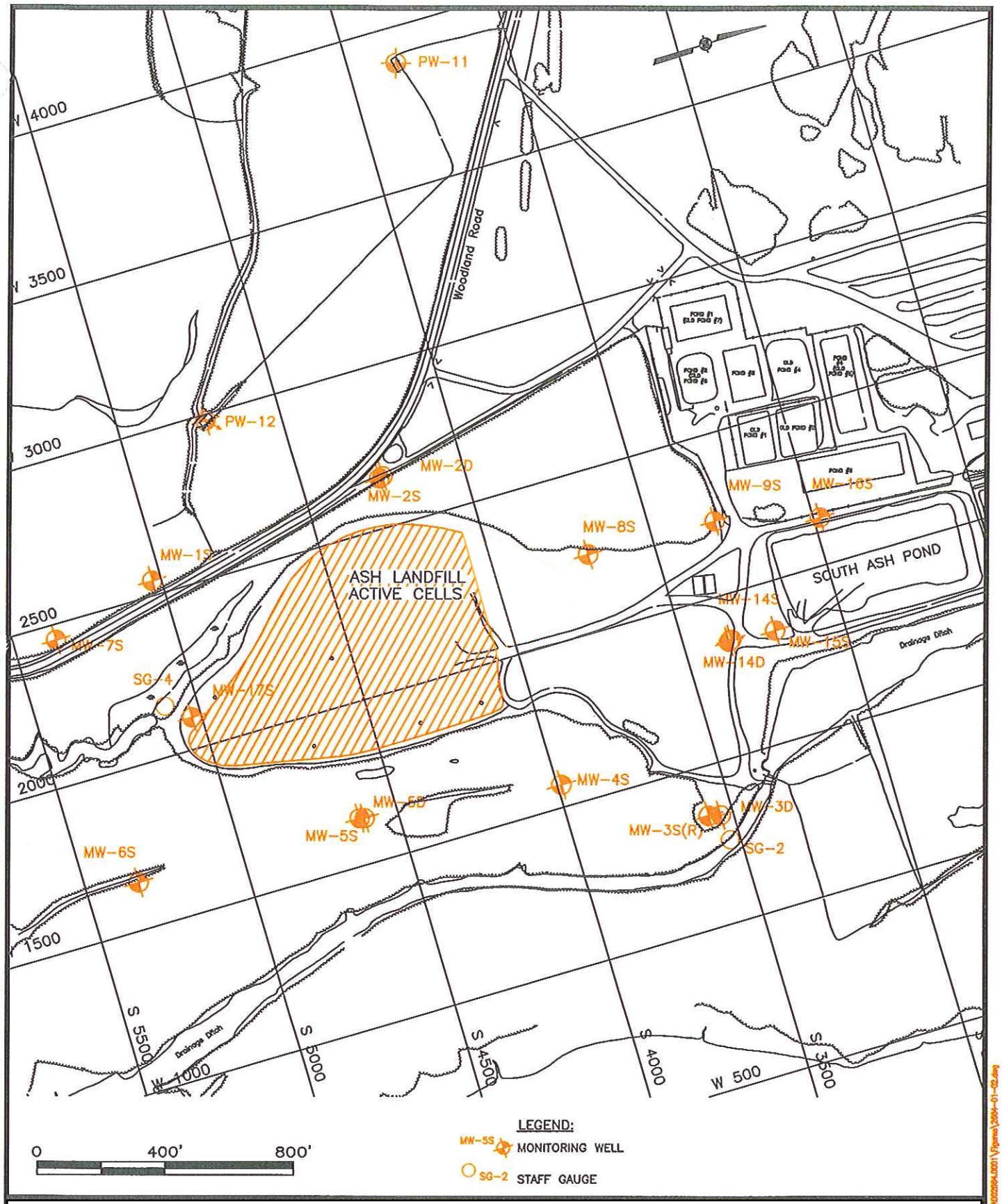


**Figure F-1**
**Monitoring Well Locations**

**Source: Arcadis Report**

ATTACHMENT A

CONTACT INFORMATION DURING POST-CLOSURE PERIOD

## ATTACHMENT A

## CONTACT INFORMATION DURING POST-CLOSURE PERIOD

The person listed below is responsible for ensuring that the activities of the Post-Closure Plan are conducted:

Name: INVISTA Seaford Site Environmental Manager

Address: INVISTA S.à.r.l

25876 DuPont Road

Seaford, Delaware 19973

Telephone No. 302-629-1221

ATTACHMENT B

POST-CLOSURE MONITORING
SAMPLING PROCEDURES AND DATA DELIVERABLES

TABLE OF CONTENTS

Page


1.0 SAMPLING PROCEDURES ..... ATTB F-1
1.1 GROUNDWATER ..... ATTB F-1
1.1.1 SAMPLING EQUIPMENT ..... ATTB F-1
1.1.2 GROUNDWATER SAMPLING PROCEDURE ..... ATTB F-2
1.1.3 GROUNDWATER ANALYTICAL REQUIREMENTS ..... ATTB F-3
1.2 SURFACE WATER ..... ATTB F-4
1.2.1 SAMPLING EQUIPMENT ..... ATTB F-4
1.2.2 SURFACE WATER SAMPLING PROCEDURE ..... ATTB F-5
1.1.3 SURFACE WATER ANALYTICAL REQUIREMENTS ..... ATTB F-5

2.0 DATA DELIVERABLES ..... ATTB F-6
2.1 QUALITY ASSURANCE ..... ATTB F-6
2.2 ANALYTICAL REPORTS ..... ATTB F-8
2.3 DATA EVALUATION REPORT ..... ATTB F-8

**ATTACHMENT B**

**POST-CLOSURE MONITORING**
**SAMPLING PROCEDURES AND DATA DELIVERABLES**

## 1.0 SAMPLING PROCEDURES

The following sampling procedures will be employed when conducting groundwater and surface water monitoring for the Coal Ash Landfill[2].

### 1.1 GROUNDWATER

#### 1.1.1 SAMPLING EQUIPMENT

The following equipment shall be used as a minimum to collect groundwater samples. Additional equipment may be deemed necessary depending on field conditions.

**Extraction Device**: An adjustable rate submersible pump shall be used to draw samples from each well. The pump shall be capable of extracting water at 0.1 to 0.5 liter per minute (L/min).

**Tubing**: Polypropylene or polyethylene tubing will be placed in each of the network wells during sampling. This tubing will be 3/8 inch (inner diameter) to ensure the tubing remains liquid-filled when pumping at low rates. The tube shall be placed such that the pump intakes are positioned within the screened interval. Brand new, clean tubing will be used in each well.

**Field Filtration**: Groundwater to be analyzed for dissolved metals will be filtered in the field before preservation in the laboratory-prepared sample bottles. A 0.45-micrometer (μm) filter will be used to filter the sampled water from the clean, never used before plastic bottle into the laboratory-prepared sample bottle using clean tubing and a peristaltic pump or attaching the filter directly to the discharge tubing.

**Water Level Probe**: Water levels in each well will be measured using an electronic water level meter capable of measuring to 0.01-foot accuracy.

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2 Analytical parameters and reporting requirements are defined by the DNREC solid water permit for this facility and are subject to change for permits amendments and renewals.

**Flow Measurement**: A graduated cylinder (approximately 1,000-milliliter [ml]) and a stopwatch will be used to measure the pumping rate.

**Power Source**: Electric power to be used by the submersible pump shall be provided by a gasoline-powered generator.

**Monitoring Instruments**: Instruments capable of measuring pH, turbidity, specific conductance, dissolved oxygen, oxidation-reduction potential, and temperature shall be used to measure field parameters prior to sampling. Use of a flow-through cell is required for all parameters except for turbidity. Each instrument shall be calibrated prior to sampling and the calibration documented in the field logbook.

**Documentation**: Field logbooks shall be used to record site activities such as personnel present, weather conditions, and general actions performed at the Site. Field data such as field parameters, sample times, analysis requested, bottle preservation, etc., will be recorded on field data sheets for each well.

**Sample Bottles**: Sample bottles needing chemical preservation will be preserved in the laboratory prior to arrival on site. To allow flexibility in sampling order, each well will have its own chain-of-custody (COC) form.

**Chain of Custody**: A COC form will document groundwater sample possession, time of collection, analysis, preservative, facility name, and sampling team. A sample COC form is presented in Appendix A. This form will be initiated by the laboratory and will accompany the samples to and from the Site. A signed copy will be maintained in the file with the analytical results.

### 1.1.2 GROUNDWATER SAMPLING PROCEDURE

Prior to collection of the samples for analysis, all wells will be purged using a low-flow (minimum drawdown) protocol with ideal purge rates of less than 0.5 L/min. The low-flow pump will be used to evacuate the groundwater from the screened area of the well. Purge water will be managed in accordance with the site-specific Waste Management Plan.

The water quality parameters (pH, specific conductivity, dissolved oxygen, and temperature) will be monitored using a flow-through cell once the water level in the well has stabilized. Purging will be considered complete and formation water accessed when all field measurements have stabilized. Stabilization will be considered achieved

when three consecutive readings, taken at 3- to 5-minute intervals are within the following limits:

- Dissolved Oxygen (10 percent)
- Specific Conductance (3 percent)
- Temperature (3 percent)
- pH (±0.1 standard unit)

The sampler will collect samples in laboratory-supplied bottles by disconnecting the flow cell and sampling water directly from the pump discharge. Dissolved metals samples will be transferred from clean plastic bottles through clean tubing and a 0.45-µm filter into the laboratory-prepared sample bottle with preservative or attaching the filter directly to the discharge tubing.

Samples will be packed in wet ice and shipped to the laboratory via laboratory courier or overnight transport.

### 1.1.3 GROUNDWATER ANALYTICAL REQUIREMENTS

The analytes listed below are required by DNREC Solid Waste Permit No. SW-09/01. Analysis will be performed using the most current edition of U.S. Environmental Protection Agency (USEPA) Publication Number SW-846. If SW-846 does not contain a test method for a required parameter, that parameter shall be tested according to methods described in the most recent edition of the USEPA Publication "Methods of Chemical Analysis for Water and Wastes" or of "Standard Methods for Examination of Water and Wastewater."

- Arsenic
- Barium
- Calcium
- Iron
- Magnesium
- Manganese
- Sodium
- Alkalinity as $CaCO_3$ at pH 4.5
- Alkalinity as $CaCO_3$ at pH 8.3
- Chloride
- Nitrate (N)
- pH (field and lab)
- Conductivity (field and lab)
- Sulfate
- Temperature (field)
- Total Dissolved Solids (TDS)
- Turbidity (field)
- Zinc

The groundwater samples will be analyzed for the following additional parameters when wells are sampled annually in October:

- Beryllium
- Boron
- Cadmium
- Cobalt
- Lead
- Molybdenum
- Thallium
- Vanadium

Field parameters to be measured include specific conductance, pH, and temperature.

To evaluate analytical precision and integrity, one field duplicate, matrix spike, and matrix spike duplicate sample will be collected for every 20 samples. To evaluate potential sampling bias, one equipment blank will be collected on each day of sampling. If pre-cleaned disposable equipment or dedicated equipment is used, no equipment blank need be collected.

## 1.2 SURFACE WATER

### 1.2.1 SAMPLING EQUIPMENT

**Monitoring Instruments**: Instruments capable of measuring pH, turbidity, specific conductance, dissolved oxygen, and temperature shall be used to measure field parameters during surface water sampling. Each instrument shall be calibrated prior to sampling and the calibration will be documented in the field logbook.

**Documentation**: Field logbooks shall be used to record site activities such as personnel present, weather conditions, and general actions performed at the Site. Field data such as field parameters, sample times, analysis requested, bottle preservation, etc., will be recorded on field data sheets.

**Sample Bottles**: Sample bottles needing chemical preservation will be preserved in the laboratory prior to arrival on site. To allow flexibility in sampling order, surface water samples will have a separate COC form.

**Field Filtration**: Surface water to be analyzed for dissolved metals will be filtered in the field before preservation in the laboratory-prepared sample bottles. A 0.45-µm filter will be used to filter the sampled water from the clean, never used before plastic bottle into the laboratory-prepared sample bottle using clean tubing and a peristaltic pump or attaching the filter directly to the discharge tubing.

**Chain of Custody**: A COC form will document surface water sample possession, time of collection, analysis, preservative, facility name, and sampling team. A copy of a generic COC form is presented in Appendix A. This record will be initiated by the laboratory and will accompany the samples to and from the Site. A signed copy will be maintained in the file with the analytical results.

### 1.2.2 SURFACE WATER SAMPLING PROCEDURE

Effluent ditch surface water samples will be collected by a Teflon© coated disposable bailer. The bailer will be extended far enough from the bank to minimize the amount of silt entering the bailer. The water will then be transferred to the laboratory-supplied bottles.

After analytical samples have been collected, a sample for field parameters will be collected. Field parameters will include temperature, specific conductance, and pH.

Samples will be packed in wet ice and shipped to the laboratory via laboratory courier or overnight transport.

### 1.1.3 SURFACE WATER ANALYTICAL REQUIREMENTS

The analytes listed below are required by DNREC Solid Waste Permit No. SW-98/01. Analysis will be performed using the most current edition of USEPA Publication Number SW-846. If SW-846 does not contain a test method for a required parameter, that parameter shall be tested according to methods described in the most recent edition of the USEPA Publication "Methods of Chemical Analysis for Water and Wastes" or of "Standard Methods for Examination of Water and Wastewater."

- Arsenic
- Barium
- Calcium
- Iron
- Magnesium
- Sodium
- Zinc
- Chloride
- pH (field + lab)
- Conductivity (field + lab)
- Sulfate
- Temperature (field)
- TDS
- Hardness as CaCO3

Field parameters to be measured include specific conductance, pH, and temperature.

## 2.0 DATA DELIVERABLES

The following data deliverable will be prepared for reporting groundwater and surface water monitoring results for the Coal Ash Landfill.

INVISTA uses a third party to collect groundwater samples, collect water level measurements, conduct data evaluations, and prepare sampling reports. The selected third party maintains the database for sample results associated with the groundwater sampling. A third party, accredited laboratory is also retained to conduct the analytical program.

All analytical data will be provided in a standard deliverable format (i.e., hardcopy) and provided as an electronic deliverable. The data will then be summarized, checked for accuracy, and tabulated upon receipt by the third party Quality Assurance (QA) Officer. The following section describes the QA Officer's function in more detail.

### 2.1 QUALITY ASSURANCE

The QA Officer will review all analytical data for:

- Precision
- Accuracy
- Completeness
- Batch Integrity
- Appropriateness

The steps taken to assess each of the above items are detailed in the following sections.

**Precision**: Precision is defined as the agreement between numeric values for two of more measurements that have been made in an identical fashion. The laboratory's objective for precision is to equal or exceed the guidelines of the analytical methods. The laboratory routinely monitors precision for each of the methods by means of relative percent difference measurements for laboratory control spikes (LCSs) versus lab control spike duplicates (LCSDs), matrix spike (MS) versus matrix spike duplicate (MSD) samples, or samples and sample duplicates (DUP) in each analytical batch.

**Accuracy**: Accuracy is the degree of agreement of a measurement with an accepted true value. The accuracy check consists of the following.

- Checking that the date analyzed/date sampled from the certificate of analysis matches the electronic disk deliverable. Hold times are also verified.
- Reviewing the reported detection limits/dilution factors on the certificate of analysis to ensure that they match the electronic deliverable.
- Reviewing the reported results for all analytes for a given analytical methodology on the certificate of analysis to ensure that they match the electronic deliverable.

**Completeness**: Completeness is a measure of the amount of valid data obtained from the measurement system compared with the amount that was expected under normal conditions. Analytical data for a given project are reviewed for completeness by the QA Officer. The definition of completeness consists of the following.

- Checking that the collected field samples were analyzed by the correct analytical method as stated in the project specifications.
- Checking that the required analytes for each collected field sample were reported by the laboratory for a given analytical method.
- Checking that the appropriate preparation method was performed for the requested analytical method.
- Reviewing the analytical data to ensure that the analytical method required holding time was achieved.

**Batch Integrity**: The QA Officer reviews the batch quality control (QC) on all of the analytical methods used for a given project. The batch process is per SW-846. For MS/MSD samples collected in the field at a rate of 1 per 20, the laboratory shall have an MS/MSD to incorporate into each analytical batch.

The QA Officer's review consists of reviewing the analytical data on a batch basis to ensure that the necessary QC samples (method blank [MB], LCS, LCSD, MS, MSD, or DUP) were performed for every batch of 20 or fewer field samples in a given project. The purpose of this review is to ensure that the accuracy and precision data are associated with every batch of samples for a given analytical method. A batch equals 20 or fewer field samples that have associated precision and accuracy QC data including:

- MB
- LCS
- LCSD
- MS
- MSD
- DUP

**Appropriateness**: Appropriateness considers the usability of the data for the project, given the results of precision and accuracy measurements, and batch QC review. The batch QC data are reviewed by the QA Officer to determine if the accuracy and precision measurements associated with every 20 field samples are within the prescribed QC limits. All batch QC sample comments made by the laboratory are also reviewed for their appropriateness for a given accuracy or precision QC measurement which is not within the designated limits.

If batch QC limits are not within the prescribed limits, it will be noted by writing a comment in the QC section of the analytical report or by writing a case narrative.

The reported practical quantitation limits (PQLs) from the laboratory are also reviewed by the QA Officer and compared against project specifications. A checklist is certified by the QA Officer who ensures that all of these steps are completed for each sample batch. Appendix B provides an example of the checklist that will be used to evaluate data.

## 2.2 ANALYTICAL REPORTS

As stated in Section B2.0, the laboratory will provide all analytical data in two formats (standard deliverable and electronic).

## 2.3 DATA EVALUATION REPORT

The data and conclusions will be included in the Annual Hydrogeological Report, as required in Permit SW-09/01, condition IV.C, to be submitted to the Solid Waste Management Branch of the Delaware DNREC.

The Annual Operations Report is produced and approved by INVISTA for submittal to DNREC.

# APPENDIX G

# CONSTRUCTION QUALITY ASSURANCE PLAN (CQAP)

May 25, 2011

# CONSTRUCTION QUALITY ASSURANCE PLAN
# COAL ASH LANDFILL COVER SYSTEM

**INVISTA SITE**
**SEAFORD, DELAWARE**

**Prepared For:**
**INVISTA S.à.r.l**

**MAY 2011**
**REF. NO. 058210 (2 – App. G)**
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TABLE OF CONTENTS

Page

1.0 INTRODUCTION ..... G-1
1.1 PURPOSE AND ORGANIZATION OF REPORT ..... G-1

2.0 PROJECT DESCRIPTION ..... G-3

3.0 PROJECT ORGANIZATION AND RESPONSIBILITIES ..... G-4
3.1 INVISTA PROJECT MANAGER ..... G-4
3.2 CONSTRUCTION MANAGER ..... G-5
3.3 CONSTRUCTION QUALITY ASSURANCE ENGINEER ..... G-5
3.4 CQA TEST LABORATORIES ..... G-6
3.5 CONTRACTOR ..... G-6

4.0 PROJECT MEETINGS ..... G-7

5.0 INSPECTION, TESTING, AND SAMPLING ACTIVITIES ..... G-8
5.1 SCOPE ..... G-8
5.2 INSPECTIONS ..... G-8
5.3 TESTING ..... G-10
5.3.1 EVALUATION OF OUTLYING DATA ..... G-10
5.4 SAMPLING PROCEDURES ..... G-11
5.5 FIELD LOGBOOKS/DOCUMENTATION ..... G-11
5.6 FINAL EVIDENCE FILES CUSTODY PROCEDURES ..... G-12

6.0 CQA DOCUMENTATION ..... G-13
6.1 GENERAL ..... G-13
6.2 CONTRACTOR'S DAILY SITE LOGBOOK ..... G-13
6.3 CQA INSTRUMENT CALIBRATION ..... G-14
6.4 FINAL CONSTRUCTION REPORT ..... G-14

LIST OF TABLES
(Following Text)

TABLE G.5.1 SUMMARY OF CONSTRUCTION QUALITY ASSURANCE INSPECTIONS

# LIST OF ACRONYMS

| | | |
|---|---|---|
| CQA | - | Construction Quality Assurance |
| CQAP | - | Construction Quality Assurance Plan |
| CRA | - | Conestoga-Rovers & Associates, Inc. |
| DNREC | - | Delaware Department of Natural Resources and Environmental Control |
| FCP | - | Final Closure Plan |
| INVISTA | - | INVISTA S.à.r.l |
| H&S | - | Health and Safety |
| HASP | - | Health and Safety Plan |
| O&M | - | Operation and Maintenance |
| QA | - | Quality Assurance |
| QC | - | Quality Control |
| Site | - | INVISTA S.à.r.l Nylon Site in Seaford, Delaware |
| TAL | - | Target Analyte List |
| TCL | - | Target Compound List |

# 1.0 INTRODUCTION

This Construction Quality Assurance Plan (CQAP) for the Coal Ash Landfill at the INVISTA S.à.r.l (INVISTA) Nylon Site in Seaford, Delaware (Site) has been prepared by Conestoga-Rovers & Associates Inc. (CRA), on behalf of INVISTA, as part of the landfill final closure activities being conducted in accordance with the Delaware Department of Natural Resources and Environmental Control (DNREC) Solid Waste Permit SW-09/01. This CQAP is appended to the Final Closure Plan (FCP) for the Coal Ash Landfill cover system and should be read in conjunction with the FCP as it defines the quality assurance program and standards that will be followed to confirm construction of the Coal Ash Landfill cover system meets the objectives specified in Title 7, Section 6.10 of the Delaware Administrative Code. The objectives are: the owner or operator of the industrial landfill must close the landfill in a manner that 1) minimizes the need for further maintenance, and 2) minimizes the post-closure impacts of solid waste to surface water, groundwater or atmosphere. The FCP, as designed, will meet these objectives.

The location of the INVISTA Site in the Seaford area and the location of the Coal Ash Landfill within the Site are presented on Figures 1 and 2, respectively.

## 1.1 PURPOSE AND ORGANIZATION OF REPORT

This CQAP presents the construction quality assurance program to be followed during implementation of the final cover system for the Coal Ash Landfill at the INVISTA Site to ensure that the construction activities meet or exceed all design criteria, plans, and specifications. Long-term operation and maintenance (O&M) requirements for the final cover system will be part of the Post-Closure Plan, which is also appended to the FCP. This CQAP is organized as follows:

**Section 2.0 – Project Description**

This section provides a description of the project.

**Section 3.0 – Project Organization and Responsibilities**

This section outlines the project organization and responsibilities.

**Section 4.0 – Project Meetings**

This section presents the project meeting requirements.

## Section 5.0 – Inspection, Testing, and Sampling Activities

This section describes the inspection, testing, and sampling activities required to ensure that construction and materials comply with all design specifications and drawings.

## Section 6.0 – CQA Documentation

This section describes documentation requirements of CQA activities.

## 2.0 PROJECT DESCRIPTION

The major components of the construction activities for the Coal Ash Landfill cover system include the following:

- implementation of Site-specific Health and Safety Plan (HASP), preparation of storm water management plan and approval by State, preparation of associated work plans and procedures as required
- mobilization of construction facilities, material, equipment, and personal necessary to perform work
- implementation of environmental and storm water controls
- provision and maintenance of construction facilities and temporary controls
- Site preparations including:
  - surveys
  - work zone identification
  - provision of temporary utilities
  - construction of temporary access roads, as required
  - clearing and grubbing of existing vegetation
- placement of coal ash materials from the Coal Ash Settling Ponds
- construction of a final cover system to design standards, in accordance with design drawings and specifications
- closeout activities including:
  - on-Site restoration
  - decontamination of Site equipment and facilities
- demobilization of construction facilities and equipment from Site

## 3.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

The construction activities performed by the selected contractor will be reviewed by a Construction Quality Assurance Engineer (CQAE). The CQAE will be responsible for ensuring that the final cover system is constructed in accordance with the FCP. The CQAE will be on-Site during key construction activities.

The primary role of the selected Contractor is to implement each of the final cover system components in accordance with the design drawings and technical specifications, and in compliance with this CQAP. Any subcontractors for specific construction activities and specific quality assurance (QA) testing activities (i.e., compaction testing, geomembrane installer, etc.) will be supervised by the Contractor. General construction activities will also be overseen by the Construction Manager, who reports directly to the Project Manager.

Brief descriptions of the duties of the key personnel are presented below.

### 3.1 INVISTA PROJECT MANAGER

The duties of the INVISTA Project Manager are as follows:

- provide overall project management
- supervise full-time on-site Construction Manager and CQAE
- ensure professional services by Construction Manager, CQAE, and Contractor are cost effective and of highest quality
- ensure all resources are available to complete the execution of the FCP
- participate in key technical negotiations with the DNREC, as required
- provide managerial guidance to the Contractor, Construction Manager, and CQAE
- reviews all submittals to DNREC
- ensure construction progresses on-schedule

## 3.2 CONSTRUCTION MANAGER

The duties of the Construction Manager are as follows:

- provide full-time on-site construction management
- oversee all field work and issue all work permits,
- approve Job Safety Analyses (JSAs)
- ensure all CQAP procedures are supported and executed
- provide daily supervision of all on-Site project activities
- interact daily with the Contractor to provide assistance to comply with the specified design

## 3.3 CONSTRUCTION QUALITY ASSURANCE ENGINEER

The duties of the Construction Quality Assurance Engineer (CQAE) are as follows:

- ensure intended design criteria as expressed in design drawings and specifications are maintained throughout construction
- provide design guidance of all CQA activities
- identify work that should be accepted, rejected, or uncovered for observation, or that may require special testing, inspection, or approval
- reject defective work and verifies that corrective measures are implemented
- ensure that defective work and corrective measures are consistent with design intent
- interact regularly with the Construction Manager to ensure work is accurately documented to comply with the specified design
- review CQA procedures and maintains records of all CQA testing performed by the Contractor
- identify acceptable CQA test laboratories
- ensure that regular calibration of testing equipment is conducted and recorded
- ensure that all Site CQA activities are recorded daily and maintained
- ensure that CQA test results are accurately recorded

Although the Contractor is responsible for overall construction and compliance with the drawings and specifications, the CQAE will act independent of the Contractor to ensure compliance with the design criteria.

Dependent on the level of activity at the Site, additional CQA Support Personnel may be utilized, or conversely this support function may be fulfilled by the Construction Manager when CQA activities are infrequent and full-time CQA observation is not required.

## 3.4 CQA TEST LABORATORIES

CQA Test Laboratories (e.g., geotechnical testing facility) that will conduct CQA testing will be identified prior to the commencement of the cover system construction activities. The duties of the QCA Test Laboratories are to provide CQA testing of appropriate construction activities and materials to confirm that these construction activities and materials are being implemented in conformance with the technical specifications and drawings.

## 3.5 CONTRACTOR

The duties of the Contractor, as they relate to QA/QC, are as follows:

- retain qualified independent testing firms (e.g., geotechnical laboratory) for testing of materials and workmanship as specified in the FCP and technical specifications
- submit samples and/or materials for testing to determine if samples/materials meet specified requirements, and submit test results directly to the CQAE
- record daily CQA activities in the Contractor's Site logbook and submit a "Daily Construction Quality Control Report" (see Section 7.2) to the CQAE
- carry out construction activities according to technical specifications and drawings.

## 4.0 PROJECT MEETINGS

Project meetings will be held during construction implementation to ensure that all tasks are accomplished according to the submitted schedule and that they are completed in accordance with the technical specifications and drawings. It is anticipated that these progress meetings will be attended, on a frequency jointly determined by the INVISTA Project Manager, Construction Manager, CQAE, and Contractor.

Anticipated meetings include:

- Pre-Construction Meeting
- Weekly Progress Meetings
- Construction Milestone Meetings
- Post-Construction Review
- Project Closeout

# 5.0 INSPECTION, TESTING, AND SAMPLING ACTIVITIES

## 5.1 SCOPE

Throughout the implementation of the construction activities, there will be numerous inspections and testing requirements for specific work tasks. The inspection and testing requirements will ensure compliance with the cover system design, as well as ensure completion of the work tasks to the highest level of quality.

Inspections and testing will provide a qualitative and quantitative means of monitoring the quality and progress of work performed.

The components of each work task that will require inspection or testing are as follows:

i) Construction Facilities and Temporary Controls

- storm water control
- clearing and grubbing
- provision of personnel and equipment decontamination facilities
- construction and/or upgrading of access roads

ii) Cover System Construction

- storm water control
- waste placement
- geomembrane installation
- final cover construction

## 5.2 INSPECTIONS

Throughout the period of construction, the quality of work completed and materials used for each of the work tasks will be maintained at its highest practical level through regular inspections of the work. Inspections will be completed throughout construction under the supervision of the Project Manager's full-time on-site Construction Manager and/or CQAE, as appropriate.

In general, inspections to be conducted include the following:

i) reviewing and approving Contractor work plans

ii) monitoring work progress

iii) inspecting materials as delivered to the Site to check for damage during delivery

iv) comparing materials and equipment delivered to the technical specifications and drawings

v) inspecting materials after they have been installed or placed to ensure that they have not been damaged during installation and they have been placed properly

vi) performing pre-construction inspection prior to beginning work, including the following:

- review of design requirements to ensure that all materials have been tested according to applicable standards and specifications,
- ensure that provisions have been made to provide required quality control testing
- examination of the work area to ascertain that all applicable preliminary work tasks have been completed

vii) performing general inspections periodically as the amount of work completed warrants an inspection, including the following:

- examination of the quality of workmanship
- testing of materials for compliance with design requirements
- any omissions
- general progress of work performed

viii) performing final inspection upon completion of each and all work tasks to ensure compliance with the technical specifications and drawings and to ensure that deficiencies identified in the general inspections have been corrected

These inspections performed/observed by the Construction Manager and/or CQAE, and documented in the Final Construction Report. Copies of the inspection reports will be provided to all parties involved in the inspection.

The component of each work task to be inspected, the types of inspections required, and the frequency of the inspections are summarized in Table G.5.1.

All observations and quality control field tests will be recorded by CQAE into Inspection Logbooks. These books will be kept on Site and maintained by the INVISTA Project Manager. The inspection logbook will include the following information:

- date, time, and weather conditions
- description or title of the inspection activity
- location of the inspection activity or location from which the sample increment was obtained
- type of inspection activity and procedure used (reference to standard method when appropriate)
- recorded observation or test data, with all necessary calculations
- results of the inspection activity and comparison with specification requirements
- personnel involved in the inspection activity
- signature of appropriate CQAE and concurrence by the INVISTA Project Manager

Items above shall be formulated into checklists so that details are not overlooked.

## 5.3 TESTING

In addition to inspections of construction progress, materials testing will be performed by Contractor with oversight by the on-site Construction Manager and/or CQAE (field testing) or geotechnical testing facility (lab testing). Materials testing will be performed to ensure compliance with material specifications and design criteria as presented in the technical specifications. All testing (field or lab) results will be subject to the review and approval or disapproval of the CQAE.

The testing requirements, testing methods, and testing frequency for each of the work task components are summarized in Table G.5.1.

### 5.3.1 EVALUATION OF OUTLYING DATA

Due to variability in materials and inaccuracies in testing, individual test results are anticipated to occasionally fail to conform to the required specifications. The allowable percentage of outliers (test results which do not meet the specifications) will be based on the technical guidance document entitled "Quality Assurance and Quality Control for Waste Containment Facilities, U.S. EPA, EPA/600/R-93/182, September 1993". The

CQAE will make all final determinations regarding data evaluations and suitability for use on the project.

## 5.4 SAMPLING PROCEDURES

All imported materials brought to the Site for cover system construction will be sampled and analyzed for the Target Analyte List (TAL) Volatile Organic Compounds (VOCs) to non-detect concentrations and Target Compound List (TCL) metals parameters within or below Typical Delaware Soil Concentrations provided in Attachment 3 of DNREC's Remediation Standards Guidance under the Delaware Hazardous Substance Cleanup Act. A minimum of one composite sample per material source will be taken.

## 5.5 FIELD LOGBOOKS/DOCUMENTATION

Field logbooks will provide the means of recording data collection activities performed. As such, entries will be described in as much detail as possible so that persons going to the Site could reconstruct a particular situation without reliance on memory.

The title page of each logbook will contain the following:

- person to whom the logbook is assigned
- logbook number
- project name
- project start date
- end date

Entries into the logbook will contain a variety of relevant information. At the beginning of each entry, the date, start time, meteorological conditions, names of all team members present, level of personal protection being used, and the signature of the person making the entry will be entered. The names of visitors participating in field sampling and the purpose of their visit will also be recorded in the field logbook.

Measurements made and samples collected will be recorded. All entries will be made in ink with no erasures. If an incorrect entry is made, the information will be crossed out with a single strike mark. Whenever a sample is collected, or a measurement is made, a detailed description of the sampling location, will also be noted which includes compass

direction and distance taken from a reference point, if any. All equipment used to make measurements will be identified, along with the date of calibration.

The equipment used to collect samples will be noted, along with the time of sampling and sample location. Sample identification numbers will be assigned during sample collection.

## 5.6 FINAL EVIDENCE FILES CUSTODY PROCEDURES

Evidentiary files for the entire project will be provided to INVISTA at the completion of the project and will consist of the following:

- project plan
- project logbooks
- field data records
- sample identification documents
- chain-of-custody records
- correspondence
- references
- literature
- final data packages
- miscellaneous - photos, maps, drawings, etc.
- final report

The evidentiary file materials will be the responsibility of the evidentiary file custodian with respect to maintenance and document removal.

The laboratory will be responsible for maintaining analytical logbooks and laboratory data.

# 6.0 CQA DOCUMENTATION

## 6.1 GENERAL

This section details the documentation requirements. Proper, thorough, and accurate documentation of all CQA site activities is important in ensuring quality installation. CQA testing will be documented daily.

## 6.2 CONTRACTOR'S DAILY SITE LOGBOOK

The selected Contractor will record daily QC activities in a Daily Site Logbook to be kept on Site at all times. The logbook will include the following information:

- date and weather conditions
- all Site activities
- decisions made regarding approval of units of material or of work, and/or corrective actions to be taken in cases of substandard quality
- submittals made by suppliers verifying material quality
- quality control test and inspection results
- construction delays and causes
- areas affected by delays
- construction problems and corrective actions
- personnel on Site
- present phase of construction
- material and equipment delivered to the Site, including equipment mobilization/demobilization
- inspections made
- health and safety considerations
- QC tests performed and results of tests taken on previous work day
- instructions given by the Project Manager, Construction Manager and/or CQAE
- changed conditions/conflicts encountered

## 6.3 CQA INSTRUMENT CALIBRATION

CQAE will record calibrations of test equipment in an Instrument Calibration Logbook, maintained on Site by the Project Engineer. Actions taken as a result of recalibration will be recorded in the Inspection logbook, as described in the next section.

## 6.4 FINAL CONSTRUCTION REPORT

At the completion of the cover system construction activities, the Contractor, in collaboration with the CQAE, will prepare and submit the Final Construction Certification Report for the Coal Ash Landfill to DNREC, subsequent to review and approval by INVISTA. This report will be certified by the CQAE per Delaware's Regulations Governing Solid Waste, Section 6.10.4.7. This certification report will include a description of the construction activities and present copies of pertinent information to the construction including Inspection Logbooks, deviations from design and material specifications (with justifying documentation), CQA test results, and as-constructed drawings (including final survey of ash placement footprint and elevations, final geomembrane panel placement survey, and final as-built elevations of completed cover system, at a minimum).

**TABLE G.5.1**

**SUMMARY OF CONSTRUCTION QUALITY ASSURANCE INSPECTIONS
COAL ASH LANDFILL COVER SYSTEM
INVISTA SEAFORD FACILITY**

| *Work Task Component to be Inspected/Tested* | *Items to be Checked (Type of Testing)* | *Type of Inspection (Method of Testing)* | *Frequency of Inspection* | *Submittals to CQA Engineer* | *Acceptance/Rejection Criteria* |
|---|---|---|---|---|---|
| ***A. Construction Facilities and Temporary Controls*** | | | | | |
| • Temporary soil erosion and sediment control | • is storm water runoff prevented from leaving work areas | • visual | • daily as required | • none | • surface water controls not implemented |
| | • is dust being generated from placement of coal ash and cover soils | • visual | • daily as required | • none | • dust control measures not implemented |
| | • are proper equipment decontamination procedures being followed | • visual | • as required | • none | • decontamination procedures not being followed |
| | • are the silt fences being maintained during construction activities | • visual | • daily as required | • none | • evidence of visual irregularities and excessive sediment build-up |
| • Clearing and Grubbing | • are limits of clearing clearly marked and are clearing and grubbing activities proceeding only within these limits | • visual | • daily as required | • none | • failure to perform as stated |
| ***B. Site Preparation Activities*** | | | | | |
| • Slope Reduction | • horizontal and vertical control | • topographic survey | • prior to, during & after removal | • survey information | • design grades not achieved |
| ***C. Landfilling Activities*** | | | | | |
| • Placement of Coal Ash Material in Landfill | • has coal ash material been compacted to specification | • lift thickness<br>• in situ density | • continuously during placement<br>• 2 per acre per lift | • none<br>• density results | • not exceeding 12 in. compacted depth<br>• 92% Standard Proctor Density |
| | • horizontal and vertical control | • survey staking | • during and upon completion of backfilling | • survey information | • failure to perform as staked |
| ***D. Cover System Construction*** | | | | | |
| • Base Preparation | • horizontal and vertical control | • topographic survey | • upon completion of excavation of slopes & coal ash placement at 100-foot grid (maximum) | • survey information | • proper design subgrade elevations not attained |
| | • does subgrade (ash) meet in place density and moisture content specifications | • ASTM D-698 | • 1 sample per 2,500 CY | • all geotechnical data | • lab test to establish criteria |
| | • are open surface areas and slopes suitable for placing geomembrane | • visual observation | • prior to installing geomembrane | • subgrade acceptance form (liner installer) | • visual surface irregularities (i.e., rocks) |

**TABLE G.5.1**

**SUMMARY OF CONSTRUCTION QUALITY ASSURANCE INSPECTIONS**
**COAL ASH LANDFILL COVER SYSTEM**
**INVISTA SEAFORD FACILITY**

| *Work Task Component to be Inspected/Tested* | *Items to be Checked (Type of Testing)* | *Type of Inspection (Method of Testing)* | *Frequency of Inspection* | *Submittals to CQA Engineer* | *Acceptance/Rejection Criteria* |
|---|---|---|---|---|---|
| ***D. Cover System Construction (cont'd)*** | | | | | |
| • Select Fill Material<br>a) Installation | • are imported soils approved for application | • visual observation | • prior to delivery to Site for each source of imported material | • none | • does not meet specifications |
| | • Maximum Dry Density | • ASTM D-698 | • 1 sample per 2,500 CY | • all geotechnical data | • lab test to establish criteria |
| | • Optimum Moisture Content | • ASTM D-698 | • 1 sample per 2,500 CY | • all geotechnical data | • lab test to establish criteria |
| | • In -place Moisture Content | • ASTM D-2216 | • 1 sample per 2,500 CY | • all geotechnical data | • lab test to establish criteria |
| | • Atterburg Limits | • ASTM D-4318 | • 1 sample per 2,500 CY | • all geotechnical data | • no ML or CL per ASTM D-2487 |
| | • Soil Classification | • ASTM D-2487 | • 1 sample per 2,500 CY | • all geotechnical data | • no ML or CL classification |
| | • Particle Size Distribution | • ASTM D-422 | • 1 sample per 2,500 CY | • all geotechnical data | • Paragraphs 2.2 & 2.4 of Section 02316 |
| | • Chemical Analyses (to verify fill is clean) | • USEPA SW-846<br>TCL VOCs (8260B)<br>TAL Inorganics (6010/7000) | • each material source area | • chemical results | • no chemicals present |
| | • does soil contain unsuitable material | • visual observation | • each source of material | • none | • unsuitable material observed |
| b) Compaction | • Density in Place | • ASTM D-6938 | • 2 per acre per lift | • all geotechnical data | • 92% of Max. Dry Density |
| | • Moisture Content in Place | • ASTM D-6938 | • 2 per acre per lift | • all geotechnical data | • 3 - 5% above Optimum |
| | • Thickness of Layers | • test pitting | • continuously during placement | • all field notes | • 6 in. compacted depth where required if ash not acceptable for liner protection<br>• lesser thickness acceptable when used to cover wet ash surface that becomes difficult to work on when placing liner |
| | • Final Elevation | • topographic survey | • during and upon fill material placement at 100-foot grid (max.) | • survey information | • tolerance of $\pm$1 in. from design elev. |
| • Sand Drainage Layer<br>a) Installation | • Particle Size Distribution | • ASTM D-422 (or C-136) | • 1 sample per 2,500 CY | • all geotechnical data | • $D_{15}$ (sand) / $D_{85}$ (common fill) < 4<br>• 4 < $D_{15}$ (sand) / $D_{15}$ (common fill) < 25<br>• $D_{50}$ (sand) / $D_{50}$ (common fill) < 25 |
| | • Maximum Dry Density | • ASTM D-698 | • 1 sample per 2,500 CY | • all geotechnical data | • lab test to establish criteria |
| | • Optimum Moisture Content | • ASTM D-698 | • 1 sample per 2,500 CY | • all geotechnical data | • lab test to establish criteria |
| | • Remolded Permeability | • ASTM D-2434 | • 1 sample per 5,000 CY | • all geotechnical data | • $1 \times 10^{-4}$ to $5 \times 10^{-5}$ cm/sec |
| | • Chemical Analyses (to verify fill is clean) | • USEPA SW-846<br>TCL VOCs (8260B)<br>TAL Inorganics (6010/7000) | • each material source area | • chemical results | • no chemicals present |
| b) Placement | • Density in Place | • no testing required | • no sampling required | • none | • spreading sand only (no compaction equipment to prevent damage to liner) |
| | • Thickness | • visual observation | • continuously during placement | • none | • not exceeding 12 in. (lightly tracked) |
| | • Elevation | • topographic survey | • during and upon fill material placement at 100-foot grid (max.) | • survey information | • tolerance of $\pm$1 in. from design elev. |

**TABLE G.5.1**

**SUMMARY OF CONSTRUCTION QUALITY ASSURANCE INSPECTIONS**
**COAL ASH LANDFILL COVER SYSTEM**
**INVISTA SEAFORD FACILITY**

| *Work Task Component to be Inspected/Tested* | *Items to be Checked (Type of Testing)* | *Type of Inspection (Method of Testing)* | *Frequency of Inspection* | *Submittals to CQA Engineer* | *Acceptance/Rejection Criteria* |
|---|---|---|---|---|---|
| ***D. Cover System Construction (cont'd)*** | | | | | |
| • Common Fill Material a) Installation | • are imported soils approved for application | • visual observation | • prior to delivery to Site for each source of imported material | • none | • does not meet specifications |
| | • Maximum Dry Density | • ASTM D-698 | • 1 sample per 2,500 CY | • all geotechnical data | • lab test to establish criteria |
| | • Optimum Moisture Content | • ASTM D-698 | • 1 sample per 2,500 CY | • all geotechnical data | • lab test to establish criteria |
| | • In -place Moisture Content | • ASTM D-2216 | • 1 sample per 2,500 CY | • all geotechnical data | • lab test to establish criteria |
| | • Atterburg Limits | • ASTM D-4318 | • 1 sample per 2,500 CY | • all geotechnical data | • no ML or CL per ASTM D-2487 |
| | • Soil Classification | • ASTM D-2487 | • 1 sample per 2,500 CY | • all geotechnical data | • no ML or CL classification |
| | • Particle Size Distribution | • ASTM D-422 | • 1 sample per 2,500 CY | • all geotechnical data | • Paragraphs 2.2 & 2.4 of Section 02316 |
| | • Hydraulic Conductivity | • ASTM D-5084 | • 1 sample per 10,000 CY | • all geotechnical data | • $1 \times 10^{-4}$ to $1 \times 10^{-5}$ cm/sec |
| | • Chemical Analyses (to verify fill is clean) | • USEPA SW-846<br>TCL VOCs (8260B)<br>TAL Inorganics (6010/7000) | • each material source area | • chemical results | • no chemicals present |
| | • does soil contain unsuitable material | • visual observation | • each source of material | • none | • unsuitable material observed |
| b) Compaction | • Density in Place | • ASTM D-6938 | • 2 per acre per lift | • all geotechnical data | • 90% of Max. Dry Density |
| | • Moisture Content in Place | • ASTM D-6938 | • 2 per acre per lift | • all geotechnical data | • 3 - 5% above Optimum |
| | • Thickness of Layers | • test pitting | • continuously during placement | • all field notes | • 6 in. compacted depth |
| | • Final Elevation | • topographic survey | • during and upon fill material placement at 100-foot grid (max.) | • survey information | • tolerance of $\pm$1 in. from design elev. |
| • Topsoil Layer a) Installation | • are imported soils approved for application | • visual observation | • prior to delivery to Site for each source of imported material | • none | • does not meet specifications |
| | • Particle Size Distribution | • ASTM D-422 | • 1 sample per 2,500 CY | | • Paragraph 2.5 of Section 02316 |
| | • Acidity Range (pH) | • ASTM D-4972 | • 1 sample per 2,500 CY | | • 5.5 to 7.5 |
| | • Organic Matter | • ASTM D-2974 | • 1 sample per 2,500 CY | | • 4% to 25% |
| | • Soil Classification | • ASTM D-2487 | • 1 sample per 2,500 CY | | • SP, SM, ML or OL |
| | • Chemical Analyses (to verify fill is clean) | • USEPA SW-846<br>TCL VOCs (8260B)<br>TAL Inorganics (6010/7000) | • each material source area | • chemical results | • no chemicals present |
| | • does soil contain unsuitable material | • visual observation | • each source of material | • none | • unsuitable material observed |
| b) Placement | • Thickness | • visual observation | • continuously during placement | • none | • not less than 6 in. |
| | • Elevation | • topographic survey | • during and upon fill material placement at 100-foot grid (max.) | • survey information | • tolerance of $\pm$ 0.1 ft from design elev. |
| • Vegetative Cover | • Seed (K-31 Fescue) | • N/A | • 100 lbs/acre | • seed certificates | • does not meet specifications |

**TABLE G.5.1**

**SUMMARY OF CONSTRUCTION QUALITY ASSURANCE INSPECTIONS**
**COAL ASH LANDFILL COVER SYSTEM**
**INVISTA SEAFORD FACILITY**

| *Work Task Component to be Inspected/Tested* | *Items to be Checked (Type of Testing)* | *Type of Inspection (Method of Testing)* | *Frequency of Inspection* | *Submittals to CQA Engineer* | *Acceptance/Rejection Criteria* |
|---|---|---|---|---|---|
| ***D. Cover System Construction (cont'd)*** | | | | | |
| • LLDPE Liner<br>a) Materials | • does liner comply with specifications | • check certificates<br>(all testing as per GRI Standard GM17) | • prior to delivery to site | • manufacturer's certificates | • does not meet specifications |
| | • Thickness | • ASTM D-5199 | • per roll | | • 40 mils* |
| | • Density | • ASTM D-1505/792 | • 1 per 200,000 lbs | | • 0.939 g/cc* maximum |
| | • Tensile strength at break | • ASTM D-6993, Type IV | • 1 per 20,000 lbs | | • 152 lbs/inch width |
| | • Elongation at break | • ASTM D-6993, Type IV | • 1 per 20,000 lbs | | • 800% |
| | • Puncture resistance | • ASTM D-4833 | • 1 per 45,000 lbs | | • 56 lbs |
| | • Tear resistance | • ASTM D-1004 | • 1 per 45,000 lbs | | • 22 lbs |
| | • Carbon black content | • ASTM D-1603/D-4218 | • 1 per 45,000 lbs | | • 2% to 3% |
| | • Carbon Black Dispersion | • ASTM D5596 | • 1 per 45,000 lbs | | |
| | • 9 out of 10 | | | | • Cat 1 or 2 |
| | • 10 out of 10 | | | | • Cat 1, 2, or 3 |
| | • Oxidation Induction Time | • ASTM D3895 (Standard) | • 1 per 200,000 lbs | | • 100 minutes |
| | | • ASTM D5885 (High Pressure) | | | • 400 minutes |
| | • Oven Aging at 85°C | • ASTM D5721 | • per formulation | | • NA |
| | • standard OIT (90 days) | • ASTM D3895 | | | • 35% |
| | • high pressure OIT (90 days) | • ASTM D5885 | | | • 60% |
| | • UV Resistance (20-hour UV cycle at 75°C) | | • per formulation | • 35% | |
| | • high pressure OIT (1,600 hours) | • ASTM D5885 | | | • 60% |
| | • has material arrived to Site undamaged | • visual | • upon delivery to Site | • none | • damaged materials |
| b) Installation | • is ambient temperature suitable for seaming | • thermometer | • continuous | • none | • >32 degrees F and <104 degrees F |
| | • Test Seams (shear and peel) | • ASTM D-4437 | • Minimum two tests per day per seamer/equipment | • shear - 1,500 psi (60 ppi)<br>• peel - 1,250 psi (50 ppi) | • seams do not meet specified criteria |
| | • Non-destructive test | • GRI GM6 | • 100% of production seams | • none | • meet or exceed requirements of GM6 |
| | • Destructive seam shear test (field test) | • ASTM D4437 (field tensiometer) | • Min. 1 test per approx. 500 lineal feet of seam or at least one per seamer | • shear - 1,500 psi (60 ppi) | • 4 of 5 replicate samples must pass |
| | • Destructive seam peel test (field test) | • ASTM D4437 (field tensiometer) | • Min. 1 test per approx. 500 lineal feet of seam or at least one per seamer | • peel - 1,250 psi (50 ppi) | • 4 of 5 replicate samples must pass |
| | • Destructive seam shear test (if field test acceptable) | • ASTM D6392 (laboratory test) | • Min. 1 test per approx. 500 lineal feet of seam or at least one per seamer | • shear - 1,500 psi (60 ppi) | • 4 of 5 replicate samples must pass |
| | • Destructive seam peel test (if field test acceptable) | • ASTM D6392 (laboratory test) | • Min. 1 test per approx. 500 lineal feet of seam or at least one per seamer | • peel - 1,250 psi (50 ppi) | • 4 of 5 replicate samples must pass |
| | • have materials been installed as specified | • visual | • continuous | • supplier-installer approval letter | • material not installed as specified |
| | • are there any visible defects, holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter | • visual | • after installation is completed and prior to placement of overlying soils | • none | • visual defects |
| | • is the installation free of wrinkles | • visual | • immediately prior to placement of overlying materials | • none | • visual irregularities/wrinkles |

**TABLE G.5.1**

**SUMMARY OF CONSTRUCTION QUALITY ASSURANCE INSPECTIONS**
**COAL ASH LANDFILL COVER SYSTEM**
**INVISTA SEAFORD FACILITY**

| *Work Task Component to be Inspected/Tested* | *Items to be Checked (Type of Testing)* | *Type of Inspection (Method of Testing)* | *Frequency of Inspection* | *Submittals to CQA Engineer* | *Acceptance/Rejection Criteria* |
|---|---|---|---|---|---|
| ***E. Miscellaneous*** | | | | | |
| • Ditches/Swales | • does ditch installation follow proper alignment and grade | • topographic survey | • every 50 feet along ditch centerline | • survey information | • ditch not installed in accordance with drawings and specifications |
| | • does erosion control fabric meet specifications | • check against supplier's specifications | • upon delivery to Site | • supplier's certification | • material does not meet specifications |
| | • does rip rap meet specifications | • $D_{50}$ = 3 inches | • prior to delivery to Site | • all geotechnical data | • does not meet specifications |

# APPENDIX H

# FINANCIAL ASSURANCE INFORMATION

U-40A

# ENDORSEMENT

Additional Premium:

Return Premium:

This endorsement, effective 11-24-10 forms a part of Policy No. MWZZ 50438

policy effective date 7-12-10 expiration date 7-12-11 issued to INVISTA S.a r.l., LLC

by **OLD REPUBLIC INSURANCE COMPANY**, Greensburg, Pennsylvania

It is agreed and understood the following form has been deleted:

GL 350 014b 0710, Financial Assurance For Closure And Post Closure - Delaware

Also, agreed and understood, the following form has been added:

GL 350 014c 0710, Financial Assurance For Closure And Post Closure -Delaware

Endorsement #2

Nothing herein contained shall be held to vary, alter, waive or extend any of the terms, conditions, agreements or limitations of the Policy or any Endorsement attached thereto, except as herein set forth.

This Endorsement shall not be valid until countersigned by a duly authorized representative of the Company.

Attest:

Secretary

President

Countersigned at Brookfield, Wisconsin this .....30th..... day of .....March..... 2011.....

Authorized Representative.

3/30/11

# IL 10 (12/06) OLD REPUBLIC INSURANCE COMPANY

THIS ENDORSEMENT CHANGES THE POLICY. PLEASE READ IT CAREFULLY.

## FINANCIAL ASSURANCE FOR CLOSURE AND POST CLOSURE - DELAWARE

This endorsement modifies insurance provided under the following:

POLLUTION LIABILITY COVERAGE FORM

**SCHEDULE**

**Insured Site:** INVISTA S.a r.l., LLC - Seaford Site
25876 DuPont Road
Seaford, DE 19973

**Waste Facility:**

| | | | **Limit Of Insurance** |
|---|---|---|---|
| **Permit No.** | **Program Area** | | **Current $ Est.** |
| SW-09/01 | Coal Ash Solid Waste Landfill | Closure | $3,810,000 |
| SW-09/01 | Coal Ash Solid Waste Landfill | Post-Closure | $2,320,000 |

(If no entry appears above, information required to complete this endorsement will be shown in the Declarations as applicable to this endorsement.)

**A.** With respect to the Insured Site or Waste Facility shown in the Schedule, this insurance applies to satisfy the requirements of the Delaware Administrative Code (relating to Insurance), as applicable and as such regulations were constituted on the effective date of the policy period shown in the Declarations. It is agreed that any provision of the policy inconsistent with such regulations is hereby amended to eliminate such inconsistency.

**B.** The following Insuring Agreement is added to **SECTION I - POLLUTION LIABILITY COVERAGE**:

**3.** Insuring Agreement - Financial Assurance For Closure and Post Closure Costs

**a.** We will pay for financial assurance for closure and post closure costs the insured becomes legally obligated to pay for the Insured Site or Waste Facility shown in the Schedule; and

**b.** This insurance applies to financial assurance for closure and post closure costs only if:

**(1)** incurred as a result of a "pollution incident" that commences during the policy period; and

**(2)** the insureds obligation to pay such costs is asserted under the statutory of the state of Delaware.

**c.** No other obligation or liability to pay sums or to perform acts or services is covered.

**C.** The following is added to **SECTION III - LIMITS OF INSURANCE**:

**4.** The Limit Of Insurance shown in the Schedule is the most we will pay for financial assurance for closure and post closure costs under Insuring Agreement 3. for the Insured Site or Waste Facility shown in the Schedule.

We will pay such costs which are in excess of the deductible amount shown in the Declarations.